City of Millbrae

November 2014

Wet Weather Alternatives Analysis Final Report

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Wet Weather Alternatives Analysis

City of Millbrae

Prepared for

City of Millbrae

November 2014

WEST YOST ASSOCIATES
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Table of Contents

Executive Summary 1
ES.1 Introduction 1
ES.1.1 Comprehensive Inspection Success 1
ES.1.2 Enhanced Preventative Maintenance Activities Success 1
ES.1.3 Hydraulic Capacity Success 2
ES.1.3 SSO Reduction Verification 2
ES.1.4 Purpose and Organization 3
ES.2 Existing Conditions 3
ES.2.1 Current Wastewater Flows 3
ES.2.2 Existing Facilities Description 4
ES.3 Wet Weather Alternatives 5
ES.3.1 WPCP 5
ES.3.2 Madrone PS 5
ES.3.3 Madrone Force Main 7
ES.3.2 Options to Decrease Wet Weather Flows 7
ES.4 Inflow and Infiltration Sources 7
ES.5 Inflow and Infiltration Reduction Options 9
ES.6 Related Improvement Projects 12
ES.7 Alternatives Evaluation 13
ES. 8 Preferred Alternative Development 16

1.0 Introduction 1
1.1 Purpose and Organization 1
1.2 Information Sources 2

2.0 Existing Conditions 3
2.1 Current Wastewater Flows 3
2.2 Existing Facilities Description 4
2.2.1 Gravity Collection System 4
2.2.2 Madrone PS 4
2.2.3 Madrone Force Main 4
2.2.4 Water Pollution Control Plant 4

3.0 Wet Weather Alternatives 6
3.1 Options to Increase Capacity 6
3.1.1 Water Pollution Control Plant 6
3.1.2 Madrone PS 6
3.1.3 Madrone Force Main 7
3.2 Options to Reduce Wet Weather Flows 7

4.0 Inflow and Infiltration Sources 8
4.1 RDII Components 8
4.2 Sources of RDII 9
4.3 Inflow Indicators 9
4.4 Infiltration Indicators 10

5.0 Inflow and Infiltration Reduction Options 11
5.1 Inflow Source Disconnections 11
5.1.1 Smoke Testing 11
5.1.2 Inflow Source Disconnection 11
5.2 Collection System Rehabilitation Options 11
5.3 Identification of Sub-Basins for RDII Reduction 14
5.3.1 RDII Levels 14
5.3.2 Pipe Size, Age, and Material 15

5.3.3 CCTV Inspection Data 17
5.3.4 Sanitary Sewer Blockages and Overflows 17
5.3.5 Rehabilitation Sub-Basins 20
5.3.6 Rehabilitation Approach 21

6.0 Related Improvement Projects 22
6.1 Consent Decree Requirements 22
6.1.1 Defect Repair Projects 22
6.1.2 Gravity Sewer Capacity Improvement Projects 24
6.1.2.1 WPCP Storage 24
6.1.3 Ongoing Collection System Asset Replacement 24

7.0 Alternatives Evaluation 29
7.1 Evaluation Criteria 29
7.2 Description of Alternatives 29
7.2.1 Alternative 1A - CAR Capacity Upgrade Recommendations with No RDII Reduction 31
7.2.2 Alternative 1B – Revised Capacity Upgrade Recommendations with No RDII Reduction 31
7.2.3 Alternative 2: RDII Reduction in Public Infrastructure 33
7.2.4 Alternative 3: RDII Reduction in Public and Private Infrastructure 36
7.3 Hydraulic Analysis Results 37
7.4 Capital Cost Assumptions 38
7.5 Economic Analysis 40
7.6 Non-Economic Analysis 42
7.7 Recommended Alternative Evaluation Criteria 44

8.0 Preferred Alternative Development 45
8.1 Planning Projects 45
8.1.1 Inflow Reduction Program 45
8.1.2 Flow and Rainfall Monitoring Program 45
8.1.3 Hydraulic Model Update 46
8.1.4 CAR Update 46
8.2 Recommended Capital Program 46
8.2.1 Capital Improvement Program 46
8.2.2 Implementation Plan 47
8.2.3 RDII Reduction Schedule 49
8.3 Other Recommendations 51
8.3.1 Private Lateral Rehabilitation Program 51
8.3.2 Collection System Rehabilitation 51

9.0 References 52

List of Appendices

Appendix A: Collection System Inventory
Appendix B : PACP Structural 5 Defect Repair and Replacement Project
Appendix C: Collection System Capacity Upgrades
Appendix D: Madrone Pump Station Improvement Costs
Appendix E: Pair-Wise Comparison Method
Appendix F: Flow Monitoring Plan
Appendix G: Detailed Project Costs

List of Tables

Table ES-1. Advantages and Disadvantages of Common Private Lateral Policies 11
Table ES-2. Alternative Elements 14
Table ES-3. Summarized Economic Analysis Results 15
Table ES-4. Non-Economic Analysis 16
Table ES-5. Recommended Program Estimated Capital Cost Summary 17
Table ES-6. Recommended Program Implementation Schedule (in $1,000) 19
Table 1. Advantages and Disadvantages of Common Private Lateral Policies 13
Table 2. RDII Levels by Basin 14
Table 3. Basin Properties 20
Table 4. Summary of Structural 5 Defect Repair and Replacement Projects 23
Table 5. Alternative Elements 30
Table 6. Alternative 2 RDII Reduction Methods 34
Table 7. Alternative 3 RDII Reduction Methods 36
Table 8. Economic Analysis Results 41
Table 9. Non-Economic Factors 42
Table 10. Non-Economic Analysis 44
Table 11. Recommended Program Estimated Capital Cost Summary 46
Table 12. Recommended Program Implementation Schedule (in $1,000) 48
Table 13. RDII Reduction Projects 50

List of Figures

Figure ES-1. City of Millbrae SSOs ES-2
Figure ES-2. Existing Peak Wet Weather Flows at the Madrone PS and WPCP ES-4
Figure ES-3. Existing Collection System ES-6
Figure ES-4. Wastewater Components ES-8
Figure ES-5. Typical Sources of RDII ES-9
Figure ES-6. Recommended Program Implementation Schedule ES-20
Figure 1. Existing Peak Wet Weather Flows at the Madrone PS and WPCP 3
Figure 2. Existing Collection System 5
Figure 3. Wastewater Components 8
Figure 4. Typical Sources of RDII 9
Figure 5. Sewer Age and Material 16
Figure 6. Approximate Pipe Installation Dates by Basin 17
Figure 7. CCTV Inspection Observations 18
Figure 8. Overflow History 19
Figure 9. Gravity Sewer Hydraulic Capacity Projects 25
Figure 10. RDII Reduction Modeling Results 38
Figure 11. Recommended Program Implementation Schedule 49
Figure 12. RDII Reduction Schedule 51

List of Acronyms

AACE	Advancement of Cost Engineering International
ac-ft	Acre-Feet
ADWF	Average Dry Weather Flow
AIMS database	City of Millbrae AIMS asset registry and related *Millbrae_Sewer_Office.mdb* database files
Bay Area	San Francisco Bay Area
CAR	Capacity Assurance Report
CCTV	Closed-Circuit Television
CIPP	Cured-In-Place Pipe
City	City of Millbrae
City GIS	City of Millbrae Geographic Information System
CIWQS database	California Integrated Water Quality System Public Records
fps	Feet per Second
ft	feet
GIS	Geographic Information System
gpm	Gallons per Minute
GWI	Groundwater Infiltration
I&I	Infiltration and Inflow
JPA	Joint Powers Agreement
JUFM	Joint Use Force Main
kW	kilowatt
LF	Linear Feet
Madrone PS	Madrone Pump Station
MG	Million Gallons
mgd	Millions Gallons per Day
MH	Man Hole
NPDES	National Pollutant Discharge Elimination System
PACP	Pipeline Assessment & Certification Program
PSWF	Peak Dry Weather Flow
Permit	Regional Board Order No. R2-2008-0071, NPDES No. CA0037532
PWWF	Peak Wet Weather Flow
Qty	Quantity
RDII	Rainfall Dependent Inflow and Infiltration
Regional Board	San Francisco Bay Regional Water Quality Control Board
Rehab	Rehabilitation
SFPUC	San Francisco Public Utilities Commission
SSO	Sanitary Sewer Overflow
TDH	Total Dynamic Head
USEPA	United States Environmental Protection Agency
VCP	Vitrified Clay Pipe
VFD	Variable Frequency Drive
WERF	Water Environment Research Foundation
WPCP	Water Pollution Control Plant

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EXECUTIVE SUMMARY

ES.1 Introduction

Effective November 15, 2010, the City of Millbrae (City) entered into a Consent Decree with San Francisco Baykeeper (Baykeeper), the purpose of which is to reduce Sanitary Sewer Overflows (SSOs) in the City's sanitary sewer collection system. In compliance with the Consent Decree, the City is working to reduce the risk of SSOs occurring in its collection system in three ways:

- Comprehensively inspecting the collection system to identify and correct defects,
- Enhancing collection system preventative maintenance activities, and
- Providing hydraulic capacity to convey and treat Peak Wet Weather Flow (PWWF).

ES.1.1 Comprehensive Inspection Success

The City has achieved the following during the implementation of the Consent Decree with respect to inspection of the collection system:

- The Consent Decree specifies that all small diameter gravity mains (15-inches in diameter and smaller) be inspected through Closed Circuit Television (CCTV) by November of 2014. All gravity mains regardless of diameter will be inspected by September 2014, ahead of the Consent Decree deadline.
- Gravity mains with National Association of Sewer Service Companies (NASSCO) Pipeline Assessment Certification Program (PACP) Severity 5 structural defects have been identified and repaired or replaced or scheduled to be repaired and replaced as part of the rehabilitation process, leading to an improved collection system with a lower risk of SSOs resulting from structural failures.

ES.1.2 Enhanced Preventative Maintenance Activities Success

The City has achieved the following during the implementation of the Consent Decree with respect to preventative maintenance activities in the collection system:

- The City's Hot Spot Cleaning List initially grew after Consent Decree as new problem areas were identified for increased maintenance frequency.
- The City's Hot Spot Cleaning List is now decreasing as increased maintenance has been effective at eliminating problem areas.
- CCTV inspection performed to conduct QA/QC of cleaned areas shows that the enhanced Operations and Maintenance program is effective.

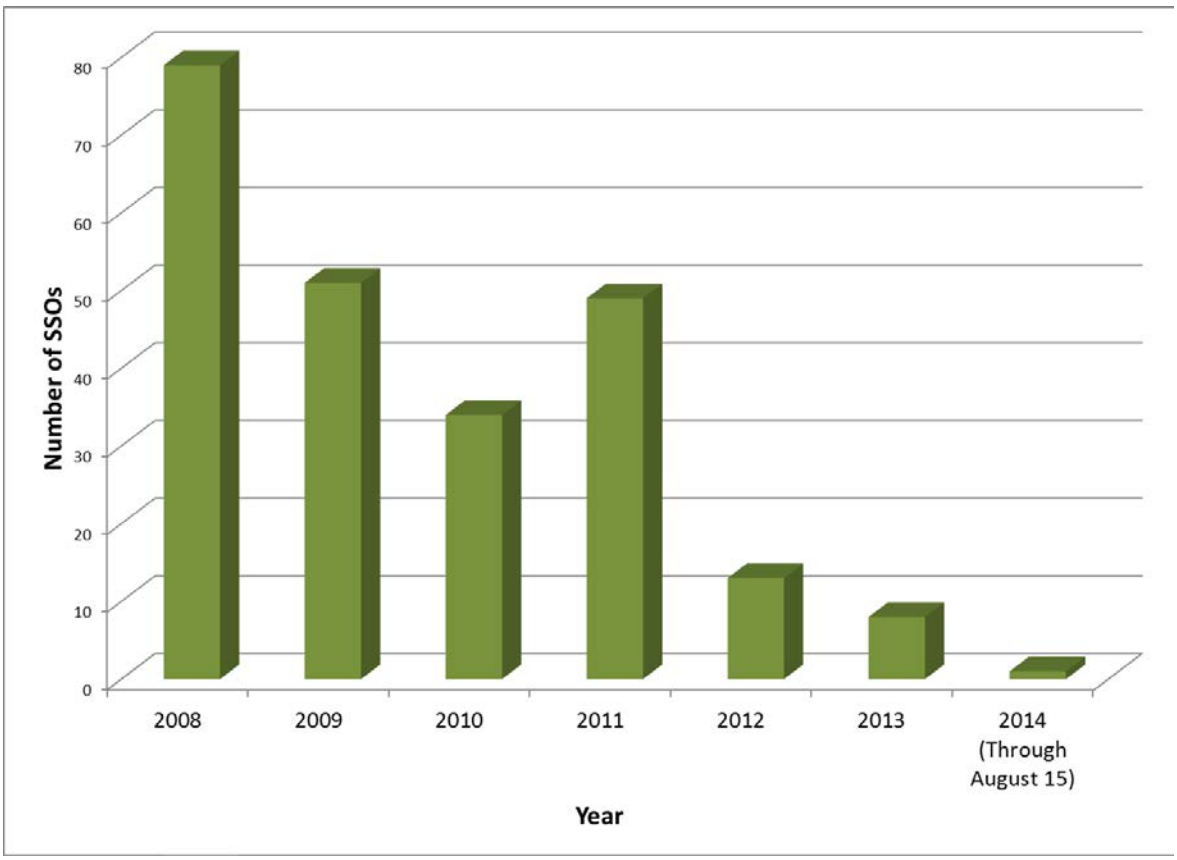
ES.1.3 Hydraulic Capacity Success

The City completed a Capacity Assurance Report (CAR) for its wastewater collection system in June 2012. The hydraulic evaluation in the CAR indicated that under design storm PWWF conditions, several portions of the City's collection system provided insufficient capacity to convey flow without SSOs. In addition to gravity mains at various locations throughout the City, the Madrone Pump Station (Madrone PS) and its associated force main, and the Water Pollution Control Plant (WPCP) were found to be hydraulically insufficient for the design storm, potentially requiring capacity improvements and the installation of wet weather storage. Improvement projects were identified and detailed in the CAR.

ES.1.3 SSO Reduction Verification

A graph of yearly SSOs in the Millbrae collection system from 2008 to 2014, presented on Figure ES-1, indicates that the City's hard work is producing quantifiable results, as SSOs have declined throughout the time period. That the decrease presented in the figure represents dry weather SSOs as well as wet weather SSOs indicates that the decline is not simply a function of low precipitation rates during the latest years.

Figure ES-1. City of Millbrae SSOs



ES.1.4 Purpose and Organization

The results of the CAR indicated that the City's collection system has adequate hydraulic capacity for Average Dry Weather Flow (ADWF) and Peak Dry Weather Flow (PDWF) conditions, and therefore it is the addition of Rainfall Dependent Inflow and Infiltration (RDII) during wet weather events that drives the required capacity improvements identified in the CAR. Although the CAR recommends projects based only on increasing infrastructure size, there are actually three methods through which insufficient capacity for PWWF in the collection system can be alleviated: 1) increasing the system's capacity to convey PWWF at the current levels of RDII; 2) reducing RDII levels such that the PWWF does not exceed the capacity of the collection system; or 3) through a combination of capacity improvement and RDII reduction.

The City of Millbrae Wet Weather Alternatives Analysis (The Report) evaluates whether an alternative to the CAR infrastructure improvements focused on RDII reduction in combination with hydraulic capacity improvements can provide a more effective, environmentally responsive, and sustainable solution while still meeting the Consent Decree requirements.

The Report is organized into the following sections:

1.0 Introduction
2.0 Existing Conditions
3.0 Wet Weather Alternatives
4.0 Inflow and Infiltration Sources
5.0 Inflow and Infiltration Reduction Options
6.0 Related Improvement Projects
7.0 Alternatives Evaluation
8.0 Preferred Alternative Development
9.0 References

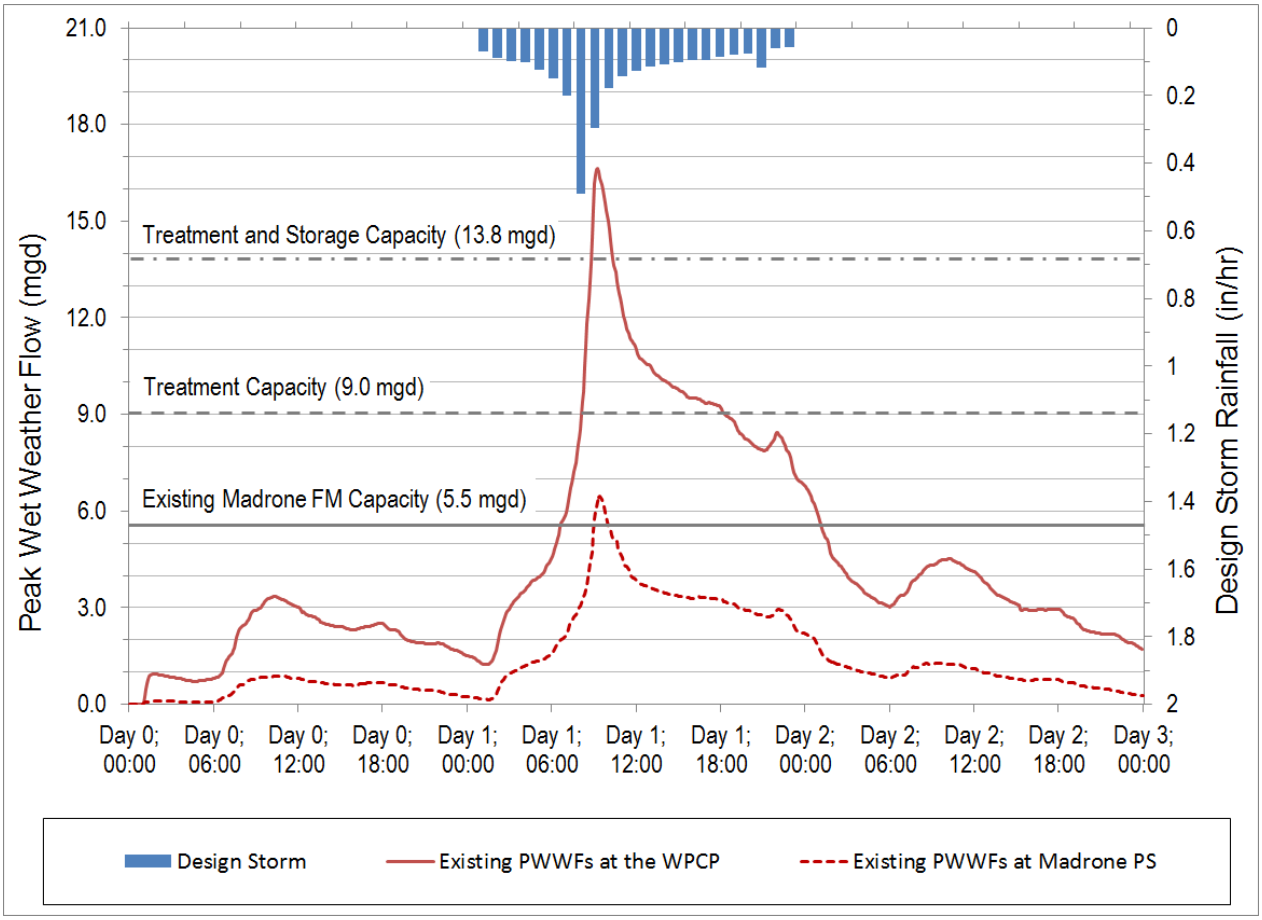
ES.2 Existing Conditions

The existing conditions in the City's collection system are described below.

ES.2.1 Current Wastewater Flows

As discussed in the CAR, the existing Madrone PS and force main are hydraulically limited to a firm pumping capacity of 2.5 million gallons per day (mgd) and a force main capacity of 5.5 mgd, respectively. Additionally, the WPCP has the capacity to treat or store up to approximately 14.0 mgd. Figure ES-2 shows the current design PWWF of 6.5 mgd and 17.0 mgd to the Madrone PS and WPCP, respectively, as well as the 10-year 24-hour design storm.

Figure ES-2. Existing Peak Wet Weather Flows at the Madrone PS and WPCP



Source: CAR

ES.2.2 Existing Facilities Description

The existing gravity collection system is comprised of approximately 55 miles of gravity sewers, ranging in diameters between 6- and 36-inches. The majority of the system (83 percent) is composed of vitrified clay pipe (VCP).

The existing Madrone PS is a wet well/dry well station. The Madrone PS has three pumps each with a rated capacity of 900 gallons per minute (gpm) at 35 feet of total dynamic head (TDH). The rated firm capacity (i.e., the capacity of the pump station with the largest pump out of service) is approximately 2.5 mgd. The existing 14-inch diameter force main for Madrone PS is composed of ductile iron, installed circa 1980. The existing force main capacity is approximately 5.5 mgd, based on limiting the force main velocity to 8.0 feet per second (fps).

The WPCP is located on the northeast corner of US Highway 101 and Millbrae Avenue. The wet weather hydraulic and treatment capacity of the WPCP is 9.0 mgd, and it has approximately 1.3 million gallons (MG) of flow equalization that allow the WPCP to accept up to 14.0 mgd during storms.

The gravity collection system, Madrone PS, Madrone Force Main, and WPCP can be seen on Figure ES-3. Further details can be found in Section 2.

ES.3 Wet Weather Alternatives

The options available for increasing the hydraulic capacity at each of the key facilities to meet the design storm conditions developed in the CAR are described below.

ES.3.1 WPCP

Given that the outfall capacity is currently contractually limited to 9.0 mgd, PWWF in excess of 9.0 mgd must be stored temporarily onsite so that discharge flows can be attenuated through the outfall. The WPCP currently has 1.3 mgd of equalization storage at the plant, but based on the PWWF analysis in the CAR, additional storage is necessary. The existing WPCP site is constrained, such that land must be acquired to locate additional storage facilities off-site.

Increasing WPCP capacity to accommodate anticipated PWWF is generally considered to be much less desirable than increasing storage capacity. In addition to the need to expand the capacity of on-site facilities, increasing WPCP capacity would require one of the following options to be undertaken:

- Upsize the existing JUFM outfall pipeline.
- Construct a new outfall to San Francisco Bay.
- Acquire more JUFM outfall capacity.

ES.3.2 Madrone PS

The CAR included a recommended capacity solution that involved relocating the Madrone PS to a City-owned right-of-way on Oak Street north of Center Street. Gravity flow that is currently conveyed to the Madrone PS would be intercepted east of Landing Lane, redirected under the BART tracks, and conveyed via gravity flow to the new pump station. The force main from the new pump station would be located within an extension of an existing easement through San Francisco Public Utilities Commission (SFPUC) property between Oak Street and Hermosa Avenue. With a significant portion of flow intercepted before Madrone PS as described above, the pump station at the existing location could be downsized to serve as a neighborhood pump station.

The solution presented in the CAR relies only on infrastructure capacity increases to remove capacity restrictions. A more sustainable and cost-effective long-term solution would be to significantly reduce the amount of RDII conveyed in the collection system. For these reasons, the City has indicated a desire to perform a study to evaluate the feasibility and cost of upgrading the Madrone PS in the current location. Upgrades to the pump station at this location will be evaluated in conjunction with RDII reduction plans that provide a more sustainable long-term plan to meet capacity limits and reduce SSOs in the collection system.

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FIGURE ES-3

City of Millbrae
Wet Weather
Alternatives Analysis

Existing Collection System

Not to Scale

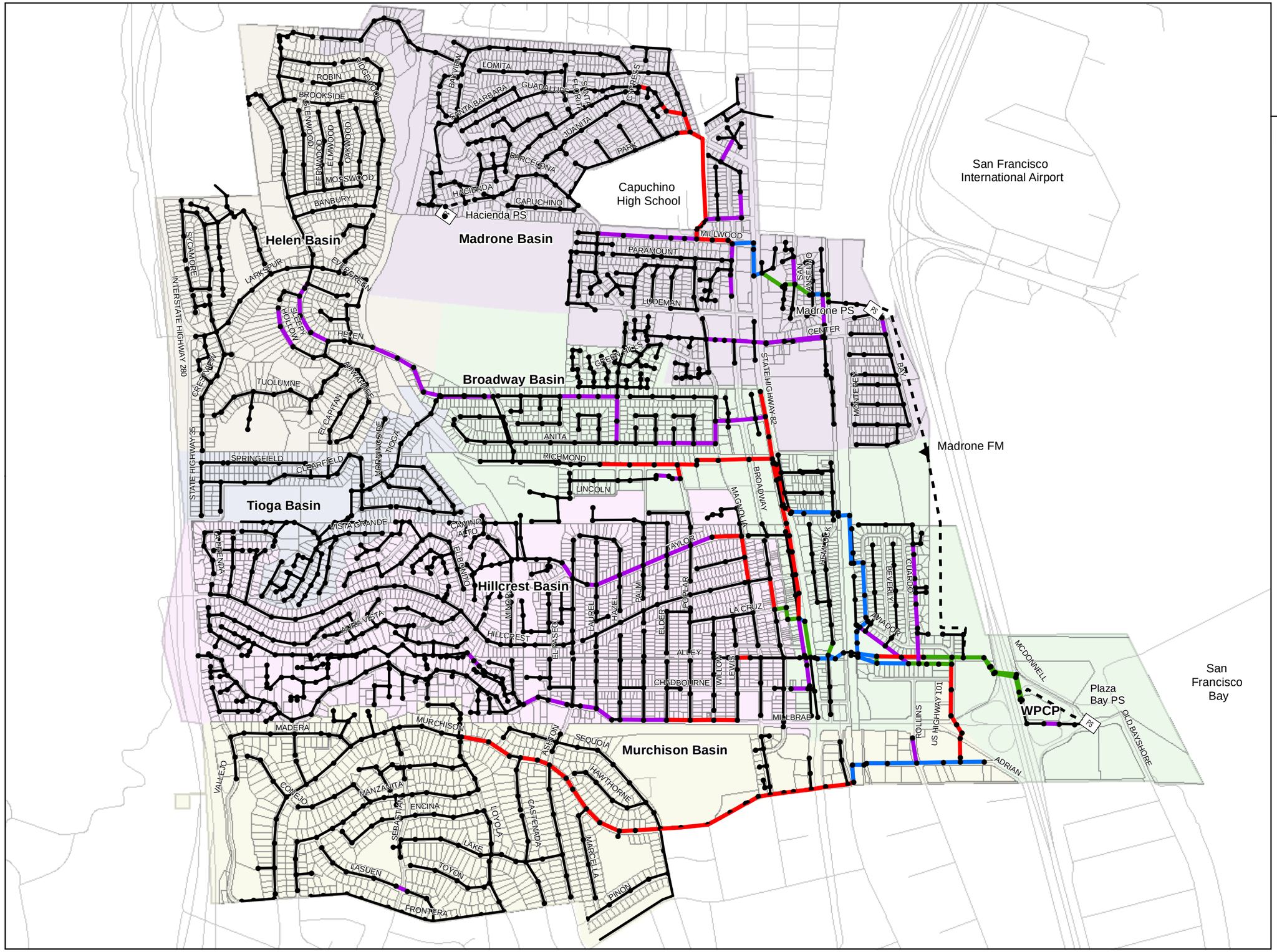
Legend

- Manhole
- PS Pump Station
- City Boundary
- Streets
- Force Main

Gravity Main

Diameter

- 6" or less
- 8"
- 10" - 12"
- 14" - 16"
- 18" - 36"



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ES.3.3 Madrone Force Main

The following two options exist to increase force main capacity:

- Install a second parallel force main of equal diameter, and
- Install a second parallel force main of incremental capacity.

For the purposes of this study, the installation of the parallel 14-inch force main is preferred in order to give the City the significant benefit of full off-peak redundancy.

ES.3.2 Options to Decrease Wet Weather Flows

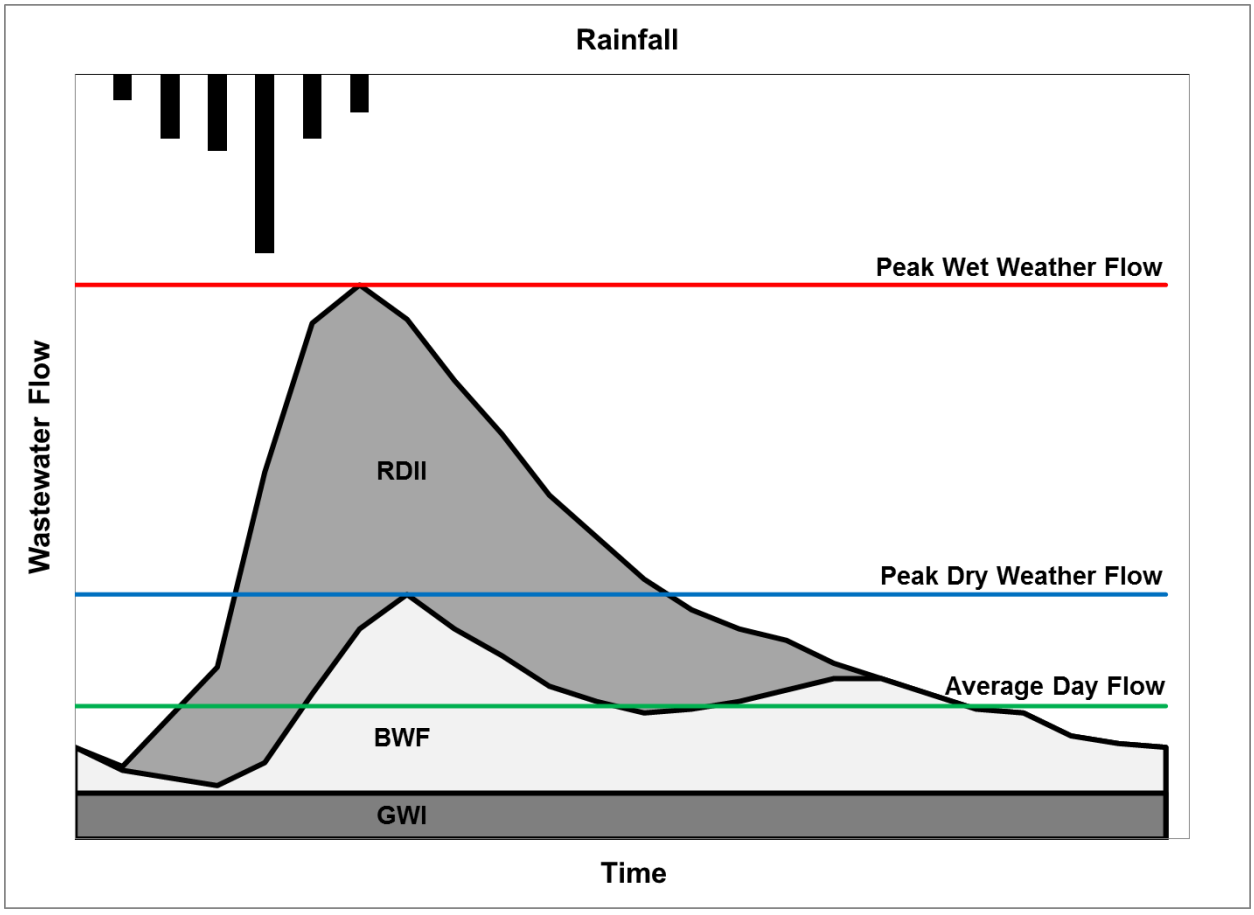
While PWWF cannot feasibly be reduced below the capacity of the Madrone PS, there exist options for reducing PWWFs below the capacity of the WPCP and the Madrone Force Main that include combinations of inflow source disconnections and collection system rehabilitation to reduce infiltration. A detailed analysis of PWWFs and the options to reduce them are critical to The Report and are developed and discussed in detail in the sections that follow.

The options to increase capacity at the WPCP, Madrone PS, and Madrone Force Main that are described above are detailed in Section 3.

ES.4 Inflow and Infiltration Sources

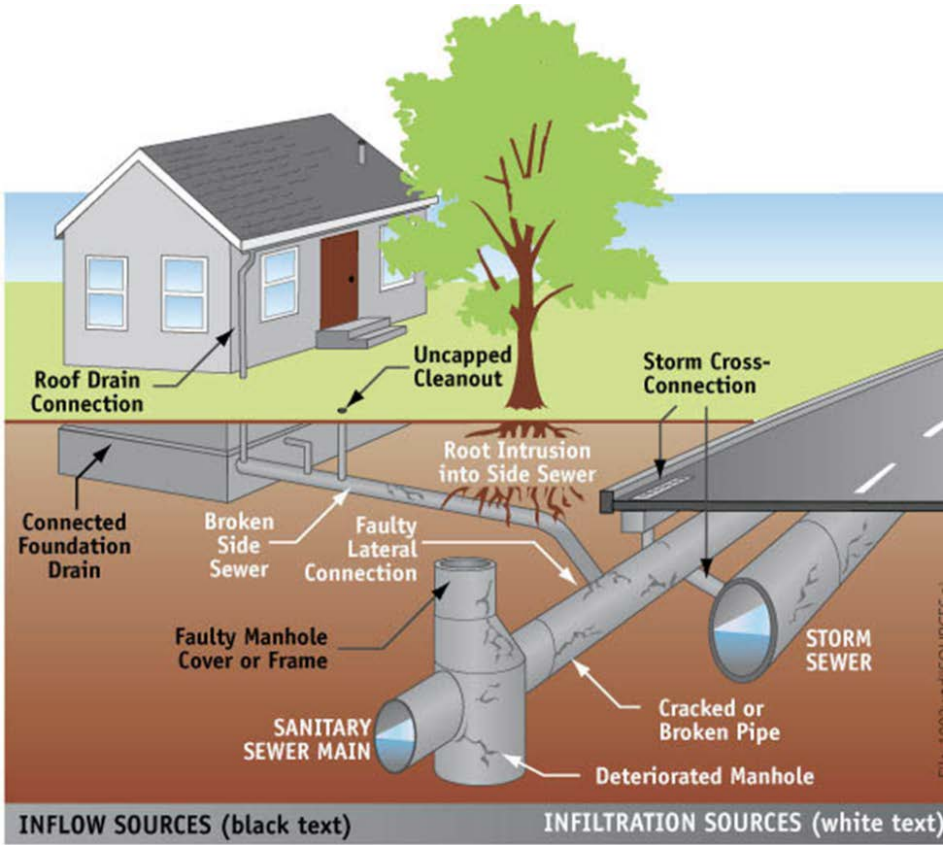
PWWF is significantly greater than PDWF in collection systems, primarily because of the presence of infiltration and inflow (I&I). As shown in Figure ES-4, I&I is considered to have a rainfall-dependent component and a non-rainfall-dependent component - groundwater infiltration (GWI). RDII is the rainfall-dependent component of I&I, and it consists of a combination of inflow and rainfall-dependent infiltration.

Figure ES-4. Wastewater Components



Typical sources of RDII into wastewater collection systems are shown in Figure ES-5. Aging and damaged lateral connections are generally accepted to be the major contributor of RDII since laterals are typically located on private property, poorly maintained, buried at shallow depths, and subject to tree root intrusions.

Figure ES-5. Typical Sources of RDII



Further detail on RDII and its physical indicators in a collection system can be found in Section 4.

ES.5 Inflow and Infiltration Reduction Options

The Report explores options for reducing inflow sources and rehabilitating the collection system to correct structural defects and leaky joints through which RDII enters the collection system.

Options considered for RDII Reduction include:

- Inflow Disconnection
- Collection System Rehabilitation
  - — Rehabilitation of mains and manholes only,
  - — Rehabilitation of mains, manholes, and lower laterals (within the public right-of-way or easement), and
  - — Rehabilitation of mains, manholes, lower laterals, and privately-owned upper laterals.

A review of documented case studies indicates the following:

1. Rehabilitation of mains and manholes, with or without rehabilitation of lower laterals, generally provides moderate to minor reductions in PWWF. Reductions of up to 30% in PWWF were reported under these conditions.
2. Rehabilitation of mains, manholes, lower laterals, and upper laterals usually achieves significant reductions in PWWF. Reductions of 50 to 70 percent of RDII were documented when upper laterals were rehabilitated along with mains, manholes, and lower laterals.

As indicated by the case studies, the decision of whether to rehabilitate the privately-owned upper laterals in addition to the mains, manholes, and lower laterals has significant impact on the amount of PWWF reduction that can be expected as part of rehabilitation. Therefore, the decision of how to handle the privately-owned upper laterals is a critical one for the City. Table ES-1 describes four common approaches to private laterals, and the advantages and disadvantages associated with each approach. A policy decision on private laterals will be required by the City.

In order to develop and evaluate wet weather alternatives, the City's collection system was divided into sub-basins for prioritization of RDII reduction. The following key data used in identifying areas of priority for RDII reduction includes:

- RDII Levels
- Pipe Size, Age, and Material
- CCTV Inspection Data
- Sanitary Sewer Blockages and Overflows

Sub-basins with higher measured RDII values, older pipes, higher numbers of defects related to RDII as documented by CCTV inspection, and higher incidents of SSOs were prioritized most highly for RDII reduction. Such sub-basins were prioritized because they will return the highest value (most RDII reduced) for the resources expended.

Table ES-1. Advantages and Disadvantages of Common Private Lateral Policies

Approach	Advantages	Disadvantages
Voluntary testing and rehabilitation partially funded by the public agency (City's current program)	• Encourages participation in the program through financial incentives • City only bears partial cost of rehabilitation • City has much less responsibility for administering the program – typically centered on public awareness and tracking permit status • Does not introduce access, liability, or funding issues related to using public funds on private property	• City does not fully control the program or its schedule • Schedule is long-term and is thus not effective at achieving short-term RDII reductions • City is not able to focus funds on problem areas • City must track program status, including project completion, for individual properties • May introduce licensing and tracking issues for the City if it certifies individual contractors to do the work
Testing and rehabilitation upon sale of property and/or remodeling	• Participation in the program is required through public policy • City does not bear the cost of testing or rehabilitation • Does not introduce access, liability, or funding issues related to using public funds on private property	• City does not fully control the program or its schedule • Schedule is long-term and is thus not effective at achieving short-term RDII reductions • City is not able to focus program on problem areas • City must track permit status and enforce the policy • May introduce licensing and tracking issues for the City if it certifies individual contractors to do the work
Testing by the City and requirement of the property owner to correct deficiencies	• Participation in the program is required through public policy • City does not bear the cost of rehabilitation • City partially controls the program, its schedule, and its cost • Allows the City to prioritize problem areas • Does not introduce funding issues related to using public funds on private property	• City must resolve access and liability issues associated with inspecting and testing on private property • City must track permit status and enforce the policy • May introduce licensing and tracking issues for the City if it certifies individual contractors to do the work
City assumes temporary control of upper lateral and performs rehabilitation using public funds	• City controls the program, its schedule, and its cost • Allows the City to prioritize and focus funds on problem areas • Allows City to establish methods and processes for completing the work • Has economy of scale associated with publically bidding larger improvement packages	• City bears full cost of repairs • City must fully administer the program, including public outreach • City must resolve access and liability issues associated with conducting work on private property • City must resolve financial issues with using public funds on private property

The approach for evaluating collection system rehabilitation and quantifying the results of the rehabilitation, as part of arriving at a recommended wet weather capacity alternative, was developed as follows:

1. Collection system facilities requiring rehabilitation will include manholes, sewer mains, and both lower and upper laterals.
2. It is assumed that sewer main rehabilitation for sewers 8-inches in diameter and smaller will involve pipe replacement using pipe bursting, whereas lines 10-inches in diameter or larger will be lined with cured-in-place pipe (CIPP). Rehabilitation of sewers larger than 12- inches in diameter is not included.
3. Manhole rehabilitation will involve the use of applied coating systems.
4. When evaluating the impact of the City implementing a focused program to rehabilitate the entire lateral, including privately owned upper laterals, reduction of 70 percent of the fast and medium RDII in the sub-basin is projected.
5. When evaluating the impact of the City implementing a focused program to rehabilitate the publically-owned mains, manholes, and lower laterals, but in which privately-owned upper laterals will only be rehabilitated voluntarily or in conjunction with the sale of property or obtaining a building permit, a reduction between 30-50 percent of the slow, medium, and fast RDII is projected. For the purposes of this analysis, 30 percent reduction in RDII is projected in such an analysis because few upper laterals will be rehabilitated during the 10-year planning period.

Further detail concerning I&I reduction options and effectiveness can be found in Section 5.

ES.6 Related Improvement Projects

The City's Consent Decree requires that the City CCTV inspect the small diameter (15-inches in diameter and smaller) portions of its collection system and that the PACP Structural 5 defects be repaired. It also requires that the City implement the CAR hydraulic improvement projects. Thus, the Consent Decree drives the need for the following:

- Defect Repair and Replacement Projects
- Gravity Sewer Capacity Improvement Projects
- Ongoing Collection System Asset Replacement

The related improvement projects that result from these requirements are presented in Section 6.

ES.7 Alternatives Evaluation

The following alternatives were developed from the options discussed above for evaluation in this analysis.

- Alternative 1A: CAR Capacity Upgrade Recommendations with No RDII Reduction
- Alternative 1B: Revised Capacity Upgrade Recommendations with No RDII Reduction
- Alternative 2: RDII Reduction in Public Infrastructure
- Alternative 3: RDII Reduction in Public and Private Infrastructure

The alternatives are summarized in Table ES-2. Alternative 1A is the project identified and recommended in the original CAR. Alternatives 1B, 2 and 3 provide different options for complying with Consent Decree requirements.

Conceptually, Alternatives 1A and 1B focus on increasing the size of existing wastewater pipelines, increasing and/or adding pumping capacity, and adding wet weather storage to capture peak wet weather flows in order to comply with Consent Decree requirements. Alternatives 2 and 3 on the other hand comply with Consent Decree requirements by eliminating RDII by repairing existing wastewater infrastructure and minimizing the need for additional wastewater facilities and capacity. The difference between Alternative 2 and Alternative 3 concern how the privately-owned upper laterals are treated. In Alternative 2, it is assumed that as sub-basins are rehabilitated for RDII reduction, the upper laterals are not rehabilitated with the other infrastructure. In Alternative 3, the upper laterals are rehabilitated in each sub-basin simultaneously with the other infrastructure.

Table ES-2. Alternative Elements

Element	Alternative 1A: CAR Capacity Upgrade Recommendations with No RDII Reduction	Alternative 1B: Revised Capacity Upgrade Recommendations with No RDII Reduction	Alternative 2: RDII Reduction in Public Infrastructure	Alternative 3: RDII Reduction in Public and Private Infrastructure
RDII Reduction	None	None	Rehabilitation of mains, manholes, and lower laterals in 17 sub-basins; Inflow disconnections in 2 sub-basins	Rehabilitation of mains, manholes, & lower and upper laterals in 7 sub-basins; Inflow disconnections in 2 sub-basins
Madrone PS Capacity	Keep Existing Madrone PS Construct New PS (6.5 MGD)	Upsize existing PS to 6.5 MGD	5.0 MGD	5.0 MGD
Madrone Force Main Modifications	None	Parallel 14-inch	None	None
WPCP Storage Basin	0.9 MG	0.9 MG	None	None
Gravity Sewer Capacity Upgrades	326 LF of 8-in 1,212 LF of 10-in 7,619 LF of 12-in 2,154 LF of 18-in 1,723 LF of 36-in	326 LF of 8-in 1,212 LF of 10-in 7,619 LF of 12-in 315 LF of 15-in 3,168 LF of 18-in 774 LF of 21-in 1,078 LF of 24-in 1,723 LF of 33-in	2,086 LF of 10-in 4,127 LF of 12-in 413 LF of 15-in 1,231 LF of 18-in	2,086 LF of 10-in 3,622 LF of 12-in 413 LF of 15-in 1,231 LF of 18-in
Structural 5 Defect Repairs	197 Spot Repairs, 3,187 LF Sewer Replacement	197 Spot Repairs, 3,187 LF Sewer Replacement	51 Spot Repairs, 1,212LF Sewer Replacement	90 Spot Repairs, 2,900LF Sewer Replacement
Ongoing Asset Replacement	0.75 miles/year for 10 years	0.75 miles/year for 10 years	Concentrated in the RDII Reduction Sub-basins listed above	Concentrated in the RDII Reduction Sub-basins listed above
Flow Monitoring Validation	Basic validation at the end of the alternative program.	Basic validation at the end of the alternative program.	Robust annual validation to confirm RDII reduction rates.	Robust annual validation to confirm RDII reduction rates.

The alternatives presented in Table ES-2 were evaluated and ranked by both economic and non-economic factors. The economic analysis results are presented in summarized form in Table ES-3.

Table ES-3. Summarized Economic Analysis Results

	Unit	$ Unit	Alternative 1A: CAR Capacity Projects with No RDII Reduction		Alternative 1B: Revised Capacity Projects with No RDII Reduction		Alternative 2: RDII Reduction in Public Infrastructure		Alternative 3: RDII Reduction Private & Public Infrastructure	
			QTY	Total	QTY	Total	QTY	Total	QTY	Total
Summarized Cost Subtotal				$16,198,000		$13,863,000		$37,698,000		$19,706,000
Contingency	%	30%		$4,860,000		$4,159,000		$11,310,000		$5,912,000
Construction Subtotal				$21,058,000		$18,022,000		$49,008,000		$25,618,000
Design, Admin., CM, etc.	%	30%		$6,318,000		$5,407,000		$14,703,000		$7,686,000
Capital Subtotal				**$27,376,000**		**$23,429,000**		**$63,711,000**		**$33,304,000**
Compliance Validation – Required Planning Projects										
Inflow Identification: Smoke Testing	LF	$1.25	-	$0	-	$0	19.251	$24,000	19.251	$24,000
Validation: Flow Monitoring & Modeling	YR	$130,000	2	$260,000	2	$260,000	10	$1,300,000	7	$910,000
Total – Consent Decree Compliance				**$27,636,000**		**$23,689,000**		**$65,035,000**		**$34,238,000**
Ongoing Collection System Asset Replacement										
Continuous Replacement Capital				$10,000,000		$10,000,000		$0		$0
Grand Total				**$37,636,000**		**$33,689,000**		**$65,035,000**		**$34,238,000**

Non-economic factors ranked for this analysis are summarized in Table ES-4.

Table ES-4. Non-Economic Analysis

Alignment Alternative	Factor										
	Institutional Issues/Public Acceptance		Implementation Time		SSO Reduction		Ease of Operation & Maintenance		Longevity/ Sustainability		Total Weighted Rating - Higher Value Preferred
Factor Importance Weight:	6		6		9		7		10		
R = Rating and **WR** = Weighted Rating:	R	WR	R	WR	R	WR	R	WR	R	WR	WR
Alternative 1A: CAR Capacity Upgrade Recommendations with No RDII Reduction	3	**18**	5	**30**	1	**9**	1	**7**	1	**10**	**74**
Alternative 1B: Revised Capacity Upgrade Recommendations with No RDII Reduction	3	**18**	4	**24**	1	**9**	2	**14**	1	**10**	**75**
Alternative 2: RDII Reduction in Public Infrastructure	5	**30**	1	**6**	5	**45**	5	**35**	4	**40**	**156**
Alternative 3 : RDII Reduction in Public and Private Infrastructure	1	**6**	5	**30**	4	**36**	4	**28**	5	**50**	**150**

Note: Rating values are based on known factors of each Alternative. Factor importance weights were developed by the pairwise comparison method described in Appendix E.

As shown in Table ES-4, the following non-economic factors favor the selection of alternatives that focus on RDII reduction:

- Longevity
- Sustainability
- Improvement of Operations and Maintenance in Collection System

Alternative 3 provides RDII reduction at significantly lower cost than Alternative 2, and at a cost that is comparable to Alternative 1B, which does not provide RDII reduction. Because the non-economic factors favor RDII reduction, Alternative 3 is the preferred alternative.

Detailed information about the alternatives and their analysis can be found in Section 7.

ES. 8 Preferred Alternative Development

The recommended Capital Improvement Program (CIP) consists of RDII reduction projects, capacity upgrades, and sewer repair/replacement projects as summarized in Table ES-5.

Table ES-5. Recommended Program Estimated Capital Cost Summary

Project Name	Total Capital
Rainfall-Dependent Inflow/Infiltration Reduction Capital Projects	
Madrone Sub-basins 1 & 2 Sewer Rehab	$7,181,000
Madrone/Hillcrest Sub-basins 3 Sewer Rehab	$6,812,000
Hillcrest Sub-basin 4 Sewer Rehab	$7,171,000
Hillcrest Sub-basins 1 & 2 Sewer Rehab	$5,950,000
RDII Reduction Projects CAPITAL TOTAL	*$27,114,000*
Capacity Improvement Projects and Repairs	
Madrone Pump Station Improvements	$1,622,000
Gravity Sewer Capacity Upgrade - Capuchino High School Vicinity	$698,000
Gravity Sewer Capacity Upgrade - Richmond Drive/Anita Drive	$1,076,000
Gravity Sewer Capacity Upgrade - Aviador Avenue and East Millbrae Drive	$683,000
Gravity Sewer Capacity Upgrade - Murchison Avenue	$519,000
Structural 5 Spot Repairs/Line Replacements (6 to 10-inch)	$1,590,000
Capacity Improvement Projects and Repairs CAPITAL TOTAL	*$6,188,000*
ALTERNATIVE 3 RECOMMENDED CAPITAL COST TOTAL	**$33,302,000**

In order to complete this large $33M capital cost program, the City will need to adopt a very aggressive implementation schedule. The recommended implementation schedule outlined in Table ES-6 and detailed on Figure ES-6 is based on the following implementation plan:

Project Packaging and Prioritization. Considerations for developing and prioritizing improvement project packages include:

- Allow for the appropriate planning activities to occur before project design begins – including sub-basin flow monitoring and hydraulic modeling to confirm sub-basin priorities for rehabilitation for RDII reduction.
- Construct downstream upgrades first in order to avoid moving potential overflow locations downstream.
- Implement sewer rehab/replacement projects in construction packages of less than three miles of pipe per year to balance construction impacts on the public with an aggressive construction schedule that allows for multiple construction crews to work simultaneously.
- Implement trunk sewer capacity improvement projects in construction packages of approximately one-half mile of pipe per year to allow for project complexities and reduce traffic impacts.

Staffing and Resources. The implementation schedule in Table ES-6 and **Error! Reference source not found.** shows the City managing four to eight contracts for design or construction of sanitary sewer projects in any given year for the duration of the program, which appears to exceed existing City resources and staff capacity. The City will need additional resources to accomplish the strategic objectives of this program, including influencing and enforcing policy changes, managing the interdependency between multiple projects, and overseeing project managers who perform contract administration to procure and manage multiple project consultants and contractors.

Procurement Procedures. The volume of contracts involved in this implementation plan will significantly increase the administrative workload for City staff, making it difficult to meet the proposed implementation schedule without additional resources. The City should also consider stream-lining procurement processes for design and construction, and/or alternative project delivery methods in order to relieve a portion of the administrative and time burden of advertising for proposals and bids, selecting consultants and awarding bids, and negotiating and initiating contracts.

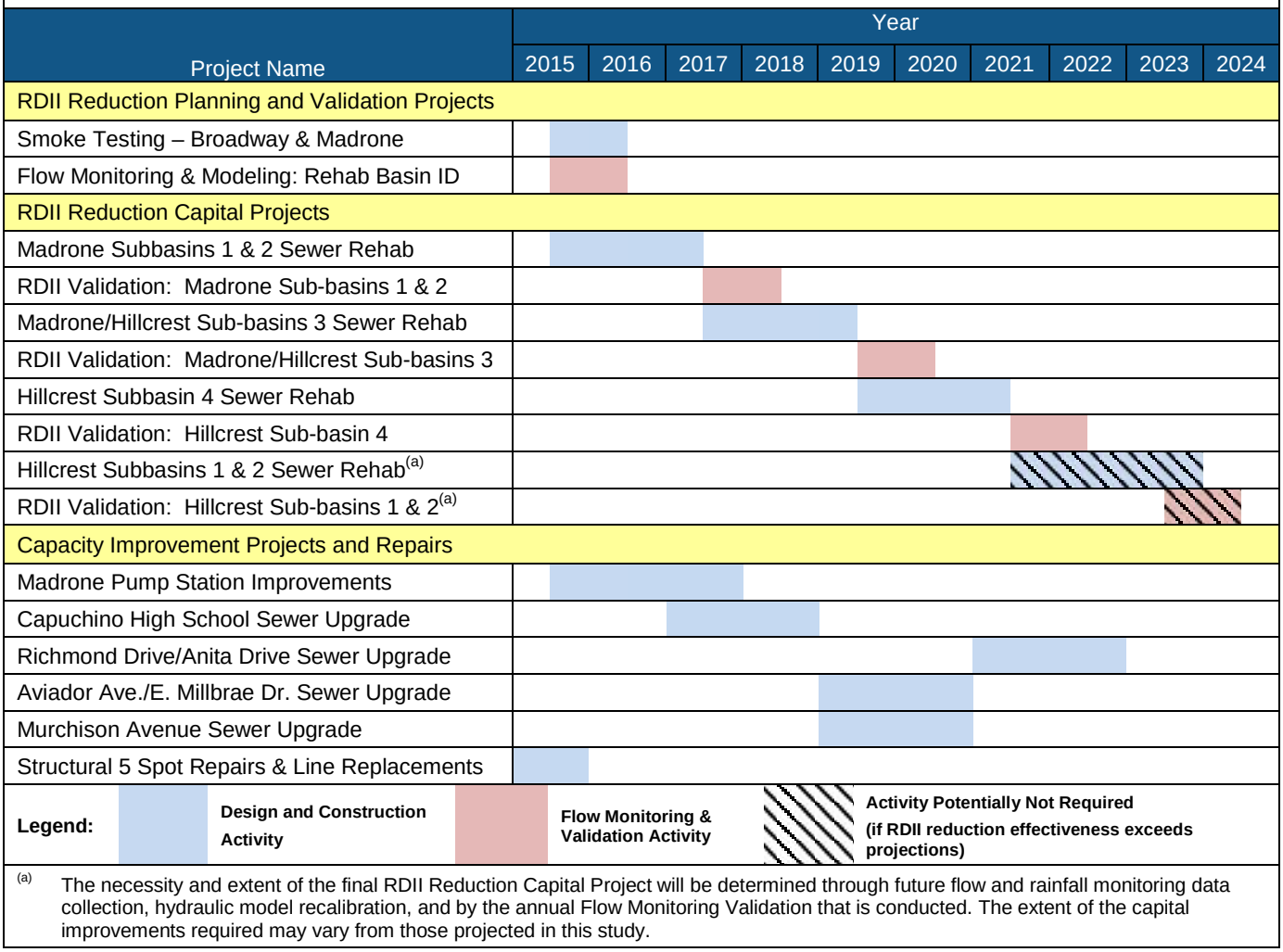
If the City's aggressive implementation schedule can be maintained by implementing the considerations described above, the implementation schedule shown in Table ES-6 and Figure ES-6 shows major rehabilitation and construction projects concluding in 2020. If RDII reduction effectiveness exceeds the projected values, some projects may not be needed, and major construction may be concluded earlier.

Table ES-6. Recommended Program Implementation Schedule (in $1,000)

Project Name	Total Capital	Year									
		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
RDII Reduction Planning and Validation Projects											
Smoke Testing – Broadway & Madrone	*$50*	*$25*	*$25*								
Flow Monitoring & Modeling[(a)]	*$910*	*$150*	*$180*	*$100*	*$160*		*$140*		*$110*		*$70*
RDII Reduction Capital Projects											
Madrone Sub-basins 1 & 2 Sewer Rehab	*$7,181*	*$1,077*	*$3,591*	*$2,513*							
Madrone/Hillcrest Sub-basins 3 Sewer Rehab	*$6,812*			*$1,022*	*$3,406*	*$2,384*					
Hillcrest Sub-basin 4 Sewer Rehab	*$7,172*					*$1,076*	*$3,586*	*$2,510*			
Hillcrest Sub-basins 1 & 2 Sewer Rehab[(a)]	*$5,951*							*$893*	*$2,975*	*$2,083*	
Capacity Improvement Projects and Repairs											
Madrone Pump Station Improvements	*$1,622*	*$300*	*$661*	*$661*							
Capuchino High School Sewer Upgrade	*$698*			*$209*	*$489*						
Richmond Drive/Anita Drive Sewer Upgrade	*$1,076*							*$323*	*$753*		
Aviador Ave./East Millbrae Dr. Sewer Upgrade	*$683*					*$205*	*$478*				
Murchison Avenue Sewer Upgrade	*$519*					*$156*	*$363*				
Structural 5 Spot Repairs & Line Replacements	*$1,400*	*$1,400*									
RECOMMENDED PROGRAM TOTAL	**$34,074**	**$2,952**	**$4,457**	**$4,505**	**$4,055**	**$3,821**	**$4,567**	**$3,726**	**$3,838**	**$2,083**	**$70**

(a) The necessity and extent of the final RDII Reduction Capital Project will be determined through future flow and rainfall monitoring data collection, hydraulic model recalibration, and by the annual Flow Monitoring Validation that is conducted. The extent of the capital improvements required may vary from those projected in this study.

Figure ES--6. Recommended Program Implementation Schedule



(a) The necessity and extent of the final RDII Reduction Capital Project will be determined through future flow and rainfall monitoring data collection, hydraulic model recalibration, and by the annual Flow Monitoring Validation that is conducted. The extent of the capital improvements required may vary from those projected in this study.

1.0 INTRODUCTION

The City of Millbrae (City) completed a Capacity Assurance Report (CAR) for its wastewater collection system in June 2012. The hydraulic evaluation in the CAR indicated that under design storm Peak Wet Weather Flow (PWWF) conditions, several portions of the City's collection system provided insufficient capacity to convey flow without Sanitary Sewer Overflows (SSOs). In addition to gravity mains at various locations throughout the City, the Madrone Pump Station (Madrone PS) and its associated force main, and the Water Pollution Control Plant (WPCP) were found to be hydraulically insufficient for the design storm, potentially requiring capacity improvements and the installation of wet weather storage.

Because the City's collection system has adequate hydraulic capacity for Average Dry Weather Flow (ADWF) and Peak Dry Weather Flow (PDWF) conditions, it is the addition of Rainfall Dependent Inflow and Infiltration (RDII) during wet weather events that drives the required capacity improvements identified in the CAR. Therefore, instances of insufficient capacity in the City's collection system can be alleviated through: 1) increasing the system's capacity to convey PWWF at the current levels of RDII; 2) reducing RDII levels such that the PWWF does not exceed the capacity of the collection system; or 3) through a combination of capacity improvement and RDII reduction.

1.1 Purpose and Organization

This Report develops and evaluates wet weather flow management alternatives for the City's collection system, including capacity upgrades and RDII reduction through direct connection repairs and collection system rehabilitation. This Report is organized into the following sections:

1.0 Introduction

2.0 Existing Conditions

3.0 Wet Weather Alternatives

4.0 Inflow and Infiltration Sources

5.0 Inflow and Infiltration Reduction Options

6.0 Related Improvement Projects

7.0 Alternatives Evaluation

8.0 Preferred Alternative Development

9.0 References

1.2 Information Sources

The following information sources were provided by the City and were used for this analysis.

- City of Millbrae Geographic Information System, provided in January 2014 (City GIS)
- City of Millbrae Capacity Assurance Report by West Yost Associates, dated June 2012 (CAR)
- California Integrated Water Quality System Public Records (CIWQS database)
- City of Millbrae AIMS asset registry and related *Millbrae_Sewer_Office.mdb* database files, dated January 2014 (AIMS database)

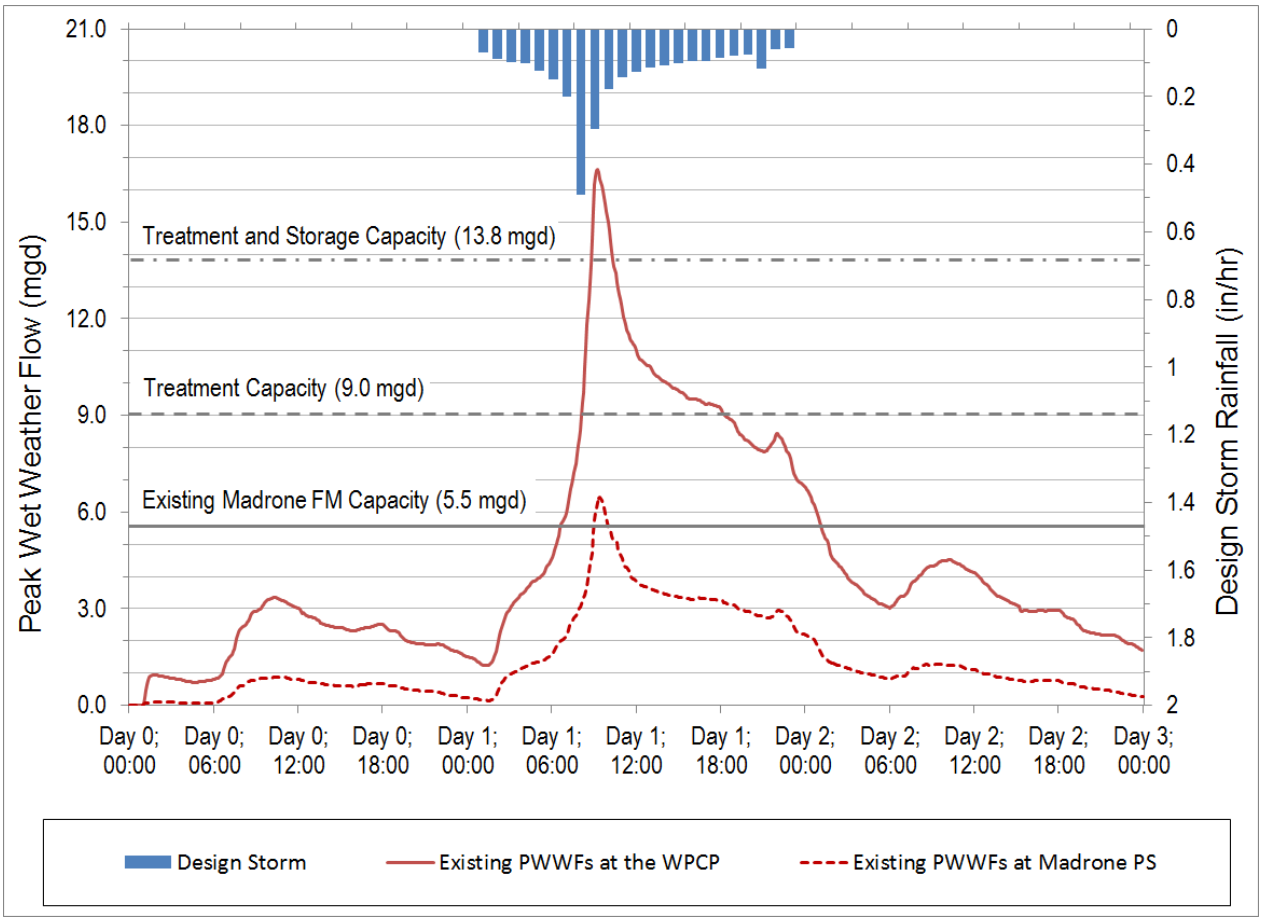
2.0 EXISTING CONDITIONS

This section provides a description of current wastewater flow conditions and the existing wastewater infrastructure.

2.1 Current Wastewater Flows

As discussed in the CAR, the existing Madrone PS and force main are hydraulically limited to a firm pumping capacity of 2.5 million gallons per day (mgd) and a force main capacity of 5.5 mgd, respectively. Additionally, the WPCP has the capacity to treat or store up to approximately 14.0 mgd. Figure 1 shows the current PWWF of 6.5 mgd and 17.0 mgd to the Madrone PS and WPCP, respectively, as well as the 10-year 24-hour design storm.

Figure 1. Existing Peak Wet Weather Flows at the Madrone PS and WPCP



Source: CAR

2.2 Existing Facilities Description

This section describes the existing gravity collection system, Madrone PS and force main, and WPCP.

2.2.1 Gravity Collection System

The existing gravity collection system is comprised of approximately 55 miles of gravity sewers, ranging in diameters between 6- and 36-inches (see Figure 2). The majority of the system (83 percent) is composed of vitrified clay pipe (VCP).

2.2.2 Madrone PS

The existing Madrone PS is a wet well/dry well station. The Madrone PS has three pumps each with a rated capacity of 900 gallons per minute (gpm) at 35 feet of total dynamic head (TDH). The rated firm capacity (i.e., the capacity of the pump station with the largest pump out of service) is approximately 2.5 mgd.

The Madrone PS electrical service is 240 volts, in three phases, with a 200 amp capacity. Utility power is backed up by a 50 kilowatt (kW) standby generator. The existing power system is sufficient for the current loads. Increasing the loads would require an increase in service size and power distribution equipment sizing.

2.2.3 Madrone Force Main

The existing 14-inch diameter force main is composed of ductile iron, installed circa 1980. The force main has not been recently inspected; therefore, its condition is not known at this time. The existing force main capacity is approximately 5.5 mgd, based on limiting the force main velocity to 8.0 feet per second (fps). The need for a replacement force main would be eliminated by relaxing the velocity constraint to 10.0 fps. However, the capital costs in this study are based upon the conservative 8.0 fps velocity constraint.

2.2.4 Water Pollution Control Plant

The WPCP is located on the northeast corner of US Highway 101 and Millbrae Avenue. The wet weather hydraulic and treatment capacity of the WPCP is 9.0 mgd, and it has approximately 1.3 million gallons (MG) of flow equalization that allow the WPCP to accept up to 14.0 mgd during storms.

Effluent from the WPCP is discharged through a joint outfall pipeline (the joint use force main (JUFM)) under a Joint Powers Agreement (JPA) with the City of Burlingame, the City of San Bruno, the City of South San Francisco, the City and County of San Francisco (San Francisco International Airport) to a deep water outfall at Oyster Point in San Francisco Bay (Bay). Under the JPA, the City has hydraulic capacity rights to 9.0 mgd in the JUFM and outfall.

Last Saved: 6/24/2014 10:44:05 AM chall; W:\Clients\478 City of Millbrae\06-13-03 Madrone Feasibility\GIS\Figures\Subbasins.mxd

FIGURE 2

City of Millbrae
Wet Weather
Alternatives Analysis

Existing Collection System

Not to Scale

Legend

- Manhole
- PS Pump Station
- City Boundary
- Streets
- Force Main

Gravity Main

Diameter

- 6" or less
- 8"
- 10" - 12"
- 14" - 16"
- 18" - 36"

Helen Basin
Madrone Basin
Broadway Basin
Tioga Basin
Hillcrest Basin
Murchison Basin
Hacienda PS
Madrone PS
Madrone FM
WPCP
Plaza Bay PS
Capuchino High School
San Francisco International Airport
San Francisco Bay
INTERSTATE HIGHWAY 280
INTERSTATE HIGHWAY 35
STATE HIGHWAY 82
US HIGHWAY 101
ROBIN
BROOKSIDE
RIDGEWOOD
GLENWOOD
FERNWOOD
ELMWOOD
OAKWOOD
MOSSWOOD
BANBURY
BAYVIEW
LOMITA
SANTA BARBARA
GUADALUPE
SANTA FLORITA
CYPRESS
JUANITA
PARK
BARCELONA
HACIENDA
CAPUCHINO
SYCAMORE
LARKSPUR
EVERGREEN
SLEEPY HOLLOW
HELEN
CRESTVIEW
TUOLUMNE
ARAWANEE
EL CAPITAN
MORNINGSIDE
TIOGA
SPRINGFIELD
CLEARFIELD
MILLWOOD
PARAMOUNT
LUDEMAN
SAN ANSELMO
CENTER
GREENHILLS
ANITA
RICHMOND
LINCOLN
MONTEREY
BAY
BROADWAY
MAGNOLIA
HEMLOCK
BEVERLY
GUADALUPE
SALVADOR
VISTA GRANDE
CAMINO ALTO
LAURELWOOD
EL BRAZIL
LAURA VISTA
MINOR
HILLCREST
EL PASEO
LAUREL
HAZEL
PALM
POPLAR
ELDER
TAYLOR
LA CRUZ
ALLEY
CHADBOURNE
WILLOW
LEWIS
MILLBRAE
MCDONNELL
OLD BAYSHORE
ADRIAN
ROLLINS
MADERA
MURCHISON
ASHTON
SEQUOIA
HAWTHORNE
VALLEJO
CONEJO
MANZANITA
SEBASTIANI
ENCINA
LOYOLA
CASTENADA
LAKE
TOYON
LASUEN
FRONTERA
MARGELLA
PINON

WEST YOST ASSOCIATES
Consulting Engineers

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3.0 WET WEATHER ALTERNATIVES

This section develops options for managing wet weather flows, which will be developed into full alternatives in Section 7.0.

3.1 Options to Increase Capacity

This section considers the options available for increasing the hydraulic capacity at each of the key facilities to meet the design storm conditions developed in the CAR.

3.1.1 Water Pollution Control Plant

Given that the outfall capacity is currently contractually limited to 9.0 mgd, PWWF in excess of 9.0 mgd must be stored temporarily onsite so that discharge flows can be attenuated through the outfall. The WPCP currently has 1.3 mgd of equalization storage at the plant, but based on the PWWF analysis in the CAR, additional storage is necessary. The existing WPCP site is constrained, such that land must be acquired to locate additional storage facilities off-site.

Increasing WPCP capacity to accommodate anticipated PWWF is generally considered to be much less desirable than increasing storage capacity. In addition to the need to expand the capacity of on-site facilities, increasing WPCP capacity would require one of the following options to be undertaken:

- **Upsize the existing JUFM outfall pipeline**. While upsizing the existing outfall may be possible, it is expected to be a difficult, lengthy, and expensive process due to: a) the existence of multiple stakeholders involved in the JPA; b) the permitting of construction work in the Bay; and c) modification of the existing underwater outfall in the Bay while maintaining the ability to discharge.
- **Construct a new outfall to San Francisco Bay**. Permitting and constructing a new underwater outfall is a prohibitively time-consuming and costly endeavor due to: a) the extensive environmental permitting required to work in the Bay and surrounding wetlands; b) underwater construction challenges; and c) uncertainties and difficulties associated with the outfall permitting process.
- **Acquire more JUFM outfall capacity.** While the hydraulic capacity of the outfall is fixed, the contractual limitation of 9.0 mgd may be negotiable. It is possible that the JPA capacities were established under the assumption that each agency discharges its contractual limitation at the same time. However, due to various factors, PWWF from the different JPA dischargers may not all occur at the same time. A study by the JPA of historical flows and rainfall distribution patterns may reveal room for negotiation between the JPA agencies for an alternative flow limitation structure and agreement.

3.1.2 Madrone PS

The CAR included a recommended capacity solution that involved relocating the Madrone PS to a City-owned right-of-way on Oak Street north of Center Street. Gravity flow that is currently conveyed to the Madrone PS would be intercepted east of Landing Lane, redirected under the BART tracks, and conveyed via gravity flow to the new pump station. The force main from the

new pump station would be located within an extension of an existing easement through San Francisco Public Utilities Commission (SFPUC) property between Oak Street and Hermosa Avenue. With a significant portion of flow intercepted before Madrone PS as described above, the pump station at the existing location could be downsized to serve as a neighborhood pump station. Although the solution presented in the CAR would solve the hydraulic restrictions that were identified, it requires the construction of a new pump station and the ongoing operation of two pump stations rather than one, both of which involve significant costs. The re-routing of the flow from the new pump station would also increase the flows in the gravity mains in El Camino Real, increasing the risk of capacity shortfalls in this important commercial area.

The solution presented in the CAR relies only on infrastructure capacity increases to remove capacity restrictions. A more sustainable and cost-effective long-term solution would be to significantly reduce the amount of RDII conveyed in the collection system. For these reasons, the City has indicated a desire to perform a study to evaluate the feasibility and cost of upgrading the Madrone PS in the current location. Upgrades to the pump station at this location will be evaluated in conjunction with RDII reduction plans that provide a more sustainable long-term plan to meet capacity limits and reduce SSOs in the collection system.

3.1.3 Madrone Force Main

The following two options exist to increase force main capacity.

Install a second parallel force main of equal diameter. The parallel force main could be sized to match the existing force main. The maximum velocity in either 14-inch force main would be approximately 5.5 fps at the 6.5 mgd peak condition. This option has the advantage of providing a redundant pipeline during dry weather to facilitate maintenance.

Install a second parallel force main of incremental capacity. To increase the force main capacity to 6.5 mgd, an 8-inch force main could be installed parallel to the existing 14-inch force main, resulting in a peak velocity of 8.0 fps in each side of the dual force main. The smaller 8-inch side of the force main would be used during wet weather events. While the smaller parallel force main has a lower capital cost compared to installing a larger force main, it increases the head required to convey the flow during wet weather events, thereby increasing the electrical improvements needed.

For the purposes of this study, the installation of the parallel 14-inch force main is preferred in order to give the City the significant benefit of full off-peak redundancy.

3.2 Options to Reduce Wet Weather Flows

While PWWF cannot feasibly be reduced below the capacity of the Madrone PS, there exist options for reducing PWWFs below the capacity of the WPCP and the Madrone Force Main that include combinations of inflow source disconnections and collection system rehabilitation to reduce infiltration. A detailed analysis of PWWFs and the options to reduce them are discussed in detail in Sections 4.0 and 5.0, respectively.

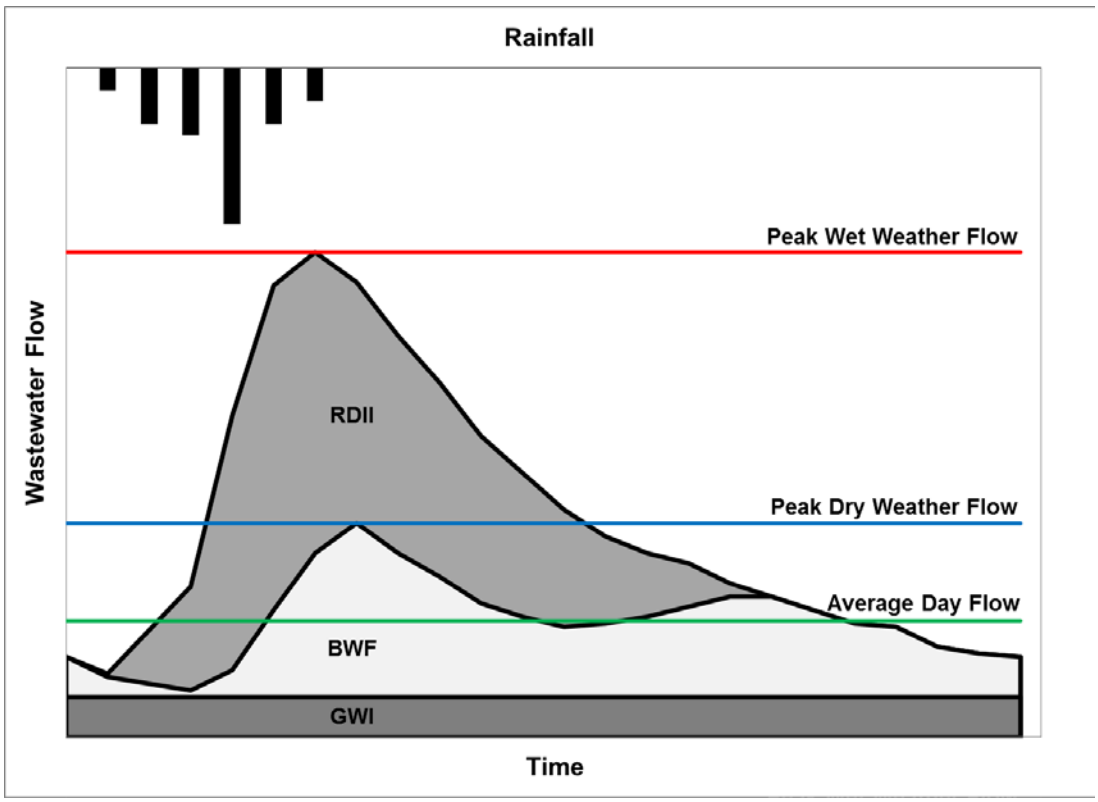
4.0 INFLOW AND INFILTRATION SOURCES

This section describes the sources and potential indicators of RDII in the collection system.

4.1 RDII Components

PWWF is significantly greater than PDWF, primarily because of the presence of infiltration and inflow (I&I). As shown in Figure 3, I&I is considered to have a rainfall-dependent component and a non-rainfall-dependent component - groundwater infiltration (GWI). RDII is the rainfall-dependent component of I&I, and it consists of a combination of inflow and rainfall-dependent infiltration. Inflow is defined as storm water runoff entering a wastewater collection system though system leaks/porosity (such as perforated manhole covers) and improper/illicit storm water connections (such as catch basins, roof leaders, cleanouts, foundation drains, drainage sump pumps, and area drains). Infiltration is defined as water traveling through the ground and entering the collection system through defective pipes, pipe joints, damaged lateral connections, and manhole walls. Non-rainfall-dependent GWI occurs when portions of a wastewater collection system are below the groundwater table for extended periods of time, even during dry weather periods. Rainfall-dependent infiltration occurs when groundwater levels briefly rise during storms to submerge portions of the wastewater collection system.

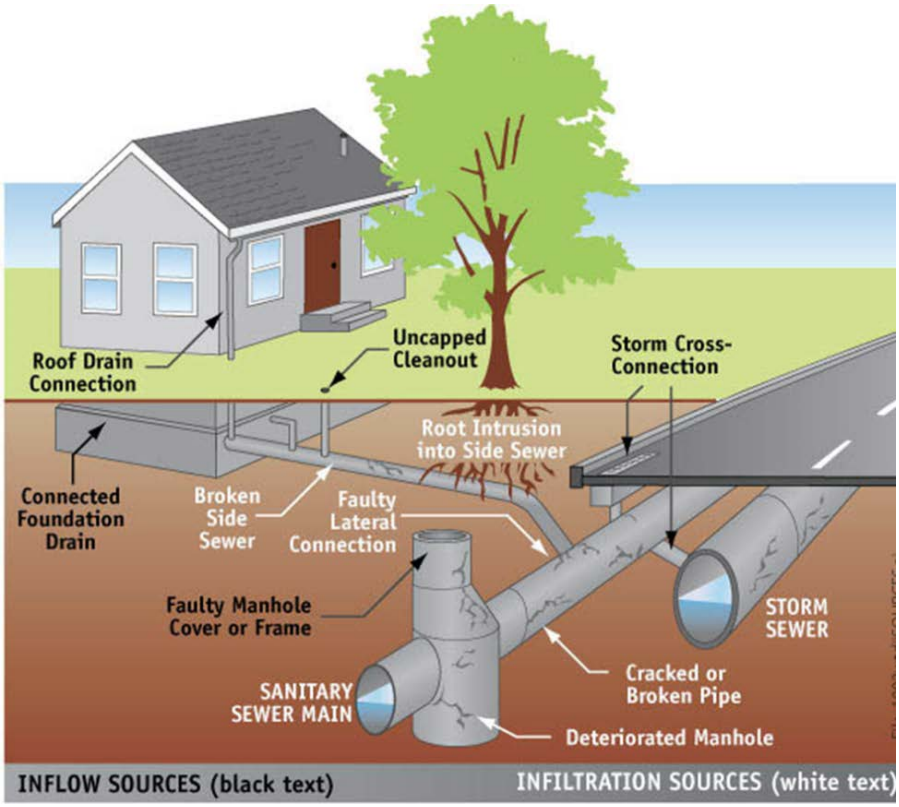
Figure 3. Wastewater Components



4.2 Sources of RDII

Typical sources of RDII into wastewater collection systems are shown in Figure 4. Aging and damaged lateral connections are generally accepted to be the major contributor of RDII since laterals are typically located on private property, poorly maintained, buried at shallow depths, and subject to tree root intrusions.

Figure 4. Typical Sources of RDII



4.3 Inflow Indicators

The first indicator of inflow is the fast response of collection system flow rates, where storm water rapidly flows into the collection system and causes a sharp increase in flows directly after rainfall begins. However, this fast response can also be contributed to infiltration from defective shallow laterals that often act as French drains for the yard and driveway area that contribute to the fast response and the resultant steep flow peaks.

Smoke testing is a commonly-used method for locating individual inflow sources, although it is also generally understood that it does not identify all sources of inflow. Smoke testing involves charging the collection system with white or grey non-toxic smoke, which fills the airspace of mains, manholes, and laterals. Once the system is charged, inspectors look for the emergence of smoke from building roof vents (indicating a legal connection of a building sewer lateral) and other illicit connections such as:

- Storm drain cross-connections
- Area drain connections
- Roof drain/downspout connections
- Basement/foundation drain connections
- Uncapped or loosely-capped cleanouts

Smoke will not pass through columns of water such as P-traps or surcharged pipes, sump pumps connected from basement drains, or moist soil. In dry summer months, smoke can sometimes be observed emerging from the dry ground surface on private property, indicating poor upper lateral condition. It is for this reason that the mid to late dry season tends to be the best time to perform such testing, when soil moisture is likely to be at a minimum. Smoke testing is typically contracted based on linear footage of main sewer line. Costs vary from $0.75 to $1.00 per linear foot, and testing of 7,000 to 10,000 feet per day is typically achievable.[1]

4.4 Infiltration Indicators

Storm water can infiltrate any portion of the collection system that is not hydrostatically sealed. Typically, pipe material and age can provide an indication of the pipes likely to be deteriorated, or subject to poor construction methods/techniques employed in the era of installation. Condition assessment data can also be used to identify possible infiltration sources. Closed-circuit television (CCTV) inspections are a common means of assessing the condition of pipelines and the potential for infiltration. Although visual CCTV inspections do not typically identify active points of RDII (because inspections are generally not practical during major storm events), some CCTV inspection observations can indicate potential infiltration problems. These include:

- Observed infiltration
- Cracks, holes, broken pipe
- Offset and separated joints
- Root intrusion locations
- Defective or break-in/hammer lateral tap connections

The proximity of deteriorated sewer mains to a concentrated source of storm water such as creeks, drainage facilities, or areas of frequent street flooding can also indicate a higher likelihood of larger infiltration rates. Typically in the San Francisco Bay Area (Bay Area), collection systems constructed in bay mud and other low-lying fill soils experience high saltwater intrusion rates due to encroaching bay water and soil subsidence under manholes causing movement that disconnects pipe joints.

[1] Sterling, Raymond L., et. al., Water Environment Research Foundation (WERF), *Methods for Cost-Effective Rehabilitation of Private Lateral Sewers*, 2006.

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5.0 INFLOW AND INFILTRATION REDUCTION OPTIONS

This analysis explores options for reducing inflow sources and rehabilitating the collection system to correct structural defects and leaky joints through which RDII enters the collection system.

5.1 Inflow Source Disconnections

Smoke testing is considered a cost-effective method to locate inflow sources, although it is also generally understood that it does not identify all sources of inflow.

5.1.1 Smoke Testing

Experience in the Bay Area indicates that generally, most agencies have conducted smoke testing at least once in the past 20 years, which enabled those agencies to eliminate large inflow sources like storm drain cross-connections. As a result, the majority of smoke testing in the Bay Area nowadays tends to identify very few large volume storm drain connections, a handful of illegal drain connections, plus a much more common occurrence of below-grade service lateral cleanout caps on private property that can act as inadvertent area drains for the yard.

In contrast to residential areas, smoke testing in non-residential areas tends to identify larger-volume illegal connections since non-residential parcels often have expansive paved areas and the potential for much higher flow-producing drainage connections.

Since the City has a record of having conducted smoke testing of the collection system roughly 15 years ago, non-residential areas of the City should be given a high priority for testing.

5.1.2 Inflow Source Disconnection

Once smoke testing has been completed, the next step is to eliminate the inflow producing sources thus identified. Many sources of inflow are illegal and the cost of the redirection of storm flows are typically borne by the private property owner. Typical inflow reduction programs involve a property owner outreach process that include a 60-day notification letter and a 6-month enforcement process. However, in the case of leaking manhole covers or storm drain cross connections, City funds will be necessary to replace manhole covers and install storm drains.

5.2 Collection System Rehabilitation Options

Sewer rehabilitation can significantly reduce RDII, depending on the type and amount of rehabilitation performed. In addition to reducing RDII rates into the collection system, sewer rehabilitation can also address structural and maintenance issues, such as root intrusions and grease accumulation, and thus reduce the occurrence of dry weather blockages and SSOs.

Collection system rehabilitation can take several forms. Experience throughout the country has shown that rehabilitation should occur on an area-wide approach. With such an approach, the entire collection system within a designated area or sub-basin is rehabilitated as compared to trying to identify and correct specific defects. The latter approach may prove ineffective because

storm water can migrate past the rehabilitated defects and enter the collection system through defects that were not rehabilitated.

Sewer rehabilitation can involve challenges related to developing and administering a program to correct RDII sources on private property. Many studies have found that approximately one half of RDII enters the collection system through defective service laterals, which are primarily located on private property. Another challenge relates to the ability to accurately predict the reduction in PWWF resulting from sewer rehabilitation, thus making it difficult to quantify the extent (and cost) of the rehabilitation necessary to achieve program goals.

Several approaches can be used to rehabilitate the collection system within a designated basin. These approaches include:

- Rehabilitation of mains and manholes only,
- Rehabilitation of mains, manholes, and lower laterals (within the public right-of-way or easement), and
- Rehabilitation of mains, manholes, lower laterals, and privately-owned upper laterals.

A review of documented case studies indicates the following:

1. Rehabilitation of mains and manholes, with or without rehabilitation of lower laterals, generally provides moderate to minor reductions in PWWF. One study showed a 30 percent reduction in PWWF with such an approach, while others demonstrated a 5 percent[2] or less reduction in PWWF.
2. Rehabilitation of mains, manholes, lower laterals, and upper laterals usually achieves significant reductions in PWWF. Reductions of 50 to 70 percent of RDII were documented when upper laterals were rehabilitated along with mains, manholes, and lower laterals.

Based on the above analysis, the sewer rehabilitation options undertaken by the City should include rehabilitation of sewer mains, manholes, lower laterals, and privately-owned upper laterals. Currently, the City has a program to fund a portion of voluntarily-replaced private laterals. Rebates in the amount of 20 percent or up to $1,000 are available to assist property owners with the cost of upgrades made to their sanitary sewer laterals in order to meet current Millbrae Municipal Code requirements. It is thus recommended that the City adopt and implement a policy to expand its current program to fund and enforce the inspection and rehabilitation of privately-owned upper laterals. Several private lateral policy approaches are discussed in Table 1.

[2] Water Environment Research Foundation, *Reducing Peak Rainfall-Derived Infiltration/Inflow Rates – Case Studies and Protocol*, 99-WWF-8

Table 1. Advantages and Disadvantages of Common Private Lateral Policies

Approach	Advantages	Disadvantages
Voluntary testing and rehabilitation partially funded by the public agency (City's current program)	• Encourages participation in the program through financial incentives • City only bears partial cost of rehabilitation • City has much less responsibility for administering the program – typically centered on public awareness and tracking permit status • Does not introduce access, liability, or funding issues related to using public funds on private property	• City does not fully control the program or its schedule • Schedule is long-term and is thus not effective at achieving short-term RDII reductions • City is not able to focus funds on problem areas • City must track program status, including project completion, for individual properties • May introduce licensing and tracking issues for the City if it certifies individual contractors to do the work
Testing and rehabilitation upon sale of property and/or remodeling	• Participation in the program is required through public policy • City does not bear the cost of testing or rehabilitation • Does not introduce access, liability, or funding issues related to using public funds on private property	• City does not fully control the program or its schedule • Schedule is long-term and is thus not effective at achieving short-term RDII reductions • City is not able to focus program on problem areas • City must track permit status and enforce the policy • May introduce licensing and tracking issues for the City if it certifies individual contractors to do the work
Testing by the City and requirement of the property owner to correct deficiencies	• Participation in the program is required through public policy • City does not bear the cost of rehabilitation • City partially controls the program, its schedule, and its cost • Allows the City to prioritize problem areas • Does not introduce funding issues related to using public funds on private property	• City must resolve access and liability issues associated with inspecting and testing on private property • City must track permit status and enforce the policy • May introduce licensing and tracking issues for the City if it certifies individual contractors to do the work
City assumes temporary control of upper lateral and performs rehabilitation using public funds	• City controls the program, its schedule, and its cost • Allows the City to prioritize and focus funds on problem areas • Allows City to establish methods and processes for completing the work • Has economy of scale associated with publically bidding larger improvement packages	• City bears full cost of repairs • City must fully administer the program, including public outreach • City must resolve access and liability issues associated with conducting work on private property • City must resolve financial issues with using public funds on private property

5.3 Identification of Sub-Basins for RDII Reduction

The following discussion addresses how to identify portions of the collection system that serve as potential candidates for sewer rehabilitation/replacement. Improvements in those areas should address both dry weather and wet weather operation and maintenance problems within the collection system by identifying portions of the system with high I&I and coincident dry weather performance issues such as blockages due to roots and other maintenance or condition related problems. Key data used in identifying areas of concern includes:

- RDII Levels
- Pipe Size, Age, and Material
- CCTV Inspection Data
- Sanitary Sewer Blockages and Overflows

5.3.1 RDII Levels

The results of the RDII analysis conducted at the basin level were provided in the CAR. Table 2 summarizes the observed RDII levels in each basin, which are presented as the percentage of the volume of rainfall that falls within each basin that inflows or infiltrates into the collection system at various rates (fast, medium, and slow).

Table 2. RDII Levels by Basin

Basin	Drainage Area, ac	Existing Basin R-factor, % Rainfall			
		Fast	Medium	Slow	Total
Madrone	307.4	5.0%	4.7%	0.7%	10.4%
Broadway	186.1	7.0%	0.0%	0.0%	7.0%
Helen	201.4	7.0%	0.0%	0.0%	7.0%
Hillcrest	301.5	2.0%	2.7%	2.5%	7.2%
Tioga	68.4	7.0%	0.0%	0.0%	7.0%
Murchison	305.0	1.75%	1.6%	1.5%	4.85%
Total	**1,369.8**				

The Murchison basin has a notably lower level of RDII than the other basins, and was thus not considered any further for RDII reduction, as reduction is other basins yields higher results. Each of the remaining basins (other than Murchison) was subdivided into smaller sub-basins (see Figure 5) in order to apply the RDII indicators described in Section 3 in an attempt to differentiate the sub-basins to prioritize RDII reduction efforts.

5.3.2 Pipe Size, Age, and Material

Although the City's current minimum sewer diameter standard is eight inches, approximately 84 percent of the City's existing collection system is comprised of pipes with a diameter of 6 inches (see Figure 2). Maintenance issues caused by roots and grease are amplified in 6–inch diameter sewers because of their reduced diameter.

Although pipe ages are unknown for the collection system, installation dates were approximated using real estate information for housing construction records. Figure 5 shows the approximate age of the sewer lines in each basin using this approach. VCP sewers installed before 1958 have short lengths with numerous, cement mortar joints, which tend to shrink and crack, thus allowing increased rates of infiltration and root intrusion[3] than post-1958 sewers that used rubber-gasket or synthetic joints. Approximately 94 percent (235,000 linear feet) of the City's collection system is estimated to have been installed before 1958 (see Figure 6).

[3] Control of Infiltration and inflow into Sewer Systems Manual of Practice, USEPA, January, 1971

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FIGURE 5

City of Millbrae
Wet Weather
Alternatives Analysis

Sewer Age and Material

Not to Scale

Madrone Basin
Helen Basin
Broadway Basin
Tioga Basin
Hillcrest Basin
Murchison Basin
Hacienda PS
Capuchino High School
San Francisco International Airport
Madrone PS
Madrone FM
McDONNELL WPCP
Plaza Bay PS
San Francisco Bay
INTERSTATE HIGHWAY 280
STATE HIGHWAY 82
US HIGHWAY 101

Legend

- Manhole
- PS Pump Station
- Force Main
- Basin Boundary
- City Boundary
- Streets
- (#) Subbasin

Gravity Main - Diameter
All pipes 6" unless otherwise noted

Gravity Main - Material
solid VCP
dashed Other/Unknown

Gravity Main - Installation Year
Approximated from Real Estate Records
- pre-1945
- 1945-1949
- 1950-1954
- 1955-1959
- 1960-1964
- 1965-1969
- 1970-1974
- 1975-1979
- post-1980

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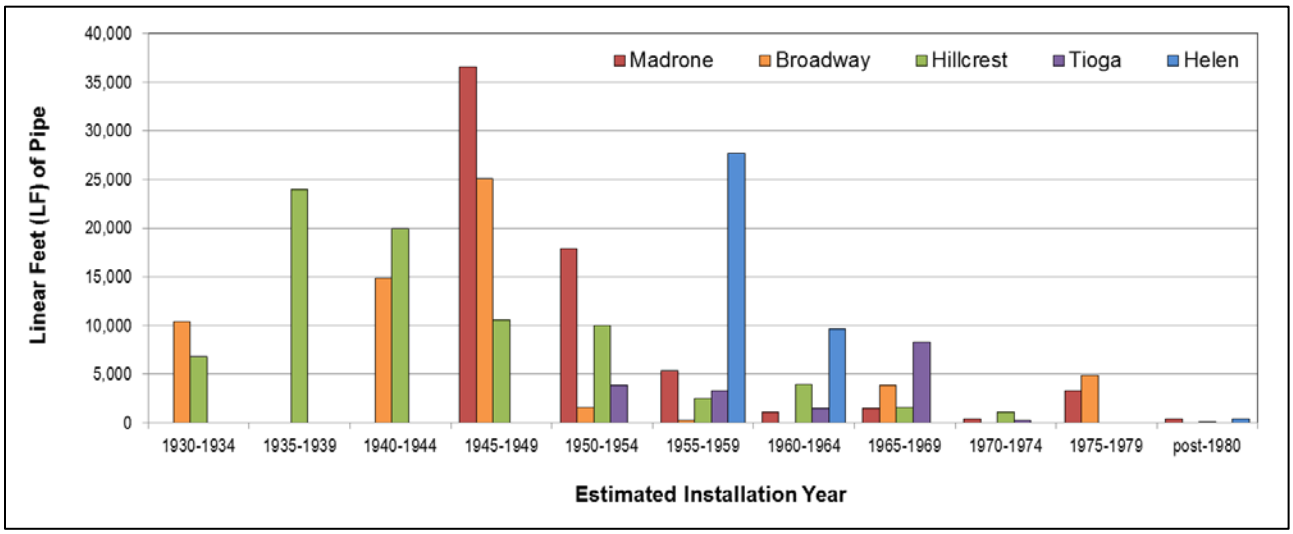
Figure 6. Approximate Pipe Installation Dates by Basin



Source: Housing construction dates as published at www.Zillow.com

5.3.3 CCTV Inspection Data

As a result of the Consent Decree, the City has undertaken a comprehensive CCTV condition assessment of the small-diameter sewers in its collection system. To date, the City has inspected 95 percent of the required gravity mains, is ahead of schedule on this condition assessment, and will complete the remaining five percent by September 2014. Because of the recent condition data collected for the majority of the system (13 percent of the inspections were abandoned, which typically occurs due to impassable roots or sags where the camera submerges underwater), there is plentiful data on which to base RDII priorities. Although CCTV inspections often do not identify active leaks, defect-related observations can be correlated to infiltration problems. Figure 7 graphically displays CCTV observations that indicate the potential for elevated levels of RDII.

5.3.4 Sanitary Sewer Blockages and Overflows

Figure 8 graphically depicts the locations of the SSOs that have occurred in the collection system between 2008 and 2013. As shown, there have been SSOs caused both by the condition of the collection system (indicating substantial dry weather maintenance issues that may potentially be alleviated by rehabilitation) and by lack of capacity (which may be alleviated by reducing RDII). Condition-related blockages and SSOs were most commonly caused by grease accumulation and root intrusions in small diameter pipes.

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FIGURE 7

City of Millbrae
Wet Weather
Alternatives Analysis

CCTV Inspection Observations

Not to Scale

Madrone Basin
Hacienda PS

Helen Basin

Broadway Basin

Tioga Basin

Hillcrest Basin

Murchison Basin

Capuchino High School

San Francisco International Airport

Madrone PS

Madrone FM

WPCP

Plaza Bay PS

San Francisco Bay

BAYVIEW, LOMITA, SANTA BARBARA, GUADALUPE, CYPRESS, JUANITA, SANTA FLORITA, PARK, HACIENDA, BARCELONA, CAPUCHINO, ROBIN, BROOKSIDE, GLENWOOD, FERNWOOD, ELMWOOD, OAKWOOD, RIDGEWOOD, MOSSWOOD, BANBURY, SYCAMORE, CRESTVIEW, LARKSPUR, EVERGREEN, SLEEPY HOLLOW, HELEN, TUOLUMNE, INTERSTATE HIGHWAY 280, STATE HIGHWAY 35, SPRINGFIELD, CLEARFIELD, EL CAPITAN, AHWAHNEE, TIOGA, MORNINGSIDE, CAMINO ALTO, VISTA GRANDE, LA PRENDA, HILLCREST, LAURA VISTA, EL BONITO, MIRCRA, HAZEL, TAYLOR, MAGNOLIA, MILLWOOD, PARAMOUNT, LUDEMAN, SAN ANSELMO, CENTER, GREEN HILLS, STATE HIGHWAY 82, MONTEREY, BAY, ANITA, RICHMOND, LINCOLN, POPLAR, BROADWAY, LA CRUZ, LEWIS, PALM, ALLEY, EL PASEO, LAUREL, ELDER, WILLOW, CHADBOURNE, MILLBRAE, HEMLOCK, BEVERLY, GUARDO, ROLLINS, US HIGHWAY 101, AVIADOR, ADRIAN, MCDONNELL, OLD BAYSHORE, MADERA, VALLEJO, CONEJO, MANZANITA, ENCINA, LAKE, LASUEN, SEBASTIAN, TOYON, FRONTERA, LOYOLA, CASTENADA, MURCHISON, SEQUOIA, ASHTON, HAWTHORNE, MARCELLA, PINON, TROUSDALE

Legend

- Manhole
- PS — Pump Station
- Force Main
- Gravity Main
- Basin Boundary
- City Boundary
- Streets
- # — Subbasin

Pipeline Defects

- Observed I/I
- Structural and Roots/Joints Defects
- Structural Defects
- Roots and Offset Joints Defects
- Structural 5 Defects

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FIGURE 8

City of Millbrae
Wet Weather
Alternatives Analysis

Overflow History (2008-2013)

Not to Scale

Legend

- Manhole
- Pump Station
- Force Main
- Gravity Main
- Basin Boundary
- City Boundary
- Streets
- Subbasin

Spill Cause

- Debri
- Grease (FOG)
- Roots
- Structural
- Capacity
- Other

Spill Type

- Main
- Lower Lateral

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5.3.5 Rehabilitation Sub-Basins

Table 3 summarizes the key RDII indicator data for each sub-basin. Rehabilitation of sub-basins would provide increased benefits to the City by reducing dry weather SSOs and maintenance issues while reducing RDII. Appendix A summarizes the collection system inventory in each sub-basin.

Table 3. Basin Properties

Basin	Sub-Basin	Total RDII[1]	Pipe Size[2]	Pipe Installed[3]	SSOs[4]	CCTV RDII Indicators[5]	Other[6]
Madrone	1	10.4%	6"	1945-64	-	◆◆◆	Multiple Drainage Crossings
	2	10.4%	6"	1945-74	◆◆	◆◆◆	-
	3	10.4%	6"	1945-54	◆	◆◆◆	-
	4	10.4%	6"-10"	1945-59	◆◆◆	◆◆◆	-
	5	10.4%	8"-10"	1945-49	-	◆◆	-
	6	10.4%	6"-12"	1945-59	◆	◆◆	Multiple Drainage Crossings
	7	10.4%	6"	1950-79	-	-	Multiple Drainage Crossings
	8	10.4%	6"-18"	1945-84	◆◆◆	◆	Drainage Crossings, Fill/Bay Mud
	9	10.4%	6"-8"	1945-59	◆◆◆	◆◆	Fill/Bay Mud
	HS	10.4%	-	1945-49	-	-	-
Broadway	1	7.0%	6"-8"	1930-77	◆◆	◆◆◆	-
	2	7.0%	6"-10"	1946-50	◆◆	◆◆	-
	3	7.0%	6"-18"	1930-68	-	◆	Multiple Drainage Crossings
	4	7.0%	6"-33"	1930-45	◆◆◆	◆	Drainage Crossings, Fill/Bay Mud
Helen	1	7.0%	6"	1960-2010	◆	◆	Multiple Drainage Crossings
	2	7.0%	6"-8"	1955-64	-	◆	-
	3	7.0%	6"	1956-62	◆	◆◆	Multiple Drainage Crossings
	4	7.0%	6"	1955-61	-	◆◆◆	Multiple Drainage Crossings
Hillcrest	1	7.2%	6"-12"	1936-38	◆	◆◆	-
	2	7.2%	6"-8"	1936-48	◆◆	◆◆◆	-
	3	7.2%	6"-18"	1930-36	◆◆◆	◆◆	-
	4	7.2%	6"-10"	1930-68	◆◆◆	◆◆◆	Multiple Drainage Crossings
	5	7.2%	6"	1940-81	◆	◆◆◆	-
	6	7.2%	6"-8"	1940-73	◆◆◆	◆	Multiple Drainage Crossings
	7	7.2%	6"	1941-50	◆◆	◆◆◆	-
	8	7.2%	6"	1940-69	◆	◆	-
Tioga	1	7.0%	6"	1953-69	-	◆◆	Multiple Drainage Crossings
	2	7.0%	6"	1953-71	◆	◆	Multiple Drainage Crossings
	3	7.0%	6"	1953-68	◆	◆◆	Multiple Drainage Crossings

Sources: 1 – CAR, 2 – City GIS, 3 – Real Estate Records, 4 – CIWQS database, 5 – AIMS database, 6 - Publically-available GIS layers

Relative Key: - = much fewer, ◆ = fewer, ◆◆ = more, ◆◆◆ = many more

Because of drought conditions occurring during the 2012-13 and 2013-14 wet weather seasons, flow monitoring of the collection system was limited to larger basin areas only, while so significant flow metering data exists at all for previous wet seasons. To ensure a sustainable cost/benefit ratio for the rehabilitation effort, more intensive flow monitoring should be performed in smaller sub-basin areas to further prioritize the need for rehabilitation among those sub-basins. Based on experience with actual rehabilitation projects, intensive flow monitoring is critical in providing the data needed to identify the specific areas where sewer mains, manholes, and laterals are most in need of rehabilitation to reduce RDII.

5.3.6 Rehabilitation Approach

The recommended approach for collection system rehabilitation is as follows:

1. Collection system facilities requiring rehabilitation will include manholes, sewer mains, and both lower and upper laterals.
2. It is assumed that sewer main rehabilitation for sewers 8-inches in diameter and smaller will involve pipe replacement using pipe bursting, whereas lines 10-inches in diameter or larger will be lined with cured-in-place pipe (CIPP). Rehabilitation of sewers larger than 12 inches in diameter is not included.
3. Manhole rehabilitation will involve the use of applied coating systems.
4. For sub-basins where the City implements a focused program to rehabilitate privately owned upper laterals, reduction of 70 percent of the fast and medium RDII in the sub-basin is projected.
5. For sub-basins where publically-owned mains, manholes, and lower laterals will be rehabilitated, but privately-owned upper laterals will only be rehabilitated voluntarily or in conjunction with the sale of property or obtaining a building permit, a reduction between 30-50 percent of the slow, medium, and fast RDII is projected. For the purposes of this analysis, 30 percent reduction in RDII is projected in such areas because few upper laterals will be rehabilitated during the 10-year planning period.

Because this analysis is in planning level only, it is difficult to predict the amount of collection system infrastructure that will need rehabilitation within each segment/sub-basin. Moreover, as indicated above, to date, flow monitoring data is only available for large basins. More intensive flow monitoring and detailed field investigations in the sub-basins are necessary to characterize how RDII is distributed within each basin and to identify portions of the sub-basins that do not need rehabilitation.

Additionally, actual RDII reduction rates achieved by collection system rehabilitation depend on many factors including the type of rehabilitation performed, the properties and condition of the existing collection system, soil properties, ground saturation conditions, the presence of antecedent storm water, etc. and will, therefore, vary between sub-basins. For rehab sub-basins with high RDII levels and similar non-rehabilitated control sub-basins, annually monitoring pre-rehab and post-rehab flows and rainfall is necessary to validate the RDII reduction efforts. This annual validation process confirms the point at which RDII reduction target levels have been achieved and no further rehabilitation need occur for I&I reduction purposes.

6.0 RELATED IMPROVEMENT PROJECTS

Related to the need for collection system rehabilitation are ongoing system improvements driven by two factors: requirements to satisfy the Consent Decree and programmatic gravity sewer infrastructure replacement projects.

6.1 Consent Decree Requirements

The City's Consent Decree requires that the City CCTV inspect the small diameter portions of its collection system and that the National Association of Sewer Service Companies Pipeline Assessment & Certification Program (PACP) Structural 5 defects be repaired. It also requires that the City implement the CAR hydraulic improvement projects by June 2016. Thus, the Consent Decree drives the need for the following:

- Defect Repair Projects
- Gravity Sewer Capacity Improvement Projects
- Ongoing Collection System Asset Replacement

6.1.1 Defect Repair Projects

The City's AIMS database provides CCTV defect data for the majority of the small diameter sewers. Table 4 includes a summary of the estimated Structural 5 defect repair projects that the City will need to perform. A detailed list of repairs and replacement projects is provided in Appendix B. Complete replacement of the pipe was assumed for conditions in which there is more than one Structural 4 or 5 defect per 100 feet of pipe length. Otherwise, a spot repair was assumed to be adequate for repairing the Structural 5 defects. Spot repairs of Structural 4 defects were not included.

Table 4. Summary of Structural 5 Defect Repair and Replacement Projects

Sub-basin	Completed Projects[a]	Spot Repairs Remaining[b] (Structural 5 Defects Only)	Length of Pipe[c] Replacement Remaining, ft	Total Projects Remaining
Broadway - 1	2	2	155	3
Broadway - 2	1	6	67	7
Broadway - 3	0	1	68	2
Broadway - 4	0	13	0	13
Broadway Total	**3**	**22**	**290**	**25**
Helen - 1	1	1	0	1
Helen - 2	0	1	0	1
Helen - 3	0	5	51	6
Helen - 4	0	0	0	0
Helen Total	**1**	**7**	**51**	**8**
Hillcrest - 1	0	1	0	1
Hillcrest - 2	0	1	0	1
Hillcrest - 3	1	9	178	10
Hillcrest - 4	7	8	0	8
Hillcrest - 5	0	5	439	8
Hillcrest - 6	2	3	293	4
Hillcrest - 7	2	2	194	4
Hillcrest - 8	1	6	94	7
Hillcrest Total	**13**	**35**	**1198**	**43**
Tioga - 1	0	0	0	0
Tioga - 2	0	0	0	0
Tioga - 3	0	6	66	7
Tioga Total	**0**	**6**	**66**	**7**
Madrone - 1	0	5	0	5
Madrone - 2	4	78	109	8
Madrone - 3	1	5	0	5
Madrone - 4	2	15	616	19
Madrone - 5	0	1	0	1
Madrone - 6	1	5	217	6
Madrone - 7	0	3	0	3
Madrone - 8	2	4	447	7
Madrone - 9	0	3	0	3
Madrone Total	**10**	**119**	**1,389**	**57**
Murchison Total	**11**	**8**	**193**	**10**

Source: AIMS database.

[a] Completed projects detailed in 2011-2013 Annual Reports and 2014 Pipe Bursting Project.

[b] Structural 5 defects were identified from the PACP Quick Scores, which were only available for 54 percent of sewers in the Broadway basin, 91 percent of sewers in the Helen basin, 70 percent of sewers in the Hillcrest basin, 83 percent of sewers in the Murchison basin, and 91 percent of sewers in the Tioga basin.

[c] Lengths shown are according to CCTV records, not GIS data.

6.1.2 Gravity Sewer Capacity Improvement Projects

Gravity main capacity improvement projects were developed in the CAR to allow for the conveyance of PWWF in the collection system without SSOs. One such project has been identified for the Madrone basin, and was developed based upon the assumption that the Madrone PS would be moved to an alternative location. The same hydraulic model developed for the CAR was used to revise the capacity improvement requirements based upon the three alternatives evaluated in this study.

Because some of the rim elevations in the study area were based upon assumed values taken from the City's topographic map, a survey was conducted upstream of the Madrone PS in order to confirm rim and invert elevations. The updated data was integrated into the hydraulic model. The gravity sewer segments outlined in Appendix C and presented graphically on Figures 9 through 12 were identified for improvement in each of the alternatives. As shown, the RDII reductions identified for Alternative 2 and Alternative 3 reduce the amount of capacity improvements required.

6.1.2.1 WPCP Storage

Modeled PWWF exceeds the limits of the WPCP hydraulic and treatment capacities, so peak flows must be diverted to and stored in a wet weather storage facility upstream of the plant. According to the CAR, under modeled existing PWWF conditions, the storage requirement is 0.9 million gallons (MG), which includes a 30 percent safety allowance for multiple consecutive storms.

6.1.3 Ongoing Collection System Asset Replacement

Regardless of the requirements under the Consent Decree, regular asset replacement must occur to keep pace with the age-related deterioration of the City's collection system assets. The City currently budgets $1.0 million per year for collection system rehabilitation, which covers emergency repairs and some other collection system rehabilitation projects. As the collection system ages, it is estimated that approximately nine miles of sewer mains and manholes will need to be replaced over the next ten years, which is at a rate of approximately 4,320 lineal feet (LF) (equivalent to 1.5 percent of the system) per year.

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FIGURE 9

City of Millbrae
Wet Weather
Alternatives Analysis

Alternative 1A: CAR Capacity Upgrade Recommendations with No RDII Reduction

Not to Scale

Capuchino High School Vicinity Project

Richmond Drive/ Anita Drive Project

Murchison Drive Project

Aviador and East Millbrae Drive Project

Madrone Basin

Helen Basin

Broadway Basin

Tioga Basin

Hillcrest Basin

Murchison Basin

Capuchino High School

San Francisco International Airport

Hacienda PS

Madrone PS

Madrone FM

Plaza Bay PS

WPCP

San Francisco Bay

Legend

- Manhole
- PS Pump Station
- Force Main
- Gravity Main
- Basin Boundary
- City Boundary
- Streets
- # Subbasin

Alternative Elements

- Capacity Improvements
- New Force Main
- WPCP Storage Basin (0.9 MGD)
- PS New Pump Station (6.5 MGD)

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FIGURE 10

City of Millbrae
Wet Weather
Alternatives Analysis

Alternative 1B: Revised Capacity Upgrade Recommendations with No RDII Reduction

Not to Scale

Capuchino High School Vicinity Project

Richmond Drive/ Anita DrivProject

Murchison Drive Project

Aviador and East Millbrae Drive Project

Madrone FM

Madrone PS

Hacienda PS

Plaza Bay PS

WPCP

Helen Basin

Madrone Basin

Broadway Basin

Tioga Basin

Hillcrest Basin

Murchison Basin

Capuchino High School

San Francisco International Airport

San Francisco Bay

Legend

- Manhole
- PS Pump Station
- Force Main
- Gravity Main
- Basin Boundary
- City Boundary
- Streets
- # Subbasin

Alternative Elements

- Capacity Improvements
- Parallel Force Main (14")
- WPCP Storage Basin (0.9 MGD)
- PS Upsized Pump Station (6.5 MGD)

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FIGURE 11

City of Millbrae
Wet Weather
Alternatives Analysis

Alternative 2: RDII Reduction in Public Infrastructure

Not to Scale

Capuchino High School Vicinity Project

Richmond Drive/ Anita Drive Project

Murchison Drive Project

Aviador and East Millbrae Drive Project

Madrone Basin
Helen Basin
Broadway Basin
Tioga Basin
Hillcrest Basin
Murchison Basin

Capuchino High School
San Francisco International Airport
San Francisco Bay
Hacienda PS
Madrone PS
Madrone FM
Plaza Bay PS
WPCP
INTERSTATE HIGHWAY 280
STATE HIGHWAY 82
STATE HIGHWAY 35

Legend

- Manhole
- PS Pump Station
- Force Main
- Gravity Main
- Basin Boundary
- City Boundary
- Streets
- # Subbasin

Alternative Elements

- Capacity Improvements
- Sub-Basin Improvements
- PS Upsized Pump Station (5.0 MGD)

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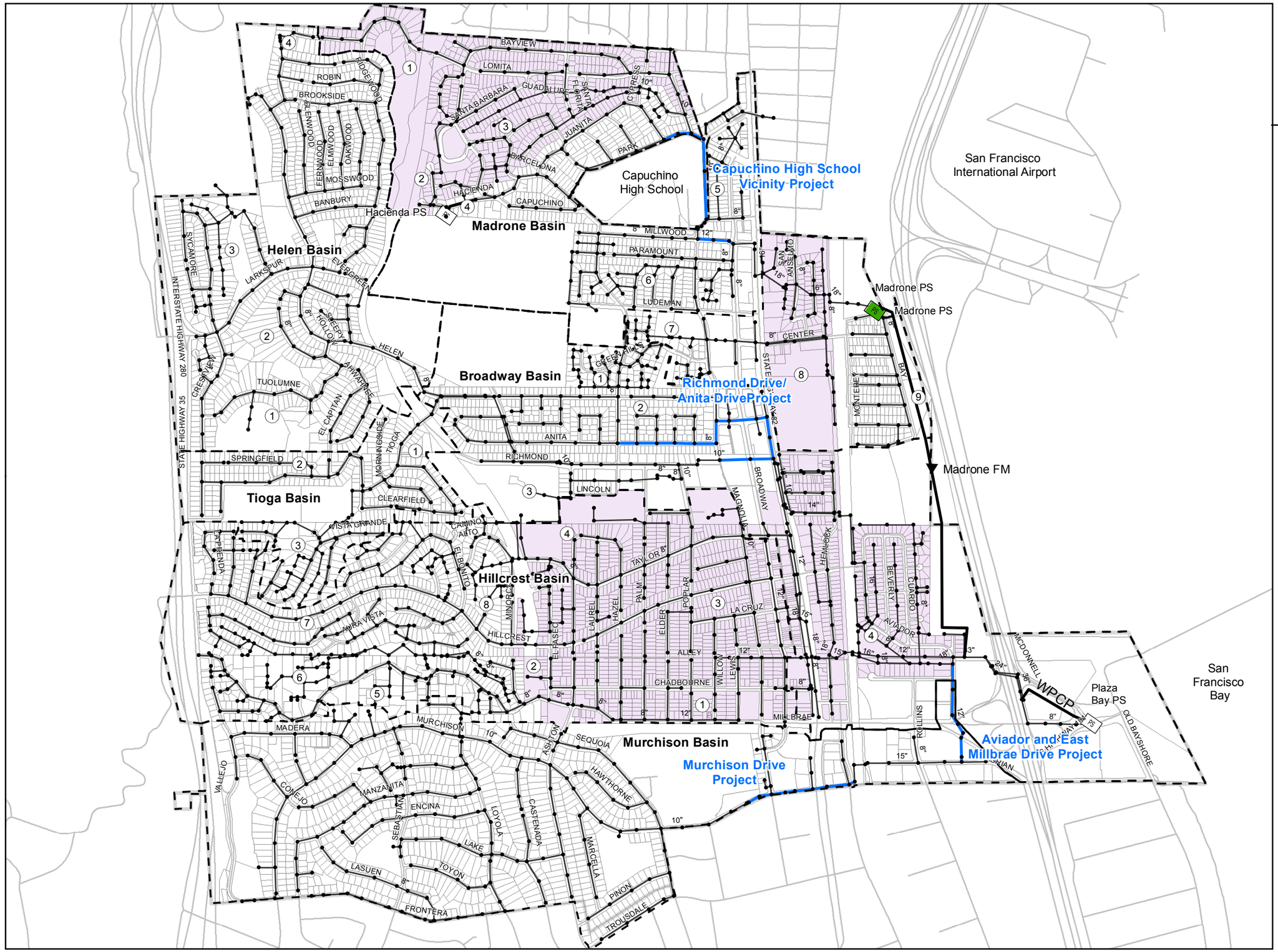
FIGURE 12

City of Millbrae
Wet Weather
Alternatives Analysis

Alternative 3: RDII Reduction in Public and Private Infrastructure

Not to Scale



Legend

- Manhole
- Pump Station
- Force Main
- Gravity Main
- Basin Boundary
- City Boundary
- Streets
- Subbasin

Alternative Elements

- Capacity Improvements
- Sub-Basin Improvements
- Upsized Pump Station (5.0 MGD)

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7.0 ALTERNATIVES EVALUATION

Four alternatives for addressing collection system capacity concerns are addressed in this section:

- Alternative 1A: CAR Capacity Upgrade Recommendations with No RDII Reduction
- Alternative 1B: Revised Capacity Upgrade Recommendations with No RDII Reduction
- Alternative 2: RDII Reduction in Public Infrastructure
- Alternative 3: RDII Reduction in Public and Private Infrastructure

The major topics covered in this section include:

- Evaluation Criteria
- Description of Alternatives
- Hydraulic Analysis Results
- Capital Cost Assumptions
- Economic Analysis
- Non-Economic Analysis
- Recommended Alternative Evaluation Criteria

7.1 Evaluation Criteria

The four alternatives under consideration are further developed and compared in this section based on the following criteria:

- Alternatives are based on conveying the design PWWF, with varying levels of RDII reduction.
- No SSOs are allowed under future design PWWF conditions (projected using the methodologies described in the CAR).
- A 10-year planning period is assumed.

In addition, the evaluation criteria used in the analysis are divided into two categories: economic and non-economic. The economic category is presented in terms of capital costs, while the non-economic criteria take into consideration factors related to implementation and long term risk. The non-economic factors are presented in this analysis as a relative comparison in terms of positive and negative impacts without the assignment of measurable costs.

7.2 Description of Alternatives

This section provides a detailed description of the improvements needed under each of the four alternatives. Key aspects of each alternative are summarized in Table 5.

Table 5. Alternative Elements

Element	Alternative 1A: CAR Capacity Upgrade Recommendations with No RDII Reduction	Alternative 1B: Revised Capacity Upgrade Recommendations with No RDII Reduction	Alternative 2: RDII Reduction in Public Infrastructure	Alternative 3: RDII Reduction in Public and Private Infrastructure
RDII Reduction	None	None	Rehabilitation of mains, manholes, and lower laterals in 17 sub-basins; Inflow disconnections in 2 sub-basins	Rehabilitation of mains, manholes, & lower and upper laterals in 7 sub-basins; Inflow disconnections in 2 sub-basins
Madrone PS Capacity	Keep Existing Madrone PS Construct New PS (6.5 MGD)	Upsize existing PS to 6.5 MGD	5.0 MGD	5.0 MGD
Madrone Force Main Modifications	None	Parallel 14-inch	None	None
WPCP Storage Basin	0.9 MG	0.9 MG	None	None
Gravity Sewer Capacity Upgrades	326 LF of 8-in 1,212 LF of 10-in 7,619 LF of 12-in 2,154 LF of 18-in 1,723 LF of 36-in	326 LF of 8-in 1,212 LF of 10-in 7,619 LF of 12-in 315 LF of 15-in 3,168 LF of 18-in 774 LF of 21-in 1,078 LF of 24-in 1,723 LF of 33-in	2,086 LF of 10-in 4,127 LF of 12-in 413 LF of 15-in 1,231 LF of 18-in	2,086 LF of 10-in 3,622 LF of 12-in 413 LF of 15-in 1,231 LF of 18-in
Structural 5 Defect Repairs	197 Spot Repairs, 3,187 LF Sewer Replacement	197 Spot Repairs, 3,187 LF Sewer Replacement	51 Spot Repairs, 1,212 LF Sewer Replacement	90 Spot Repairs, 2,900 LF Sewer Replacement
Ongoing Asset Replacement	0.75 miles/year for 10 years	0.75 miles/year for 10 years	Concentrated in the RDII Reduction Sub-basins listed above	Concentrated in the RDII Reduction Sub-basins listed above
Flow Monitoring Validation	Basic validation at the end of the alternative program.	Basic validation at the end of the alternative program.	Robust annual validation to confirm RDII reduction rates.	Robust annual validation to confirm RDII reduction rates.

7.2.1 Alternative 1A - CAR Capacity Upgrade Recommendations with No RDII Reduction

This alternative (see Figure 9) includes the capital improvements as they are recommended in the CAR, with the exception of the Ongoing Asset Replacement rate, which has been expanded to a 10-year program – rather than the 5-year program described in the CAR.

RDII Reduction. No RDII reduction measures are included in this alternative.

Madrone PS. Downsizing the existing Madrone PS and constructing a new pump station at an alternate location, as described in the CAR.

WPCP Storage Basin. The wet weather storage facility identified in the CAR is 0.9 mgd and includes a 30 percent allowance for multiple consecutive storms.

Gravity Sewer Capacity Upgrades. Capacity upgrades to the gravity collection system as described in the CAR, which include 8-, 10-, 12-, 18-, and 36-inch improvements.

Structural 5 Defect Repairs. The Structural 5 defect repair projects summarized in Appendix B will need to be completed in order to meet the City's Consent Decree requirements.

Ongoing Asset Replacement. As portions of the collection system approach the end of their useful lives over the next ten years, approximately 7.5 miles of sewer mains and manholes will need to be replaced at a rate of approximately 4,230 LF per year. For this alternative, collection system spot repairs, rehabilitation efforts, and asset replacements occur throughout the collection system as maintenance or structural defects are discovered or as failures occur. This type of piecemeal rehabilitation of the collection system does not reduce RDII rates since I&I flows simply enter the collection system through the next downstream defect.

7.2.2 Alternative 1B – Revised Capacity Upgrade Recommendations with No RDII Reduction

This alternative (see Figure 10) includes the capital improvements recommended in the CAR, with the exception of the following three improvements:

- Madrone PS, which under this alternative, gets upgraded in its existing location and a parallel force main gets constructed to the wastewater treatment plant.
- Gravity Sewer Capacity upgrades, which are reduced to convey flows to the existing Madrone PS location rather than to a new pump station location.
- Ongoing Asset Replacement rate, which has been expanded to a 10-year program – rather than a 5-year program, as described in the CAR.

RDII Reduction. No RDII reduction measures are included in this alternative.

Madrone PS and Force Main. The improvement of the Madrone PS to 6.5 mgd firm capacity would require the following improvements to the force main and pump station:

1. To increase the force main capacity to 6.5 mgd, a 14-inch force main would be installed parallel to the existing 14-inch force main.
2. Replace the pumps: The larger pumps would have a duty point of approximately 2,255 gpm (3.25 mgd each) at 55 feet TDH (based on parallel 14-inch force main). The TDH could be reduced to 142 feet if a parallel 8-inch force main is used.
3. Replace the 10-inch suction piping with 14-inch piping.
4. Replace discharge piping and valves with 12-inch piping and valves.
5. Replace the electrical service, and power distribution equipment. The new service should be sized for approximately 300 amps, 480-volt, three-phase (400-amp, 480-volt service is assumed for the 8-inch force main option).
6. The pumps should be equipped with variable frequency drives (VFDs) to allow them to cover the range of flow and to use the existing wet well.
7. Replace the standby generator with a new 200-kW unit (a 300-kW generator is assumed for the 8-inch force main option).
8. Replace the control system to accommodate the new VFD equipment.
9. Construct an interconnection of the existing force main and the parallel force main downstream of the flow meter. It is anticipated that the existing 8-inch magnetic flow meter would be used for flows up to 6.5 mgd.

WPCP Storage Basin. The wet weather storage facility identified in the CAR is 0.9 mgd and includes a 30 percent allowance for multiple consecutive storms.

Gravity Sewer Capacity Upgrades. Capacity upgrades to the gravity collection system include 8-, 10-, 12-, 15-, 18-, 21-, and 33-inch improvements. The required improvements are summarized in Appendix C.

Structural 5 Defect Repairs. The Structural 5 defect repair projects summarized in Appendix B will need to be completed in order to meet the City's Consent Decree requirements.

Ongoing Asset Replacement. As portions of the collection system approach the end of their useful lives over the next ten years, approximately 7.5 miles of sewer mains and manholes will need to be replaced at a rate of approximately 4,230 LF per year. For this alternative, collection system spot repairs, rehabilitation efforts, and asset replacements occur throughout the collection system as maintenance or structural defects are discovered or as failures occur. This type of piecemeal rehabilitation of the collection system does not reduce RDII rates since I&I flows simply enter the collection system through the next downstream defect.

7.2.3 Alternative 2: RDII Reduction in Public Infrastructure

This alternative (See Figure 11) includes rehabilitation of publically-owned collection system infrastructure for RDII reduction (which eliminates the need for the storage facility at the WPCP and the parallel Madrone force main), and includes upgrading the existing Madrone PS, rather than relocating it as described in the CAR.

RDII Reduction. Conduct smoke testing in the non-residential areas of Madrone Sub-basin 8 and Broadway Sub-basin 4, and enforce disconnection of illicit/improper connections to the collection system. Given the prevalence of non-residential land use in these two sub-basins, it is expected that an overall reduction in RDII of 10 percent would be achieved in these basins through the disconnection of inflow sources. Rehabilitate mains, manholes, and publically-owned lower laterals in the sub-basins listed in Table 6 to achieve a 30 percent reduction in total RDII by reducing the fast, medium, and slow response of the sub-basins.

Table 6. Alternative 2 RDII Reduction Methods

Basin	Sub-Basin	Drainage Area, ac	Existing Basin R-factor	Proposed RDII Reduction Method	Approximate % RDII Reduction				Projected R-factor
					Fast	Medium	Slow	Total	Total
Madrone	1	43.4	10.4%	Rehab Mains, MHs, & Lower Laterals	30%	35%	-	30%	7.3%
	2	38.3	10.4%	Rehab Mains, MHs, & Lower Laterals	30%	35%	-	30%	7.3%
	3	20.4	10.4%	Rehab Mains, MHs, & Lower Laterals	30%	35%	-	30%	7.3%
	4	33.1	10.4%	Rehab Mains, MHs, & Lower Laterals	30%	35%	-	30%	7.3%
	5	13.4	10.4%	Rehab Mains, MHs, & Lower Laterals	30%	35%	-	30%	7.3%
	6	44.5	10.4%	Rehab Mains, MHs, & Lower Laterals	30%	35%	-	30%	7.3%
	8	45.8	10.4%	Smoke Testing / Inflow Disconnections	20%	-	-	10%	9.4%
	9	22.1	10.4%	Rehab Mains, MHs, & Lower Laterals	30%	35%		30%	7.3%
Broadway	1	42.6	7.0%	Rehab Mains, MHs, & Lower Laterals	30%	-	-	30%	4.9%
	2	23.0	7.0%	Rehab Mains, MHs, & Lower Laterals	30%	-	-	30%	4.9%
	4	74.9	7.0%	Smoke Testing / Inflow Disconnections	10%	-	-	10%	6.3%
Helen	4	68.0	7.0%	Rehab Mains, MHs, & Lower Laterals	30%	-	-	30%	4.9%
Hillcrest	1	23.7	7.2%	Rehab Mains, MHs, & Lower Laterals	30%	30%	30%	30%	5.0%
	2	25.6	7.2%	Rehab Mains, MHs, & Lower Laterals	30%	30%	30%	30%	5.0%
	3	31.8	7.2%	Rehab Mains, MHs, & Lower Laterals	30%	30%	30%	30%	5.0%
	4	67.8	7.2%	Rehab Mains, MHs, & Lower Laterals	30%	30%	30%	30%	5.0%
	5	28.0	7.2%	Rehab Mains, MHs, & Lower Laterals	30%	30%	30%	30%	5.0%
	7	31.0	7.2%	Rehab Mains, MHs, & Lower Laterals	30%	30%	30%	30%	5.0%
Tioga	1	23.5	7.0%	Rehab Mains, MHs, & Lower Laterals	30%			30%	4.9%

Madrone Pump Station and Force Main. For the assumed RDII reductions in this alternative, the existing force main capacity is adequate. The firm capacity of the Madrone PS would need to be increased to approximately 5.0 mgd by improvements to the pump station alone. The required pump station improvements would include the following modifications:

- Replace the pumps: The larger pumps would have a duty point of approximately 1,910 gpm (2.75 mgd each) at 108 feet TDH.
- Replace the 10-inch suction piping with 12-inch piping.
- Replace discharge piping as needed to accommodate the new pump configuration. Upsizing is not necessary.
- Replace the electrical service, and power distribution equipment. The new service should be sized for approximately 300 amps, 480-volt, three-phase.
- The pumps should be equipped with VFDs to allow them to cover the range of flow and to use the existing wet well.
- Replace the standby generator with a new 200-kW unit.
- Replace the control system to accommodate the new VFD equipment.

WPCP Storage Basin. The assumed RDII reduction would reduce the PWWF to the point that no additional storage capacity would be needed.

Gravity Sewer Capacity Upgrades. Given the RDII reductions described above, the need for capacity upgrades to the gravity collection system is greatly reduced. Notably, the requirements for improvements in El Camino Real and alongside the canal leading to the WPCP are eliminated. The required improvements are itemized in Appendix C.

Structural 5 Defect Repairs. The repair and replacement of PACP Structural 5 defects in the sub-basins listed in Table 6 would no longer be required since those portions of the collection system would be completely rehabilitated. Repairs of Structural 5 defects in the remaining basins would still be required.

Ongoing Asset Replacement. Under this alternative, the ongoing replacement needs would be satisfied by the rehabilitation of the sub-basins listed in Table 6, so no additional replacement is anticipated.

RDII Reduction Validation (Flow Monitoring and Modeling). An annual RDII reduction validation process is necessary to confirm the point at which RDII reduction target levels have been achieved and no further rehabilitation need occur for I&I reduction purposes. This validation process includes annual monitoring of pre-rehab and post-rehab flows and rainfall and hydraulic modeling for rehabilitated sub-basins plus similar non-rehabilitated control sub-basins.

7.2.4 Alternative 3: RDII Reduction in Public and Private Infrastructure

This alternative (see Figure 12) includes rehabilitation of publically- and privately-owned collection system infrastructure for RDII reduction (which eliminates the need for the storage facility at the WPCP and the parallel Madrone force main), and includes upgrading the existing Madrone PS, rather than relocating it as described in the CAR.

RDII Reduction. Conduct smoke testing in the non-residential areas of Madrone Sub-basin 8 and Broadway Sub-basin 4, and enforce disconnection of illicit/improper connections to the collection system. As with Alternative 2, it is expected that an overall reduction in RDII of 10 percent would be achieved in these basins. Rehabilitate mains, manholes, and both lower and privately-owned upper laterals in the sub-basins listed in Table 7 to achieve an estimated 70 percent reduction in total RDII. This alternative requires a private lateral replacement policy for upper lateral improvements on private property.

Table 7. Alternative 3 RDII Reduction Methods

Basin	Sub-Basin	Drainage Area, ac	Existing Basin R-factor	Proposed RDII Reduction Method	Approximate % RDII Reduction				Projected R-factor
					Fast	Medium	Slow	Total	Total
Madrone	1	43.4	10.4%	Rehab Mains, MHs, Lower & Upper Laterals	85%	64%	-	70%	3.1%
	2	38.3	10.4%	Rehab Mains, MHs, Lower & Upper Laterals	85%	64%	-	70%	3.1%
	3	20.4	10.4%	Rehab Mains, MHs, Lower & Upper Laterals	85%	64%	-	70%	3.1%
	8	45.8	10.4%	Smoke Testing / Inflow Disconnections	20%	-	-	10%	9.4%
Broadway	4	74.9	7.0%	Smoke Testing / Inflow Disconnections	10%	-	-	10%	6.3%
Hillcrest	1	23.7	7.2%	Rehab Mains, MHs, Lower & Upper Laterals	65%	65%	65%	65%	2.5%
	2	25.6	7.2%	Rehab Mains, MHs, Lower & Upper Laterals	65%	65%	65%	65%	2.5%
	3	31.8	7.2%	Rehab Mains, MHs, Lower & Upper Laterals	65%	65%	65%	65%	2.5%
	4	67.8	7.2%	Rehab Mains, MHs, Lower & Upper Laterals	65%	65%	65%	65%	2.5%

Madrone PS and Force Main. For the assumed RDII reductions in this alternative, the existing force main capacity is adequate. The improvements required to increase the firm capacity of the Madrone PS from 2.5 mgd to 5.0 mgd are identical to those described above in Alternative 2.

WPCP Storage Basin. Similar to Alternative 2, the assumed RDII reduction would reduce the PWWF to the point that no additional storage capacity would be needed.

Gravity Sewer Capacity Upgrades. Given the RDII reductions described above, the need for capacity upgrades to the gravity collection system is greatly reduced. Notably, the requirements for improvements in El Camino Real and alongside the canal leading to the WPCP are eliminated. The requirements are itemized in Appendix C.

Structural 5 Defect Repairs. The repair and replacement of PACP Structural 5 defects in the sub-basins listed in Table 7 would no longer be required since those portions of the collection system would be completely rehabilitated. Repairs of Structural 5 defects in the remaining basins would still be required.

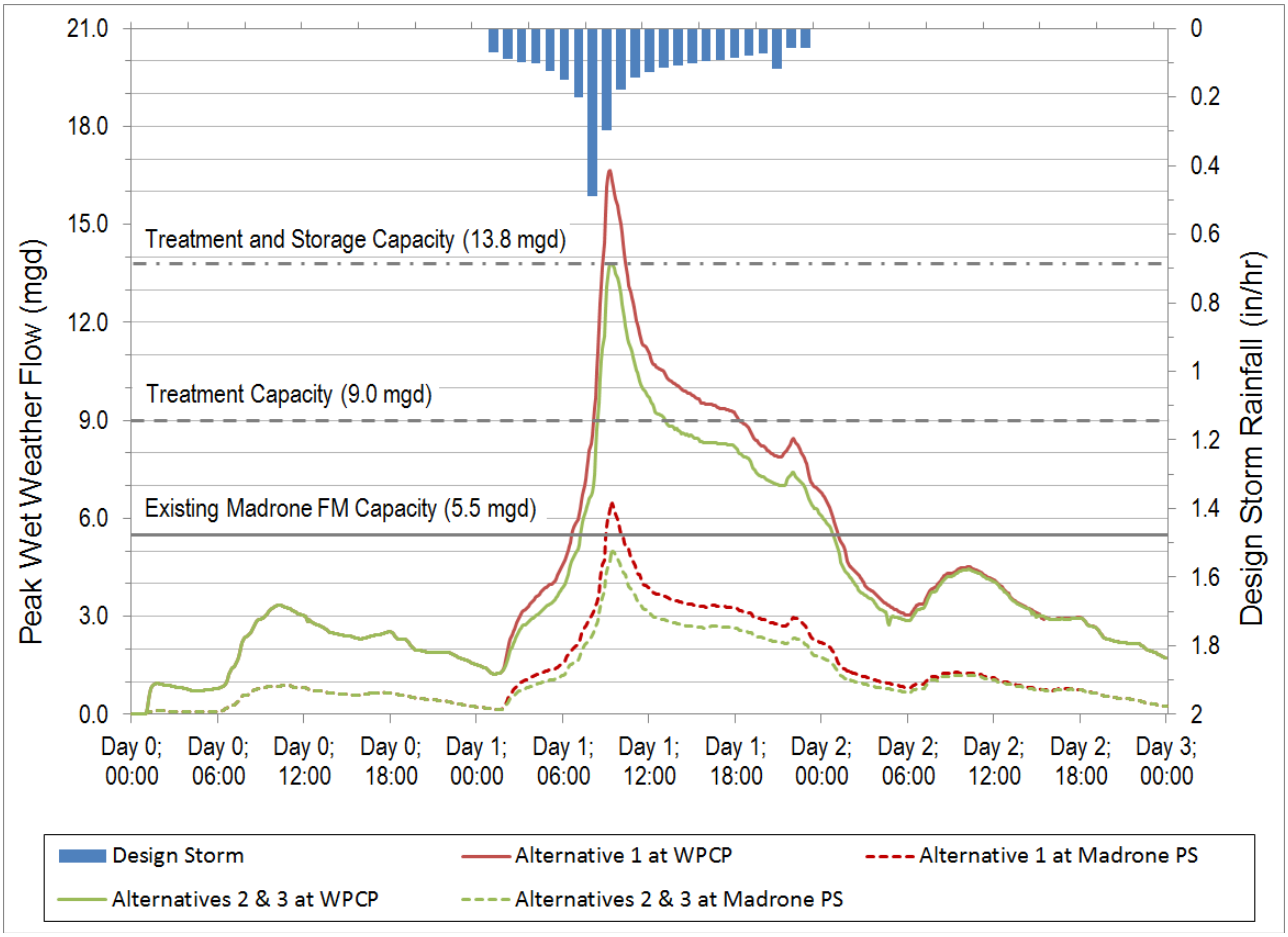
Ongoing Asset Replacement. Under this alternative, the sub-basins listed in Table 7 would be completely rehabilitated, so the ongoing replacement needs of these areas of the City would be satisfied by these projects. For this alternative, funds allocated for collection system rehab/replacement are targeted for sub-basin-wide rehabilitation for RDII reduction, as listed above under "RDII Reduction". No additional replacement are anticipated.

RDII Reduction Validation (Flow Monitoring and Modeling). An annual RDII reduction validation process is necessary to confirm the point at which RDII reduction target levels have been achieved and no further rehabilitation need occur for I&I reduction purposes. This validation process includes annual monitoring of pre-rehab and post-rehab flows and rainfall and hydraulic modeling for rehabilitated sub-basins plus similar non-rehabilitated control sub-basins.

7.3 Hydraulic Analysis Results

Sewer rehabilitation was modeled in the City's hydraulic model (as detailed in the CAR) by reducing fast, medium, and slow RDII, as summarized in Table 6 and Table 7. The gravity sewer network included in the CAR was then modeled using PWWF values based on the assumed RDII reductions. The hydraulic simulation following the assumed rehabilitation resulted in the reduction of PWWF at the Madrone PS and at the WPCP as shown in Figure 13.

Figure 13. RDII Reduction Modeling Results



7.4 Capital Cost Assumptions

West Yost Associates (West Yost) developed independent planning level capital cost estimates for each of the alternative elements in June 2014 dollars. The estimates were prepared using West Yost experience, published data, and bid results from similar projects. The estimates are considered Class 5 estimates, based on the Association for the Advancement of Cost Engineering International (AACE) criteria. A Class 5 estimate is defined as a Conceptual Level or Project Viability Estimate, typically with engineering from 0 percent to 2 percent complete. Class 5 estimates are used to complete alternative comparisons, prepare planning level cost scopes, or evaluate design options and form the base work for the Class 4 Design Baseline or Control Estimate. Expected accuracy for Class 5 estimates typically range from minus 50 percent on the low side to plus 100 percent on the high side, depending on the technological complexity of the project, the reliability of available reference information, and the contingencies used for cost determination.

A combined estimating and construction contingency of 30 percent is used in the estimated construction costs to account for unknown site conditions, design completion level of the project, and bidding climate factors. The total capital costs are developed by adding an allowance of

30 percent to the estimated construction costs to cover planning level activities, environmental reviews, legal, administration, construction services, change orders, and other related items. The following sections describe the estimating procedures used in the analysis for the specific types of facilities under consideration. It should be noted that the original costs identified for the capacity improvement projects in the CAR have been updated to June 2014 dollars to reflect the most recent cost information available in order to facilitate a meaningful comparison between alternatives in this analysis.

Inflow Identification. Smoke testing costs were estimated at a rate of $0.75/LF for field testing and public notification, and $0.50/LF for analysis and project identification. This analysis assumes that the vast majority of inflow reduction projects will be located on private property, and that the cost inflow source disconnection costs will be borne by the property owner. Thus, no improvement costs are included.

Collection System Rehabilitation. Collection system rehabilitation includes manholes, sewer mains, lower laterals, and upper laterals. Recent bid results were used to estimate the collection system rehabilitation costs, which include: mobilization; demobilization; traffic control; normal sheeting, shoring and bracing; excavation and dewatering; erosion, sediment and storm water control; overhead; and profit.

Manhole rehabilitation is assumed to involve the use of applied coating systems. Sewer main rehabilitation is assumed to consist of the replacement of sewers 8-inches in diameter and smaller using pipe bursting construction methods at $15.00 per inch-diameter-foot. Sewers 6-inches in diameter and smaller are assumed to be replaced with a minimum 8-inch diameter sewer. Rehabilitation of sewers larger than 8 inches in diameter is not included.

Lower lateral rehabilitation involves the point of connection to the sewer main as well as the lateral pipe in the public right-of-way or easement. A cleanout is typically installed where the lower lateral connects to the upper lateral. If the home or business is at or below the sewer elevation, a backflow preventer is typically installed near the lateral connection to the building. Lower lateral rehabilitation is assumed to involve replacement of the existing lower lateral pipe with new 4-inch diameter pipe. Upper lateral rehabilitation is assumed to involve replacing the existing upper lateral pipe with new pipe from the point of connection to the lower lateral to within 3 feet of the building. This analysis assumes that upper lateral rehabilitation costs are borne by the City and that upper laterals will be rehabilitated at the same time as lower laterals. This provides significant economy of scale savings over individual private lateral improvements whose costs are borne by the homeowner, requiring contractor mobilization for each individual upper lateral, which can more than double the unit cost of upper lateral rehabilitation.

Storage Facilities. Storage facility costs are based upon similar wet weather storage facilities designed and constructed in Northern California. The costs for storage facilities of different volumes are estimated using the following relationship between cost and capacity: $C_2/C_1 = (S_2/S_1)^R$, where C_1 is the cost of the known facility, S_1 is the size or capacity of the known facility, and S_2 is the size or capacity of the new facility. R typically ranges between 0.6 and 0.75, depending on the facility. For this analysis, we used the more conservative value of 0.6. C_2 is then determined from the relationship: $C_2 = C_1*(S_2/S_1)^{0.6}$.

All storage facilities are assumed to be covered, below-ground storage, with a weir/diversion structure to divert flow into storage, a pump station to return flow to the WPCP, odor control equipment, and associated yard piping. Costs for land acquisition were included at $1,000,000 per acre.

Gravity Sewer Capacity Upgrades. Gravity sewer unit costs are based on an evaluation of recent bid tabs for shallow open-cut construction, and are estimated at $18.60 per inch-diameter-foot. Costs include: mobilization; demobilization; traffic control; normal sheeting, shoring and bracing; excavation and dewatering; standard manholes at typical intervals; typical surface restoration; erosion, sediment and storm water control; overhead; and profit.

Ongoing Rehabilitation. As noted above, the City currently budgets $1.0 million per year for collection system rehabilitation. This budget covers emergency repairs and some other collection system rehabilitation projects. This analysis assumes the City continues to allocate $1.0 million per year for emergency repairs and other rehabilitation projects independent of the collection system rehabilitation discussed above for RDII reduction. Since this ongoing rehabilitation is primarily structural or maintenance-oriented, no reduction in RDII is projected for Alternative 1. However, Alternatives 2 and 3 assume that these rehabilitation funds are being concentrated on area-wide rehabilitation for the purposes of RDII reduction in the sub-basins listed in Table 6 and Table 7.

Madrone PS and Force Main. Recent bid results were analyzed and used to develop the planning level cost estimates provided in Appendix D.

7.5 Economic Analysis

Table 8 shows a summary of the economic analysis of the four alternatives, based upon the capital cost assumptions described above. As shown in the table, the total costs for Alternative 1B and Alternative 3 are nearly equal. Alternative 1A is approximately 12 percent more expensive than alternative 1B, based primarily upon the relocation of the Madrone Pump Station in Alternative 1A. Alternative 2 is 90 percent more expensive than Alternative 1B and Alternative 3 due to the large amount of rehabilitation required in this public rehabilitation only option.

Table 8. Economic Analysis Results[a]

	Unit	$/Unit	Alternative 1A: CAR Capacity Projects with No RDII Reduction		Alternative 1B: Revised Capacity Projects with No RDI/I Reduction		Alternative 2: RDI/I Reduction in Public Infrastructure		Alternative 3: RDI/I Reduction Private & Public Infrastructure	
			QTY	Total	QTY	Total	QTY	Total	QTY	Total
Rainfall-Dependent Inflow/Infiltration Reduction - Consent Decree Compliance Through Flow Reduction										
Collection System Rehabilitation										
Manhole Rehabilitation	EA	$5,500	-	$0	-	$0	745	$4,098,000	280	$1,540,000
Lower Lateral Replacement	EA	$4,400	-	$0	-	$0	3,383	$14,885,000	-	$0
Upper & Lower Lateral Replacement	EA	$6,050	-	$0	-	$0	-	$0	1,383	$8,367,000
8-inch Rehabilitation	LF	$110	-	$0	-	$0	142,029	$15,623,000	55,782	$6,136,000
Capacity Enhancement - Consent Decree Compliance Through Increased Capacity										
Madrone Pump Station Improvements										
Downsize Madrone & New PS	LS	$4,723,000	1	$4,723,000	-	$0	-	$0	-	$0
Upsize to 6.5 mgd	LS	$1,115,000	-	$0	1	$1,115,000	-	$0	-	$0
Upsize to 5.0 mgd	LS	$960,000	-	$0	-	$0	1	$960,000	1	$960,000
Madrone Forcemain Improvements										
Parallel 14-inch Forcemain	LF	$231	-	$0	4,900	$1,132,000	-	$0	-	$0
WWTP Storage Basin										
0.9 MG	LS	$4,900,000	1	$4,900,000	1	$4,900,000	-	$0	-	$0
Land	AC	$1,000,000	0.6	$600,000	0.6	$600,000	-	$0	-	$0
Gravity Sewer Capacity Improvements										
Normal Remove & Replace										
8-inch	LF	$137	326	$45,000	326	$45,000	-	$0	-	$0
10-inch	LF	$172	1,212	$208,000	1,212	$208,000	2,086	$359,000	2,086	$359,000
12-inch	LF	$206	6,890	$1,419,000	6,890	$1,419,000	2,893	$596,000	3,398	$700,000
15-inch	LF	$257	-	$0	315	$81,000	413	$106,000	413	$106,000
18-inch	LF	$308	1,370	$422,000	1,370	$422,000	957	$295,000	957	$295,000
21-inch	LF	$360	-	$0	774	$279,000	-	$0	-	$0
33-inch	LF	$565	-	$0	1,652	$933,000		$0		$0
36-inch	LF	$616	1,652	$1,018,000	-	$0	-	$0	-	$0
Jack and Bore										
18-inch	LF	$396	274	$109,000	274	$109,000	274	$109,000	274	$109,000
36-inch	LF	$792	71	$56,000	71	$56,000	-	$0	-	$0
Microtunneling										
12-inch	LF	$264	729	$192,000	729	$192,000	729	$192,000	729	$192,000
18-inch	LF	$396	510	$202,000	1,524	$604,000	-	$0	-	$0
24-inch	LF	$528	2,092	$1,105,000	1,078	$569,000	-	$0	-	$0
Structural 5 Spot Repairs										
6 - 10-inch Spot Repairs	EA	$6,050	126	$762,000	126	$762,000	51	$309,000	90	$545,000
Structural 5 Line Replacements										
8-inch Rehabilitation	LF	$137	3,187	$437,000	3,187	$437,000	1,212	$166,000	2,900	$397,000
Subtotal				**$16,198,000**		**$13,863,000**		**$37,698,000**		**$19,706,000**
Contingency	%	30%		$4,860,000		$4,159,000		$11,310,000		$5,912,000
Construction Subtotal				**$21,058,000**		**$18,022,000**		**$49,008,000**		**$25,618,000**
Design, Admin., CM, etc.	%	30%		$6,318,000		$5,407,000		$14,703,000		$7,686,000
Capital Subtotal				**$27,376,000** [b]		**$23,429,000**		**$63,711,000**		**$33,304,000**
Compliance Validation - Required Planning Projects										
Inflow Identification: Smoke Testing	LF	$1.25	-	$0	-	$0	19,251	$24,000	19,251	$24,000
Validation: Flow Monitoring & Modeling	YR	$130,000	2	$260,000	2	$260,000	10	$1,300,000	7	$910,000
TOTAL - Consent Decree Compliance				**$27,636,000**		**$23,689,000**		**$65,035,000**		**$34,238,000**
Ongoing Collection System Asset Replacement										
Continuous Replacement Capital				**$10,000,000**		**$10,000,000**		**$0**		**$0**
GRAND TOTAL				**$37,636,000**		**$33,689,000**		**$65,035,000**		**$34,238,000**

[a] All costs presented in June 2014 values.

[b] As explained in Section 7.3, the costs presented in the CAR have been updated to reflect the most recent cost information available. The value presented here replaces the value of $21,397,650 presented for the capacity projects in Table ES-3 of the CAR.

7.6 Non-Economic Analysis

Table 9 describes the non-economic factors applied in this alternatives analysis. The application of these factors to the four alternatives under consideration are described below.

Table 9. Non-Economic Factors

Factors	Description
Institutional Issues/Public Acceptance	The ability to locate facilities outside of public rights-of-way, to gain public acceptance, and implement enforcement activities.
Implementation Time	Ability of the alternative to be staged, constructed, and comply with the City's overall schedule.
SSO Reduction	Ability of the alternative to reduce the annual number of SSOs. Wet weather SSOs occur less frequently than maintenance SSOs.
Ease of Operation & Maintenance	Some alternatives renew the aging collection system and have added maintenance benefits.
Longevity/Sustainability	For alternatives that do not include system rehabilitation, RDII rates will continue to increase over time due to the decay of the system. The capacity of facilities built to handle the current RDII levels will be exceeded in the future, prompting another round of investment in larger facilities.

Institutional Issues/Public Acceptance. Work within public rights-of-way or City-owned properties are significantly more desirable than work on private property. Alternative 2 includes construction only within City rights-of-way, and is thus relatively desirable. Alternatives 1A and 1B require the City to acquire a 0.6-acre site near the WPCP and adjacent to trunk sewers carrying large flows, which will be difficult to find and acquire and is thus less desirable than Alternatives 2 or 3. Alternative 3 requires significant policy changes, public outreach, and enforcement to allow work on private property, and is therefore significantly less desirable than Alternatives 1A, 1B, and 2.

Implementation Time. Alternative 1A requires acquiring property for and constructing a wet weather storage facility and a new pump station, and constructing approximately 12 miles of sanitary sewer. At the aggressive installation rate of three miles per year, Alternative 1B may take approximately seven years to implement.

Alternative 1B requires acquiring property for and constructing a wet weather storage facility, upgrading the Madrone PS, and installing approximately 13 miles of sanitary sewers and force mains – including work in environmentally sensitive area of the force main easement. At the aggressive installation rate of three miles per year, Alternative 1 may take approximately eight years to implement.

Alternative 2 involves upgrading the Madrone PS and constructing approximately 29 miles of sanitary sewer within the public right-of-way. Assuming the same installation rate, Alternative 2 may take approximately 12 years to implement.

Alternative 3 includes upgrading the Madrone PS and constructing approximately 12 miles of sanitary sewers plus upper laterals on private property. Assuming that it may take the City one year to develop and approve a policy to allow the targeted private laterals to be replaced using public funds, Alternative 3 may take approximately several years beyond this time to implement. The actual time to complete the implementation will depend on the actual RDII removal rates achieved by the City. The RDII removal rates depend both on the amount of RDII removed per rehabilitation project completed, and on the number of rehabilitation projects completed, which is a function of the staffing and consultant support available to the City to design, manage, and inspect the rehabilitation projects. The RDII removed each year will be calculated by the flow monitoring/modeling validation process, which will be completed annually. With an expedited approach to policy development, project administration and RDII reduction, it is anticipated that Alternative 3 may be completed in six or fewer years.

SSO Reduction. All four alternatives are expected to reduce the risk of wet weather SSOs from capacity constraints approximately equally. However, the risk of dry weather SSOs due to roots, grease, and debris are significantly reduced after collection system rehabilitation. Thus, Alternatives 2 and 3 are much more desirable than Alternatives 1A and 1B (which have less rehabilitation), and Alternative 2 is more desirable than Alternative 3 because it includes more length of pipe that will be rehabilitated.

Ease of Operation & Maintenance. The more rehabilitation occurs, the easier the system is to operate and maintain. Thus, Alternatives 2 and 3 are generally preferred over Alternative 1A and Alternative 1B based on this criterion. Alternative 1A adds an additional pump station facility which makes it slightly less desirable than Alternative 1B.

Longevity/Sustainability. The alternatives that do not include RDII reduction (Alternatives 1A and 1B) are ranked lower in longevity, because RDII will increase over time if not addressed creating further capacity problems and the capacity solutions developed today will become outdated over time as flows continue to increase. Similarly, alternatives that do not include RDII reduction measures are considered less sustainable due to the fact that conveying and treating RDII is less efficient in terms of both energy and capital expenditure than improving the collection system to reduce RDII. Therefore, Alternatives 2 and 3 are much more desirable than Alternatives 1A and 1B, and Alternative 3 is slightly more desirable since it includes private lateral improvements which have the highest risk of contributing more RDII (with higher peaks) to the system in the future.

The non-economic analysis of each alternative based upon the factors described above was performed using the screening matrix shown in Table 10 Decision factor importance weights were developed by the pairwise comparison method described in Appendix E. Ratings for each alternative are provided as a relative comparison to the other alternatives. Rating values range from 1 (least desirable) to 5 (most desirable).

Table 10. Non-Economic Analysis

Alignment Alternative	Factor										
	Institutional Issues/Public Acceptance		Implementation Time		SSO Reduction		Ease of Operation & Maintenance		Longevity/ Sustainability		Total Weighted Rating - Higher Value Preferred
Factor Importance Weight:	6		6		9		7		10		
R = Rating and **WR** = Weighted Rating:	R	WR	R	WR	R	WR	R	WR	R	WR	WR
Alternative 1A: CAR Capacity Upgrade Recommendations with No RDII Reduction	3	**18**	5	**30**	1	**9**	1	**7**	1	**10**	**74**
Alternative 1B: Revised Capacity Upgrade Recommendations with No RDII Reduction	3	**18**	4	**24**	1	**9**	2	**14**	1	**10**	**75**
Alternative 2: RDII Reduction in Public Infrastructure	5	**30**	1	**6**	5	**45**	5	**35**	4	**40**	**156**
Alternative 3 : RDII Reduction in Public and Private Infrastructure	1	**6**	5	**30**	4	**36**	4	**28**	5	**50**	**150**

Note: Rating values are based on known factors of each Alternative. Factor importance weights were developed by the pairwise comparison method described in Appendix E.

7.7 Recommended Alternative Evaluation Criteria

The total planning level costs for Alternatives 1A, 1B, and 3 are nearly identical and well within the margin of error for this planning level cost estimate. Alternative 1A is approximately 12 percent higher than the cost of Alternative 1B and Alternative 3, while the cost of Alternative 2 is nearly double the cost of the two lowest-cost alternatives. Given the similarity of the costs between Alternatives 1A, 1B, and 3, non-economic factors will be used to determine the alternative selected for implementation. Given that Alternative 3 has a much higher non-economic analysis score, Alternative 3 is the selected preferred alternative.

8.0 PREFERRED ALTERNATIVE DEVELOPMENT

This section further develops the preferred alternative identified in Section 7.7 by identifying capital projects and other recommendations, and develops an implementation plan for the City.

8.1 Planning Projects

Four planning projects were identified and are listed below. A detailed cost estimate for each project is included in Appendix G.

8.1.1 Inflow Reduction Program

As a part of the City's ongoing I&I reduction program, the City should develop an Inflow Reduction Program to:

1. Conduct smoke testing during dry summer months,
2. Document and analyze the findings of the smoke testing returns,
3. Recommend and prioritize I&I reduction methods and improvements, and
4. Enforce inflow source disconnections on private property.

8.1.2 Flow and Rainfall Monitoring Program

During the 2014/2015 wet weather season, the City should implement a Flow and Rainfall Monitoring Program with the primary goals of:

1. **Confirming large-basin I&I rates**. Previous flow monitoring and hydraulic modeling studies relied on small-magnitude storm data (often with low levels of soil saturation) to project the design storm conditions summarized in the City's CAR. If adequately-sized storms are captured in 2014/2015, these storms will be used to validate the calibration of the CAR hydraulic model.
2. **Quantifying I&I in sub-basins**. Because of drought conditions occurring during the 2012/2013 and 2013/2014 wet weather seasons, only gross-scale flow monitoring of large basins within the collection system has occurred. To ensure a sustainable cost/benefit ratio for the rehabilitation efforts recommended in the Wet Weather Alternatives Evaluation, more intensive flow monitoring should be performed in 2014/2015 to further prioritize rehabilitation among sub-basins.
3. **Validating RDII reduction efforts**. Due to the inherent variability of weather and ground saturation conditions, it is difficult to quantitatively determine the success of rehabilitation efforts by simply comparing the hydrograph prior to and following rehabilitation (rehab). Instead, a control method approach is necessary to provide flow and rainfall data for comparable sub-basins with similar rainfall patterns to serve as control points for validating RDII reduction efforts. By monitoring pre-rehab and post-rehab flows for a rehab basin and a similar non-rehabilitated control basin, the effects of storm intensity, duration, and ground saturation conditions can be considered. The sub-basins being compared must have similar construction and physical condition and must be near enough to each other to be subject to the same rainfall.

Details of the proposed 2014/2015 Flow Monitoring Program, including flow and rain monitor locations, are provided in a Draft Technical Memorandum located in Appendix F.

8.1.3 Hydraulic Model Update

The existing hydraulic model should be updated periodically to reflect changes in the collection system, including sewer rehabilitation and construction of gravity sewer capacity upgrades. Wet weather flow monitoring data described above should be used to recalibrate the model.

8.1.4 CAR Update

The CAR should be updated or appended with this recommended program.

8.2 Recommended Capital Program

This section outlines the recommended capital improvement program (CIP), proposed implementation plan, and anticipated RDII reduction schedule.

8.2.1 Capital Improvement Program

The recommended CIP consists of RDII reduction projects, capacity upgrades, and sewer repair/replacement projects as summarized in Table 11. Detailed cost estimates for each project are provided in Appendix G.

Table 11. Recommended Program Estimated Capital Cost Summary

Project Name	Total Capital
Rainfall-Dependent Inflow/Infiltration Reduction Capital Projects	
Madrone Sub-basins 1 & 2 Sewer Rehab	$7,181,000
Madrone/Hillcrest Sub-basins 3 Sewer Rehab	$6,812,000
Hillcrest Sub-basin 4 Sewer Rehab	$7,171,000
Hillcrest Sub-basins 1 & 2 Sewer Rehab	$5,950,000
RDII Reduction Projects CAPITAL TOTAL	*$27,114,000*
Capacity Improvement Projects and Repairs	
Madrone Pump Station Improvements	$1,622,000
Gravity Sewer Capacity Upgrade - Capuchino High School Vicinity	$698,000
Gravity Sewer Capacity Upgrade - Richmond Drive/Anita Drive	$1,076,000
Gravity Sewer Capacity Upgrade - Aviador Avenue and East Millbrae Drive	$683,000
Gravity Sewer Capacity Upgrade - Murchison Avenue	$519,000
Structural 5 Spot Repairs/Line Replacements (6 to 10-inch)	$1,590,000
Capacity Improvement Projects and Repairs CAPITAL TOTAL	*$6,188,000*
ALTERNATIVE 3 RECOMMENDED CAPITAL COST TOTAL	**$33,302,000**

8.2.2 Implementation Plan

In order to complete this large $33M capital cost program, the City will need to adopt an aggressive implementation schedule. The recommended implementation schedule outlined in Table 2 and detailed on Figure 14 is based on the following implementation plan:

Project Packaging and Prioritization. Considerations for developing and prioritizing improvement project packages include:

- Allow for the appropriate planning activities to occur before project design begins – including sub-basin flow monitoring and hydraulic modeling to confirm subbasin priorities for rehabilitation for RDII reduction.
- Construct downstream upgrades first in order to avoid moving potential overflow locations downstream.
- Implement rehab/replacement projects in construction packages of less than three miles of pipe to balance construction impacts on the public with an aggressive construction schedule that allows for multiple construction crews to work simultaneously.
- Implement trunk sewer capacity improvement projects in construction packages of approximately one-half mile of pipe per year to allow for project complexities and reduce traffic impacts.

Staffing and Resources. The implementation schedule in Table 2 and Figure 14 shows the City managing three to nine contracts for design, construction, or construction management of sanitary sewer projects in any given year for the duration of the program, which appears to exceed existing City resources and staff capacity. The City will need additional resources to accomplish the strategic objectives of this program, including influencing and enforcing policy changes, managing the interdependency between multiple projects, and overseeing project managers who perform contract administration to procure and manage multiple project consultants and contractors.

Procurement Procedures. The volume of contracts involved in this implementation plan will significantly increase the administrative workload for City staff, making it difficult to meet the proposed implementation schedule without additional resources. The City should also consider stream-lining procurement processes for design and construction, and/or alternative project delivery methods in order to relieve a portion of the administrative and time burden of advertising for proposals and bids, selecting consultants and awarding bids, and negotiating and initiating contracts.

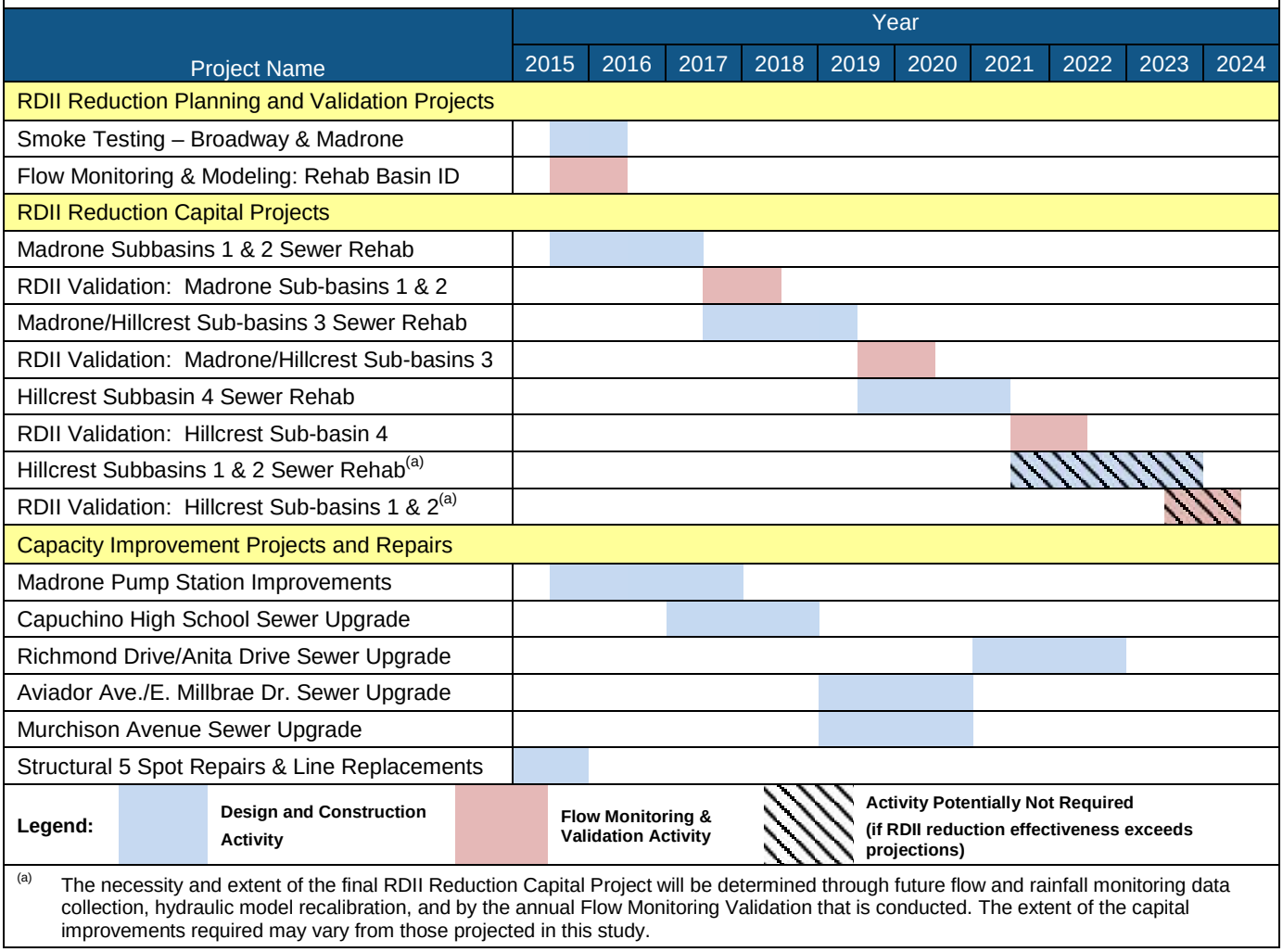
If the City's aggressive implementation schedule can be maintained by implementing the considerations described above, the implementation schedule shown in Table 12 and Figure 14 shows major rehabilitation and construction projects concluding in 2024. If RDII reduction effectiveness exceeds the projected values, some projects may not be needed, and major construction may be concluded earlier.

Table 12. Recommended Program Implementation Schedule (in $1,000)

Project Name	Total Capital	Year									
		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
RDII Reduction Planning and Validation Projects											
Smoke Testing – Broadway & Madrone	*$50*	*$25*	*$25*								
Flow Monitoring & Modeling[(a)]	*$910*	*$150*	*$180*	*$100*	*$160*		*$140*		*$110*		*$70*
RDII Reduction Capital Projects											
Madrone Sub-basins 1 & 2 Sewer Rehab	*$7,181*	*$1,077*	*$3,591*	*$2,513*							
Madrone/Hillcrest Sub-basins 3 Sewer Rehab	*$6,812*			*$1,022*	*$3,406*	*$2,384*					
Hillcrest Sub-basin 4 Sewer Rehab	*$7,172*					*$1,076*	*$3,586*	*$2,510*			
Hillcrest Sub-basins 1 & 2 Sewer Rehab[(a)]	*$5,951*							*$893*	*$2,975*	*$2,083*	
Capacity Improvement Projects and Repairs											
Madrone Pump Station Improvements	*$1,622*	*$300*	*$661*	*$661*							
Capuchino High School Sewer Upgrade	*$698*			*$209*	*$489*						
Richmond Drive/Anita Drive Sewer Upgrade	*$1,076*							*$323*	*$753*		
Aviador Ave./East Millbrae Dr. Sewer Upgrade	*$683*					*$205*	*$478*				
Murchison Avenue Sewer Upgrade	*$519*					*$156*	*$363*				
Structural 5 Spot Repairs & Line Replacements	*$1,400*	*$1,400*									
RECOMMENDED PROGRAM TOTAL	**$34,074**	**$2,952**	**$4,457**	**$4,505**	**$4,055**	**$3,821**	**$4,567**	**$3,726**	**$3,838**	**$2,083**	**$70**

[(b)] The necessity and extent of the final RDII Reduction Capital Project will be determined through future flow and rainfall monitoring data collection, hydraulic model recalibration, and by the annual Flow Monitoring Validation that is conducted. The extent of the capital improvements required may vary from those projected in this study.

Figure 14. Recommended Program Implementation Schedule



(a) The necessity and extent of the final RDII Reduction Capital Project will be determined through future flow and rainfall monitoring data collection, hydraulic model recalibration, and by the annual Flow Monitoring Validation that is conducted. The extent of the capital improvements required may vary from those projected in this study.

8.2.3 RDII Reduction Schedule

As described above, the effectiveness of the RDII Reduction Capital Projects will vary from basin to basin, and the RDII reduction program will be adjusted to account for the true effectiveness measured during each RDII reduction validation period. Because of the varied nature of RDII reduction results achieved in systems similar to this one, the necessity and extent of the RDII Capital Reduction Projects will vary from those projected in this study.

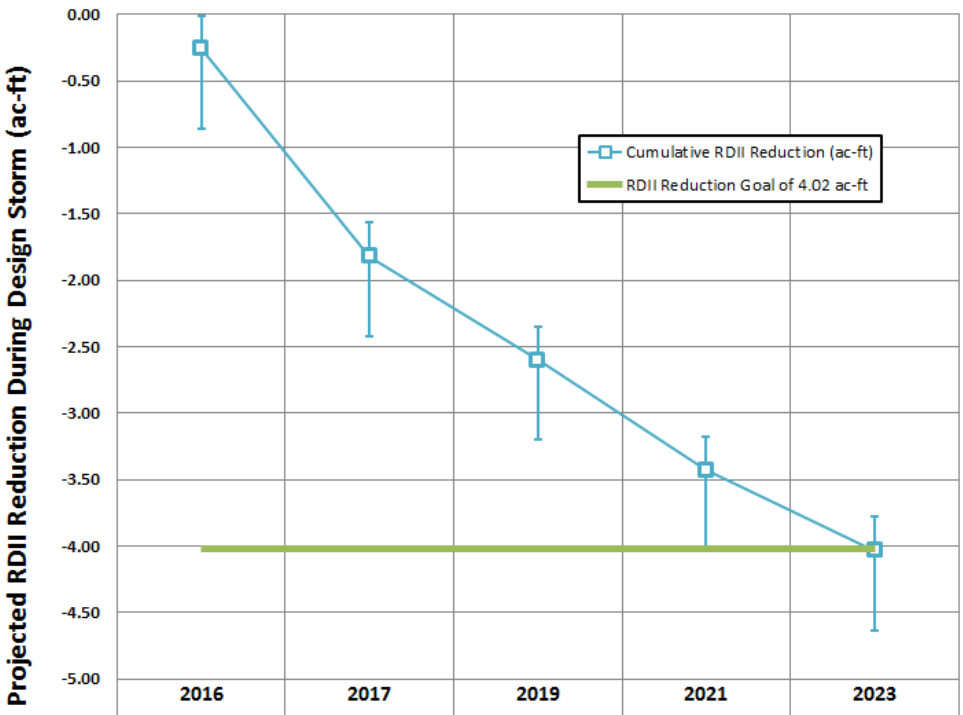
Based on the assumptions presented in the alternatives analysis above, as RDII reduction projects are completed, PWWF in the system will drop. The potential RDII reduction from each project is summarized in Table 13. Figure graphically displays the projected decline in RDII in the City's collection system over time as each RDII reduction project is completed. As described above, the RDII reduction effectiveness may exceed the effectiveness projected in this study, so both the expected and potential reduction is presented on Figure 15.

Table 13. RDII Reduction Projects

Project Name	Project Completion Year	Sub-basin	RDII Reduced, ac-ft	Smoke Testing, LF	Rehabilitation		
					Manholes, Qty	Laterals, Qty	Mains, LF
Phase 1 Smoke Testing (Madrone 8 & Broadway 4)	2016	Madrone 8	0.12	7,353	-	-	-
		Broadway 4	0.14	11,898	-	-	-
		Project Total	**0.26**	**19,251**	-	-	-
Madrone Sub-basins 1 & 2 Sewer Rehab	2017	Madrone 1	0.83	-	34	198	7,676
		Madrone 2	0.73	-	37	169	7,213
		Project Total	**1.56**	-	**71**	**367**	**14,889**
Madrone & Hillcrest Sub-basins 3 Sewer Rehab	2018	Madrone 3	0.39	-	37	118	5,736
		Hillcrest 3	0.39	-	36	242	7,459
		Project Total	**0.78**	-	**73**	**360**	**13,195**
Hillcrest Sub-basin 4 Sewer Rehab[(a)]	2019	Hillcrest 4 **Project Total**	**0.83**	**-**	**82**	**338**	**15,883**
Hillcrest Sub-basins 1 & 2 Sewer Rehab[(a)]	2020	Hillcrest 1	0.29	-	27	155	5,716
		Hillcrest 2	0.31	-	27	163	6,099
		Project Total	**0.60**	-	**54**	**318**	**11,815**
GRAND TOTAL			**4.03**	**19,251**	**280**	**1,383**	**55,782**

[(a)] The necessity and extent of the final two RDII Reduction Capital Projects will be determined through future flow and rainfall monitoring data collection, hydraulic model recalibration, and by the annual Flow Monitoring Validation that is conducted. The extent of the capital improvements required may vary from those projected in this study.

Figure 15. RDII Reduction Schedule



	2016 Phase 1 Smoke Testing	2017 Madrone Subbasins 1 & 2 Sewer Rehab	2019 Madrone & Hillcrest Subbasins 3 Sewer Rehab	2021 Hillcrest Subbasin 4 Sewer Rehab	2023 Hillcrest Subbasins 1 & 2 Sewer Rehab(a)
Cumulative RDII Reduction (ac-ft)	-0.26	-1.82	-2.60	-3.43	-4.03
RDII Reduction Goal of 4.02 ac-ft	-4.02	-4.02	-4.02	-4.02	-4.02

(a) The necessity and extent of the final RDII Reduction Capital Project will be determined through future flow and rainfall monitoring data collection, hydraulic model recalibration, and by the annual Flow Monitoring Validation. The extent of the capital improvements required may vary from those projected in this study.

8.3 Other Recommendations

Other recommendations were developed during the course of this analysis, and are listed below.

8.3.1 Private Lateral Rehabilitation Program

The City should expand its efforts to control and reduce RDII by implementing a rigorous private lateral inspection and rehab program. RDII from private laterals has been found to account for approximately 50 percent of the total RDII in several Bay Area cities. A program to inspect and rehabilitate private service laterals can provide on-going RDII control at low cost to the City.

8.3.2 Collection System Rehabilitation

The City should continue its sewer rehabilitation program. This program is focused on structural and maintenance problems in the collection system. Addressing these problems reduces the risk of SSOs and can reduce RDII.

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APPENDIX A

Collection System Inventory

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Appendix A. Collection System Asset Inventory

Basin	Subbasin	Total Length of Sewer Mains										Total No. of Manholes	Total No. of Laterals
		6"	8"	10"	12"	14"	15"	16"	18"	33"	Total		
Madrone	1	7,676	-	-	-	-	-	-	-	-	7,676	34	198
	2	7,213	-	-	-	-	-	-	-	-	7,213	37	169
	3	5,736	-	-	-	-	-	-	-	-	5,736	37	118
	4	8,306	-	1,995	-	-	-	-	-	-	10,301	50	207
	5	3,589	1,103	-	134	-	-	-	-	-	4,826	25	93
	6	9,818	1,721	-	545	-	-	749	-	-	12,833	69	245
	7	3,686	774	-	-	-	-	-	-	-	4,460	34	61
	8	4,667	1,658	-	-	-	-	130	898	-	7,353	44	96
	9	5,608	218	-	-	-	-	-	-	-	5,826	24	158
	HS	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**56,299**	**5,474**	**1,995**	**679**	**0**	**0**	**879**	**898**	**0**	**66,224**	**354**	**1345**
Broadway	1	12,505	2,169	-	-	-	-	-	-	-	14,674	87	312
	2	4,017	1,612	839	-	-	-	-	-	-	6,468	29	139
	3	15,098	2,021	3,624	1,532	509	255	486	734	-	24,259	42	68
	4	5,952	2,177	-	601	-	-	2,088	952	128	11,898	122	406
	Total	**37,572**	**7,979**	**4,463**	**2,133**	**509**	**255**	**2,574**	**1,686**	**128**	**57,299**	**280**	**925**
Helen	1	4,838	-	-	-	-	-	-	-	-	4,838	26	129
	2	5,904	2,268	-	-	-	-	-	-	-	8,172	41	204
	3	10,572	-	-	-	-	-	-	-	-	10,572	57	207
	4	14,114	-	-	-	-	-	-	-	-	14,114	60	400
	Total	**35,428**	**2,268**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**37,696**	**184**	**941**
Hillcrest	1	5,426	290	-	1,035	-	-	-	-	-	6,751	27	155
	2	5,117	982	-	-	-	-	-	-	-	6,099	27	163
	3	7,459	-	289	385	-	-	-	294	-	8,427	36	242
	4	13,995	1,888	637	-	-	-	-	-	-	16,520	82	338
	5	9,191	-	-	-	-	-	-	-	-	9,191	58	107
	6	14,677	476	-	-	-	-	-	-	-	15,153	113	225
	7	7,656	-	-	-	-	-	-	-	-	7,656	40	220
	8	10,340	-	-	-	-	-	-	-	-	10,340	70	191
	Total	**73,861**	**3,636**	**926**	**1,420**	**-**	**-**	**-**	**294**	**-**	**80,137**	**453**	**1641**

Appendix A. Collection System Asset Inventory													
Basin	Subbasin	Total Length of Sewer Mains										Total No. of Manholes	Total No. of Laterals
		6"	8"	10"	12"	14"	15"	16"	18"	33"	Total		
Tioga	1	4,620	-	-	-	-	-	-	-	-	4,620	23	119
	2	5,859	-	-	-	-	-	-	-	-	5,859	24	139
	3	7,307	-	-	-	-	-	-	-	-	7,307	52	103
	Total	**17,786**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**17,786**	**99**	**361**
Murchison	**Total**	**41,016**	**466**	**5,240**	**935**	**-**	**1,841**	**-**	**-**	**-**	**49,498**		

APPENDIX B

PACP Structural 5 Defect Repair and Replacement Project

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Appendix B. PACP Structural 5 Defect Repair/Replacement Projects

Basin	Subbasin	Asset ID	Diameter, in	Length, ft	NASCO Quick Rating	Repair/ Replace	Date Completed[(a)]	Project Type	Spot Repairs Remaining (Structural 5 Defects Only)	Length of Pipe Replacement Remaining, ft
Broadway	1	Up 407009 - 407001 Dn	6	113	5142	Repair	12/21/2011	Repair	0	0
	1	Up 409016 - 409015 Dn	6	225	5131	Repair	8/7/2013	Replace	0	0
	1	Up 410047 - 410046 Dn	6	155	5121	Repair			1	0
	1	Up 410058 - 410057 Dn	6	239	5133	Repair			1	0
	1	Up 407016 - 407015 Dn	6	155	5311	Replace			0	155
	2	Up 410099 - 410014 Dn	6	67	5100	Replace			0	67
	2	Up 410034 - 410030 Dn	6	238	5134	Repair			1	0
	2	Up 410036 - 410034 Dn	6	236	5141	Repair			1	0
	2	Up 410027 - 410026 Dn	6	229	5241	Repair			2	0
	2	Up 410008 - 410007 Dn	10	270	5141	Repair			1	0
	2	Up 410019 - 410018 Dn	6	232	5131	Repair	4/13/2012	Repair	0	0
	2	Up 410025 - 410024 Dn	6	158	5131	Repair			1	0
	3	Up 410079 - 410078 Dn	6	310	5134	Repair			1	0
	3	Up 410084 - 410083 Dn	6	68	5121	Replace			0	68
	4	Up 114020 - 114019 Dn	6	355	5131	Repair			1	0
	4	Up 114018 - 114017 Dn	6	364	5138	Repair			1	0
	4	Up 115034 - 115035 Dn	6	290	5141	Repair			1	0
	4	Up 115018 - 115019 Dn	6	317	5142	Repair			1	0
	4	Up 118011 - 114013 Dn	6	388	5221	Repair			2	0
	4	Up 111031 - 111029 Dn	6	211	5221	Repair			2	0
	4	Up 114023 - 114009 Dn	6	293	5123	Repair			1	0
	4	Up 114022 - 114021 Dn	6	427	5331	Repair			3	0
	4	Up 118007 - 114004 Dn	6	467	5121	Repair			1	0
	Broadway Basin Total								**22**	**290**

Appendix B. PACP Structural 5 Defect Repair/Replacement Projects

Basin	Subbasin	Asset ID	Diameter, in	Length, ft	NASCO Quick Rating	Repair/ Replace	Date Completed[(a)]	Project Type	Spot Repairs Remaining (Structural 5 Defects Only)	Length of Pipe Replacement Remaining, ft
Helen	1	Up 508016 - 508017 Dn	6	255	5131	Repair			1	0
	1	Up 508031 - 508032 Dn	6	248	5241	Repair	3/25/2013	Repair	0	0
	2	Up 504016 - 504015 Dn	6	210	5141	Repair			1	0
	3	Up 504001 - 504002 Dn	6	190	5111	Repair			1	0
	3	Up 504006 - 504007 Dn	6	285	5131	Repair			1	0
	3	Up 505004 - 505007 Dn	6	133	5100	Repair			1	0
	3	Up 505008 - 505009 Dn	6	51	5100	Replace			0	51
	3	Up 505011 - 505010 Dn	6	145	5131	Repair			1	0
	3	Up 505040 - 505041 Dn	6	286	5141	Repair			1	0
	4	*No Structural 5 Defects*							0	0
						Helen Basin Total			**7**	**51**
Hillcrest	1	Up 317003 - 317002 Dn	6	188	5100	Repair			1	0
	2	Up 317014 - 317012 Dn	6	330	5132	Repair			1	0
	3	Up 314028 - 314011 Dn	6	241	5241	Repair			2	0
	3	Up 317007 - 314036 Dn	6	472	5100	Repair			1	0
	3	Up 313019 - 313018 Dn	6	178	5231	Replace			0	178
	3	Up 314012 - 314011 Dn	6	410	5241	Repair			2	0
	3	Up 314018 - 314017 Dn	6	429	5135	Repair			1	0
	3	Up 314029 - 314028 Dn	6	246	5242	Repair			2	0
	3	Up 314032 - 314029 Dn	6	296	5141	Repair	3/25/2013	Replace	0	0
	3	Up 318002 - 314005 Dn	6	150	5131	Repair			1	0
	4	Up 313044 - 313043 Dn	6	199	5234	Replace	1/11/2012	Replace	0	0
	4	Up 313104 - 313102 Dn	6	128	5100	Repair	3/25/2013	Replace	0	0
	4	Up 313051 - 313047 Dn	6	174	5123	Repair			1	0
	4	Up 313047 - 313046 Dn	6	149	5132	Repair			1	0
	4	Up 313021 - 313020 Dn	6	359	5141	Repair	2014	Replace	0	0

Appendix B. PACP Structural 5 Defect Repair/Replacement Projects

Basin	Subbasin	Asset ID	Diameter, in	Length, ft	NASCO Quick Rating	Repair/ Replace	Date Completed[(a)]	Project Type	Spot Repairs Remaining (Structural 5 Defects Only)	Length of Pipe Replacement Remaining, ft
	4	Up 313045 - 313044 Dn	6	188	5142	Repair			1	0
	4	Up 313054 - 313053 Dn	6	431	5445	Repair	1/31/2012	Replace	0	0
	4	Up 313105 - 313104 Dn	6	352	5100	Repair			1	0
	4	Up 314016 - 314015 Dn	6	359	5141	Repair	3/25/2013	Replace	0	0
	4	Up 314040 - 314039 Dn	6	219	5131	Repair			1	0
	4	Up 314042 - 314039 Dn	8	311	5241	Repair			2	0
	4	Up 314046 - 314042 Dn	6	393	5131	Repair	4/31/2013	Repair	0	0
	4	Up 314047 - 314046 Dn	6	300	5132	Repair			1	0
	4	Up 314049 - 314042 Dn	8	327	5133	Repair	1/9/2013	Replace	0	0
	5	Up 216017 - 216016 Dn	6	226	5242	Repair			2	0
	5	Up 216011 - 216008 Dn	6	80	5131	Replace			0	80
	5	Up 216018 - 216017 Dn	6	191	5111	Repair			1	0
	5	Up 216019 - 216018 Dn	6	228	5331	Replace			0	228
	5	Up 217012 - 217011 Dn	6	194	5100	Repair			1	0
	5	Up 217013 - 217012 Dn	6	162	5131	Repair			1	0
	5	Up 217014 - 217011 Dn	6	131	5342	Replace			0	131
	6	Up 312047 - 312046 Dn	6	83	5100	Replace	12/21/2011	Repair	0	0
	6	Up 312084 - 312083 Dn	6	116	5100	Repair			1	0
	6	Up 312082 - 312081 Dn	6	144	5100	Repair			1	0
	6	Up 312102 - 312100 Dn	6	168	5100	Repair			1	0
	6	Up 313007 - 313003 Dn	6	43	5121	Replace	2014	Replace	0	0
	6	Up 313008 - 313007 Dn	6	293	5443	Replace			0	293
	7	Up 313119 - 313118 Dn	6	126	5243	Replace			0	126
	7	Up 312024 - 312022 Dn	6	122	5112	Repair			1	0
	7	Up 312028 - 312026 Dn	6	158	5100	Repair	11/16/2011	Repair	0	0
	7	Up 312030 - 312029 Dn	6	68	5131	Replace			0	68

Appendix B. PACP Structural 5 Defect Repair/Replacement Projects

Basin	Subbasin	Asset ID	Diameter, in	Length, ft	NASCO Quick Rating	Repair/ Replace	Date Completed[(a)]	Project Type	Spot Repairs Remaining (Structural 5 Defects Only)	Length of Pipe Replacement Remaining, ft
	7	Up 312039 - 312038 Dn	6	106	5121	Repair	3/25/2013	Replace	0	0
	7	Up 313118 - 313117 Dn	6	217	5143	Repair			1	0
	8	Up 312006 - 312005 Dn	6	240	5132	Repair			1	0
	8	Up 312008 - 312007 Dn	6	140	5100	Repair			1	0
	8	Up 312012 - 312011 Dn	6	94	5111	Replace			0	94
	8	Up 313070 - 313062 Dn	6	133	5144	Repair			1	0
	8	Up 313077 - 313133 Dn	6	171	5143	Repair	12/8/2011	Repair	0	0
	8	Up 313080 - 313079 Dn	6	253	5142	Repair			1	0
	8	Up 313086 - 313085 Dn	6	333	5131	Repair			1	0
	8	Up 313108 - 313107 Dn	6	515	5141	Repair			1	0
	Hillcrest Basin Total								**35**	**1198**
Tioga	1	*No Structural 5 Defects*							0	0
	2	*No Structural 5 Defects*							0	0
	3	Up 512029 - 512028 Dn	6	66	5100	Replace			0	66
	3	Up 512030 - 512029 Dn	6	125	5100	Repair			1	0
	3	Up 512028 - 512026 Dn	6	149	5100	Repair			1	0
	3	Up 512013 - 512012 Dn	6	138	5132	Repair			1	0
	3	Up 512019 - 512018 Dn	6	265	5132	Repair			1	0
	3	Up 512032 - 512031 Dn	6	275	5121	Repair			1	0
	3	Up 512056 - 512019 Dn	6	260	5100	Repair			1	0
	Tioga Basin Total								**6**	**66**

Appendix B. PACP Structural 5 Defect Repair/Replacement Projects

Basin	Subbasin	Asset ID	Diameter, in	Length, ft	NASCO Quick Rating	Repair/ Replace	Date Completed[(a)]	Project Type	Spot Repairs Remaining (Structural 5 Defects Only)	Length of Pipe Replacement Remaining, ft
Madrone	1	Up 601006 - 601007 Dn	6	259	5145	Repair			1	0
	1	Up 602011 - 602010 Dn	6	138	5122	Repair			1	0
	1	Up 603089 - 603088 Dn	6	268	5131	Repair			1	0
	1	Up 603090 - 603089 Dn	6	264	5200	Repair			2	0
	2	Up 603043 - 603044 Dn	6	149	5122	Repair			1	0
	2	Up 602040 - 602039 Dn	6	299	5224	Repair			2	0
	2	Up 602015 - 602014 Dn	6	106	5121	Repair			1	0
	2	Up 602019 - 602013 Dn	6	314	5121	Repair	2014	Replace	0	0
	2	Up 602026 - 602025 Dn	6	262	5131	Repair			1	0
	2	Up 602033 - 602031 Dn	6	394	5141	Repair			1	0
	2	Up 602034 - 602033 Dn	6	247	5100	Repair			1	0
	2	Up 602035 - 602034 Dn	6	109	5200	Replace			0	109
	2	Up 602037 - 602036 Dn	6	137	5100	Repair	11/14/2012	Replace	0	0
	2	Up 602039 - 602019 Dn	6	301	5121	Repair	2014	Replace	0	0
	2	Up 603038 - 603040 Dn	6	333	5144	Repair	2014	Replace	0	0
	3	Up 602043 - 603048 Dn	6	262	5132	Repair			1	0
	3	Up 602047 - 602046 Dn	6	152	5131	Repair			1	0
	3	Up 602049 - 602043 Dn	6	199	5142	Repair			1	0
	3	Up 602056 - 602052 Dn	6	155	5131	Repair			1	0
	3	Up 602093 - 602054 Dn	6	121	5131	Repair			1	0
	3	Up 603048 - 603049 Dn	6	152	5141	Repair	1/31/2012	Replace	0	0
	4	Up 603058 - 603059 Dn	6	108	5111	Repair			1	0
	4	Up 603059 - 603060 Dn	6	118	5111	Repair			1	0
	4	Up 603054 - 603056 Dn	10	119	5223	Replace	2/3/2012	Repair	0	0
	4	Up 602075 - 603031 Dn	6	125	5111	Repair			1	0
	4	Up 602078 - 603020 Dn	6	164	5111	Repair			1	0

Appendix B. PACP Structural 5 Defect Repair/Replacement Projects

Basin	Subbasin	Asset ID	Diameter, in	Length, ft	NASCO Quick Rating	Repair/ Replace	Date Completed[(a)]	Project Type	Spot Repairs Remaining (Structural 5 Defects Only)	Length of Pipe Replacement Remaining, ft
	4	Up 602079 - 602078 Dn	6	205	5142	Repair			1	0
	4	Up 602082 - 602081 Dn	6	147	5232	Replace			0	147
	4	Up 602083 - 602082 Dn	6	122	5142	Repair			1	0
	4	Up 602084 - 602083 Dn	6	127	5341	Replace			0	127
	4	Up 602090 - 603016 Dn	6	251	5238	Repair			2	0
	4	Up 603016 - 603017 Dn	6	180	5232	Replace			0	180
	4	Up 603018 - 603020 Dn	6	162	5200	Replace			0	162
	4	Up 603027 - 603028 Dn	6	329	5241	Repair			2	0
	4	Up 603032 - 603033 Dn	6	357	5241	Repair			2	0
	4	Up 603033 - 603034 Dn	6	249	5233	Repair			2	0
	4	Up 603036 - 603037 Dn	6	176	5200	Replace	11/15/2012	Replace	0	0
	4	Up 603037 - 603087 Dn	10	167	5132	Repair			1	0
	5	Up 603070 - 603069 Dn	6	226	5142	Repair			1	0
	6	Up 707073 - 707072 Dn	6	292	5131	Repair			1	0
	6	Up 607071 - 607070 Dn	6	142	5121	Repair			1	0
	6	Up 707053 - 707052 Dn	6	167	5121	Repair			1	0
	6	Up 707059 - 707058 Dn	6	217	5443	Replace	9/10/2012	Repair	0	217
	6	Up 707067 - 707066 Dn	6	214	5131	Repair			1	0
	6	Up 707070 - 707061 Dn	6	125	5141	Repair			1	0
	7	Up 407051 - 707017 Dn	6	300	5232	Repair			2	0
	7	Up 407055 - 407054 Dn	8	117	5111	Repair			1	0
	8	Up 711010 - 711020 Dn	6	54	5241	Replace			0	54
	8	Up 707006 - 707003 Dn	8	210	5100	Repair	5/17/2012	Repair	1	0
	8	Up 711002 - 711004 Dn	6	385	5442	Replace			0	385
	8	Up 711006 - 711008 Dn	8	8	5100	Replace			0	8
	8	Up 711007 - 707006 Dn	8	129	5100	Repair	5/17/2012	Repair	0	0

Appendix B. PACP Structural 5 Defect Repair/Replacement Projects

Basin	Subbasin	Asset ID	Diameter, in	Length, ft	NASCO Quick Rating	Repair/ Replace	Date Completed[(a)]	Project Type	Spot Repairs Remaining (Structural 5 Defects Only)	Length of Pipe Replacement Remaining, ft
	8	Up 711009 - 711008 Dn	6	301	5221	Repair			2	0
	8	Up 711014 - 711013 Dn	6	161	5100	Repair			1	0
	9	Up 111008 - 111009 Dn	6	296	5122	Repair			1	0
	9	Up 111010 - 111011 Dn	6	210	5121	Repair			1	0
	9	Up 111021 - 111022 Dn	6	159	5121	Repair			1	0
	Madrone Basin Total								**48**	**1389**
Murchison		Up 216055 - 219010 Dn	6	301	5232	Repair			2	0
		Up 219052 - 219053 Dn	6	293	5231	Repair	5/29/2013	Replace	0	0
		Up 219057 - 219011 Dn	6	190	5141	Repair			1	0
		Up 220024 - 220025 Dn	6	175	5131	Repair	2/3/2012	Repair	0	0
		Up 220025 - 220026 Dn	6	281	5142	Repair	12/21/2011	Repair	0	0
		Up 220026 - 220027 Dn	6	172	5141	Repair			1	0
		Up 220031 - 220032 Dn	6	269	5141	Repair	7/2/2013	Replace	0	0
		Up 221007 - 221004 Dn	6	269	5100	Repair			1	0
		Up 223004 - 223006 Dn	6	315	5141	Repair			1	0
		Up 223033 - 223034 Dn	6	337	5100	Repair	12/21/2011	Repair	0	0
		Up 223040 - 223010 Dn	6	300	5133	Repair	5/28/2013	Replace	0	0
		Up 224021 - 224022 Dn	6	311	5141	Repair	12/21/2011	Repair	0	0
		Up 224022 - 224023 Dn	6	72	5241	Replace	12/21/2011	Repair	0	72
		Up 224026 - 224027 Dn	6	121	5232	Replace	12/21/2011	Repair	0	121
		Up 224031 - 220040 Dn	6	272	5111	Repair	12/21/2011	Repair	0	0
		Up 220022 - 224027 Dn	6	261	5244	Repair	1/31/2012	Replace	0	0
		Up 224047 - 224049 Dn	10	294	5200	Repair			2	0
	Murchison Basin Total								**8**	**193**

[(a)] Completed repairs found in 2011- 2013 Annual Reports and 2014 Pipe Bursting Project.

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APPENDIX C

Collection System Capacity Upgrades

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Appendix C. Gravity Sewer Capacity Upgrades - Alternative 1A				
Project	Pipe Segment ID	Proposed Diameter, in	Length, ft	Construction Method
Capuchino High School Vicinity	603037-603087	12	167	Remove & Replace
Capuchino High School Vicinity	603087-603086	12	162	Remove & Replace
Capuchino High School Vicinity	603036-603037	12	176	Remove & Replace
Capuchino High School Vicinity	603086-603084	12	419	Remove & Replace
Capuchino High School Vicinity	603084-603064	12	564	Remove & Replace
Capuchino High School Vicinity	607052-607050	15	200	Remove & Replace
Capuchino High School Vicinity	607050-607051	15	150	Remove & Replace
Capuchino High School Vicinity	607051-707045	15	63	Remove & Replace
Capuchino High School Vicinity	603064-603002	15	49	Remove & Replace
Capuchino High School Vicinity	603002-603001	15	79	Remove & Replace
Capuchino High School Vicinity	603001-607053	15	55	Remove & Replace
Capuchino High School Vicinity	607053-607052	15	132	Remove & Replace
Richmond Drive/Anita Drive	410036-410034	10	236	Remove & Replace
Richmond Drive/Anita Drive	410034-410030	10	238	Remove & Replace
Richmond Drive/Anita Drive	410030-410028	10	226	Remove & Replace
Richmond Drive/Anita Drive	410028-410024	10	237	Remove & Replace
Richmond Drive/Anita Drive	410024-410023	10	275	Remove & Replace
Richmond Drive/Anita Drive	410023-410017	10	265	Remove & Replace
Richmond Drive/Anita Drive	410017-410014	10	255	Remove & Replace
Richmond Drive/Anita Drive	410014-410011	10	249	Remove & Replace
Richmond Drive/Anita Drive	410011-410009	10	105	Remove & Replace
Richmond Drive/Anita Drive	410009-410008	12	265	Microtunneling
Richmond Drive/Anita Drive	410008-410007	12	270	Microtunneling
Richmond Drive/Anita Drive	410061-410098	12	380	Remove & Replace
Richmond Drive/Anita Drive	410098-410007	12	286	Remove & Replace
Richmond Drive/Anita Drive	410064-410063	12	244	Remove & Replace
Richmond Drive/Anita Drive	410063-410062	12	86	Remove & Replace
Richmond Drive/Anita Drive	410062-410061	12	241	Remove & Replace
Madrone PS Upstream	707003-707002	21	91	Remove & Replace
Madrone PS Upstream	707002-707001	21	102	Remove & Replace
Madrone PS Upstream	707001-707088	21	146	Remove & Replace
Madrone PS Upstream	707088-707089	21	174	Remove & Replace
Madrone PS Upstream	707089-707090	21	117	Remove & Replace
Madrone PS Upstream	707090-707091	21	56	Remove & Replace
Madrone PS Upstream	707091-707092	21	50	Remove & Replace
Madrone PS Upstream	707092-WetWell	21	38	Remove & Replace
Aviador Avenue and East Millbrae Drive	221021-221026	18	51	Remove & Replace

Appendix C. Gravity Sewer Capacity Upgrades - Alternative 1A				
Project	Pipe Segment ID	Proposed Diameter, in	Length, ft	Construction Method
Aviador Avenue and East Millbrae Drive	221026-221023	18	235	Remove & Replace
Aviador Avenue and East Millbrae Drive	221023-221024	18	137	Remove & Replace
Aviador Avenue and East Millbrae Drive	221024-221030	18	58	Jack & Bore
Aviador Avenue and East Millbrae Drive	221030-115065	18	216	Jack & Bore
Aviador Avenue and East Millbrae Drive	115065-115064	18	290	Remove & Replace
Aviador Avenue and East Millbrae Drive	115064-115063	18	244	Remove & Replace
Murchison Avenue	224052-224063	12	46	Remove & Replace
Murchison Avenue	224063-221001	12	253	Remove & Replace
Murchison Avenue	221001-221002	12	165	Remove & Replace
Murchison Avenue	221002-221041	12	150	Remove & Replace
Murchison Avenue	221041-221042	12	131	Remove & Replace
Murchison Avenue	221042-221064	12	154	Remove & Replace
Murchison Avenue	221064-221010	12	194	Microtunneling
Murchison Avenue	221010-221011	12	253	Remove & Replace
Murchison Avenue	221011-221025	12	92	Remove & Replace
Highline Canal ROW	218002-318012	12	323	Remove & Replace
Highline Canal ROW	318012-318011	12	301	Remove & Replace
Highline Canal ROW	318011-318010	12	152	Remove & Replace
Highline Canal ROW	318009-318006	12	129	Remove & Replace
Highline Canal ROW	318006-318002	12	280	Remove & Replace
Highline Canal ROW	114003-114028	33	216	Remove & Replace
Highline Canal ROW	114028-115071	33	74	Remove & Replace
Highline Canal ROW	115071-115069	33	71	Jack and Bore
Highline Canal ROW	115069-115040	33	143	Remove & Replace
Highline Canal ROW	115040-115068	33	205	Remove & Replace
Highline Canal ROW	115068-115043	33	295	Remove & Replace
Highline Canal ROW	115043-115047	33	429	Remove & Replace
Highline Canal ROW	115047-115053	33	290	Remove & Replace
El Camino Real	410007-410006	18	41	Microtunneling
El Camino Real	410006-410003	18	221	Microtunneling
El Camino Real	410003-410094	18	248	Microtunneling
El Camino Real	410094-114011	18	338	Microtunneling
El Camino Real	114011-114010	18	109	Microtunneling
El Camino Real	114010-114024	18	245	Microtunneling
El Camino Real	114024-114025	18	322	Microtunneling
El Camino Real	114025-114026	24	241	Microtunneling
El Camino Real	114026-114006	24	277	Microtunneling

Appendix C. Gravity Sewer Capacity Upgrades - Alternative 1A				
Project	Pipe Segment ID	Proposed Diameter, in	Length, ft	Construction Method
El Camino Real	114006-114005	24	112	Microtunneling
El Camino Real	114005-114004	24	448	Microtunneling

Appendix C. Gravity Sewer Capacity Upgrades - Alternative 1B				
Project	Pipe Segment ID	Proposed Diameter, in	Length, ft	Construction Method
Capuchino High School Vicinity	603086-603084	12	419	Remove & Replace
Capuchino High School Vicinity	603084-603064	12	564	Remove & Replace
Capuchino High School Vicinity	607052-607050	15	200	Remove & Replace
Capuchino High School Vicinity	607050-607051	15	150	Remove & Replace
Capuchino High School Vicinity	607051-707045	15	63	Remove & Replace
Richmond Drive/Anita Drive	410036-410034	10	236	Remove & Replace
Richmond Drive/Anita Drive	410034-410030	10	238	Remove & Replace
Richmond Drive/Anita Drive	410030-410028	10	226	Remove & Replace
Richmond Drive/Anita Drive	410028-410024	10	237	Remove & Replace
Richmond Drive/Anita Drive	410024-410023	10	275	Remove & Replace
Richmond Drive/Anita Drive	410023-410017	10	265	Remove & Replace
Richmond Drive/Anita Drive	410017-410014	10	255	Remove & Replace
Richmond Drive/Anita Drive	410014-410011	10	249	Remove & Replace
Richmond Drive/Anita Drive	410011-410009	10	105	Remove & Replace
Richmond Drive/Anita Drive	410009-410008	12	265	Microtunneling
Richmond Drive/Anita Drive	410008-410007	12	270	Microtunneling
Richmond Drive/Anita Drive	410061-410098	12	380	Remove & Replace
Richmond Drive/Anita Drive	410098-410007	12	286	Remove & Replace
Richmond Drive/Anita Drive	410064-410063	12	244	Remove & Replace
Richmond Drive/Anita Drive	410063-410062	12	86	Remove & Replace
Richmond Drive/Anita Drive	410062-410061	12	241	Remove & Replace
Aviador Avenue and East Millbrae Drive	221021-221026	18	51	Remove & Replace
Aviador Avenue and East Millbrae Drive	221026-221023	18	235	Remove & Replace
Aviador Avenue and East Millbrae Drive	221023-221024	18	137	Remove & Replace
Aviador Avenue and East Millbrae Drive	221024-221030	18	58	Jack & Bore
Aviador Avenue and East Millbrae Drive	221030-115065	18	216	Jack & Bore
Aviador Avenue and East Millbrae Drive	115065-115064	18	290	Remove & Replace
Aviador Avenue and East Millbrae Drive	115064-115063	18	244	Remove & Replace
Murchison Avenue	224052-224063	12	46	Remove & Replace
Murchison Avenue	224063-221001	12	253	Remove & Replace
Murchison Avenue	221001-221002	12	165	Remove & Replace
Murchison Avenue	221002-221041	12	150	Remove & Replace
Murchison Avenue	221041-221042	12	131	Remove & Replace
Murchison Avenue	221042-221064	12	154	Remove & Replace
Murchison Avenue	221064-221010	12	194	Microtunneling
Murchison Avenue	221010-221011	12	253	Remove & Replace
Murchison Avenue	221011-221025	12	92	Remove & Replace
Highline Canal ROW	218002-318012	12	323	Remove & Replace
Highline Canal ROW	318012-318011	12	301	Remove & Replace
Highline Canal ROW	318011-318010	12	152	Remove & Replace
Highline Canal ROW	318009-318006	12	129	Remove & Replace
Highline Canal ROW	318006-318002	12	280	Remove & Replace
Highline Canal ROW	114003-114028	36	216	Remove & Replace
Highline Canal ROW	114028-115071	36	74	Remove & Replace
Highline Canal ROW	115071-115069	36	71	Jack and Bore

Appendix C. Gravity Sewer Capacity Upgrades - Alternative 1B				
Project	Pipe Segment ID	Proposed Diameter, in	Length, ft	Construction Method
Highline Canal ROW	115069-115040	36	143	Remove & Replace
Highline Canal ROW	115040-115068	36	205	Remove & Replace
Highline Canal ROW	115068-115043	36	295	Remove & Replace
Highline Canal ROW	115043-115047	36	429	Remove & Replace
Highline Canal ROW	115047-115053	36	290	Remove & Replace
El Camino Real	410007-410006	18	41	Microtunneling
El Camino Real	410006-410003	18	221	Microtunneling
El Camino Real	410003-410094	18	248	Microtunneling
El Camino Real	410094-114011	24	338	Microtunneling
El Camino Real	114011-114010	24	109	Microtunneling
El Camino Real	114010-114024	24	245	Microtunneling
El Camino Real	114024-114025	24	322	Microtunneling
El Camino Real	114025-114026	24	241	Microtunneling
El Camino Real	114026-114006	24	277	Microtunneling
El Camino Real	114006-114005	24	112	Microtunneling
El Camino Real	114005-114004	24	448	Microtunneling

Appendix C. Gravity Sewer Capacity Upgrades - Alternative 2 & 3				
Project	Pipe Segment ID	Proposed Diameter, in	Length, ft	Construction Method
Capuchino High School Vicinity	603086-603084	12	419	Remove & Replace
Capuchino High School Vicinity	60384-603064	12	564	Remove & Replace
Capuchino High School Vicinity	607052-607050	15	200	Remove & Replace
Capuchino High School Vicinity	607050-607051	15	150	Remove & Replace
Capuchino High School Vicinity	607051-707045	15	63	Remove & Replace
Richmond Drive/Anita Drive	410036-410034	10	236	Remove & Replace
Richmond Drive/Anita Drive	410034-410030	10	238	Remove & Replace
Richmond Drive/Anita Drive	410030-410028	10	226	Remove & Replace
Richmond Drive/Anita Drive	410028-410024	10	237	Remove & Replace
Richmond Drive/Anita Drive	410024-410023	10	275	Remove & Replace
Richmond Drive/Anita Drive	410023-410017	10	265	Remove & Replace
Richmond Drive/Anita Drive	410017-410014	10	255	Remove & Replace
Richmond Drive/Anita Drive	410014-410011	10	249	Remove & Replace
Richmond Drive/Anita Drive	410011-410009	10	105	Remove & Replace
Richmond Drive/Anita Drive	410009-410008	12	265	Microtunneling
Richmond Drive/Anita Drive	410008-410007	12	270	Microtunneling
Richmond Drive/Anita Drive	410061-410098	12	380	Remove & Replace
Richmond Drive/Anita Drive	410098-410007	12	286	Remove & Replace
Aviador Avenue and East Millbrae Drive	221021-221026	18	51	Remove & Replace
Aviador Avenue and East Millbrae Drive	221026-221023	18	235	Remove & Replace
Aviador Avenue and East Millbrae Drive	221023-221024	18	137	Remove & Replace
Aviador Avenue and East Millbrae Drive	221024-221030	18	58	Jack & Bore
Aviador Avenue and East Millbrae Drive	221030-115065	18	216	Jack & Bore
Aviador Avenue and East Millbrae Drive	115065-115064	18	290	Remove & Replace
Aviador Avenue and East Millbrae Drive	115064-115063	18	244	Remove & Replace
Murchison Avenue	224052-224063	12	46	Remove & Replace
Murchison Avenue	224063-221001	12	253	Remove & Replace
Murchison Avenue	221001-221002	12	165	Remove & Replace
Murchison Avenue	221002-221041	12	150	Remove & Replace
Murchison Avenue	221041-221042	12	131	Remove & Replace
Murchison Avenue	221042-221064	12	154	Remove & Replace
Murchison Avenue	221064-221010	12	194	Microtunneling
Murchison Avenue	221010-221011	12	253	Remove & Replace
Murchison Avenue	221011-221025	12	92	Remove & Replace
Capuchino High School Vicinity	603037-603087	12	167	Remove & Replace
Capuchino High School Vicinity	603087-603086	12	162	Remove & Replace
Capuchino High School Vicinity	603036-603037	12	176	Remove & Replace
Note: Highlighted pipelines are included in Alternative 3 Only				

APPENDIX D

Madrone Pump Station Improvement Costs

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Project: Madrone PS Improvements
Client: City of Millbrae
Planning Level Cost Estimate
5.5 improvements

5 mgd Madrone Improvements						
Division	Item	Quantity	Unit	Unit Cost	Install Adj	Cost
Div 1	General					
	Mobilization/Demobilization, 8%	1	LS	$ 57,000	1.00	$ 57,000
					Division 1 General Subtotal	**$ 57,000**
Div 2	Sitework					
	Bypass Pumping	1	LS	$ 100,000	1.00	$ 100,000
					Division 2 Sitework Subtotal	**$ 100,000**
Div 3	Concrete					
	Wall Modifications	1	LS	$ 25,000	1.00	$ 25,000
					Division 3 Concrete Subtotal	**$ 25,000**
Div 4	Masonry - Not Used					
					Division 4 - Masonry Subtotal	**$ -**
Div 5	Metals - Not Used					
					Division 5 Metals Subtotal	**$ -**
Div 6	Wood and plastics - Not Used					
					Division 6 Wood and Plastics Subtotal	**$ -**
Div 7	Thermal and Moisture Protection - Not Used					
					Division 7 Thermal and Moisture Protection Subtotal	**$ -**
Div 8	Doors and Windows - Not Used					
					Division 8 Doors and Windows Subtotal	**$ -**
Div 9	Finishes					
	Paint	1	LS	$ 5,000	1.00	$ 5,000
					Division 9 - Finishes Subtotal	**$ 5,000**
Div 10	Specialties					
	Warning Signs	3	EA	$ 50	1.00	$ 150
					Division 10 Specialties Subtotal	**$ 150**
Div 11	Equipment					
	60 HP Pumps	3	EA	$ 46,000	1.68	$ 232,000
					Division 11 Equipment Subtotal	**$ 232,000**
Div 12	Furnishings - Not Used					
					Division 12 Furnishings Subtotal	**$ -**
Div 13	Special Construction - Not Used					
					Division 13 Special Construction Subtotal	**$ -**
Div 14	Conveying Systems - Not Used					
					Division 14 Conveying Systems Subtotal	**$ -**
Div 15	Mechanical					
	Demolish Existing Pumps and Suction Piping	1	LS	$ 22,500	1.00	$ 22,500
	12" piping, suction side	1	LS	$ 15,000	1.00	$ 15,000
	12" plug valves	3	EA	$ 2,500	1.50	$ 11,250
	12" elbow	2	EA	$ 1,175	1.50	$ 3,525
	Wall Penetration	3	EA	$ 500	1.50	$ 2,250
	Pipe supports	1	LS	$ 2,500	1.00	$ 2,500
	Restrained Flexible Coupling	3	EA	$ 1,500	1.50	$ 6,750
	Miscellaneous Piping and Appurtenances	1	LS	$ 5,000	1.00	$ 5,000
					Division 15 - Mechanical Subtotal	**$ 69,000**
Div 16	Electrical					
	Main Switchboard	1	LS	$ 10,000	1.00	$ 10,000
	MCC	1	LS	$ 35,000	1.00	$ 35,000
	VFDs	3	EA	$ 19,000	1.68	$ 95,760
	Instrumentation	1	LS	$ 15,000	1.00	$ 15,000
	PLC and SCADA Programming	1	LS	$ 25,000	1.00	$ 25,000
	Site Electrical	1	LS	$ 25,000	1.00	$ 25,000
	Generator, 200 kW	1	LS	$ 75,000	1.00	$ 75,000
					Division 16 - Electrical Subtotal	**$ 270,800**
					Project Subtotal	**$ 759,000**
					Overhead and Profit, 15%	**$ 113,850**
					Adjusted Construction Subtotal	**$ 873,000**

Project: Madrone PS Improvements
Client: City of Millbrae
Planning Level Cost Estimate

6.5 mgd Improvements with 8" FM						
Division	Title	Quantity	Unit	Unit Cost	Install Adj	Cost
Div 1	General					
	Mobilization/Demobilization, 8%	1	LS	$ 120,000	1.00	$ 120,000
					Division 1 General Subtotal	**$ 120,000**
Div 2	Sitework					
	8" parallel FM	4900	LF	$ 120	1.00	$ 588,000
	14 to 6 inter connection vault	1	LS	$ 25,000	1.00	$ 25,000
	Bypass Pumping	1	LS	$ 100,000	1.00	$ 100,000
					Division 2 Sitework Subtotal	**$ 713,000**
Div 3	Concrete					
	Wall Modifications	1	LS	$ 25,000	1.00	$ 25,000
					Division 3 Concrete Subtotal	**$ 25,000**
Div 4	Masonry - Not Used					
					Division 4 - Masonry Subtotal	**$ -**
Div 5	Metals - Not Used					
					Division 5 Metals Subtotal	**$ -**
Div 6	Wood and plastics - Not Used					
					Division 6 Wood and Plastics Subtotal	**$ -**
Div 7	Thermal and Moisture Protection - Not Used					
					Division 7 Thermal and Moisture Protection Subtotal	**$ -**
Div 8	Doors and Windows - Not Used					
					Division 8 Doors and Windows Subtotal	**$ -**
Div 9	Division 9 - Finishes					
	Paint	1	LS	$ 5,000	1.00	$ 5,000
					Division 9 - Finishes Subtotal	**$ 5,000**
Div 10	Specialties					
	Warning Signs	3	EA	$ 50	1.00	$ 150
					Division 10 Specialties Subtotal	**$ 150**
Div 11	Equipment					
	110 HP Pumps	3	EA	$ 56,000	1.68	$ 282,000
					Division 11 Equipment Subtotal	**$ 282,000**
Div 12	Furnishings - Not Used					
					Division 12 Furnishings Subtotal	**$ -**
Div 13	Special Construction - Not Used					
					Division 13 Special Construction Subtotal	**$ -**
Div 14	Conveying Systems - Not Used					
					Division 14 Conveying Systems Subtotal	**$ -**
Div 15	Mechanical					
	Demolish Existing Pumps and Suction Piping	1	LS	$ 22,500	1.00	$ 22,500
	14" piping, suction side	1	LS	$ 20,000	1.00	$ 20,000
	14" plug valves	3	EA	$ 3,500	1.50	$ 15,750
	14" elbow	2	EA	$ 2,500	1.50	$ 7,500
	12" discharge piping	30	LF	$ 800	1.00	$ 24,000
	12" plug valve	3	EA	$ 2,500	1.50	$ 11,250
	12" check valve	3	EA	$ 1,200	1.50	$ 5,400
	12 x 14 Wye	3	EA	$ 2,500	1.50	$ 11,250
	Wall Penetration	3	EA	$ 600	1.50	$ 2,700
	Pipe supports	1	LS	$ 2,500	1.00	$ 2,500
	Restrained Flexible Coupling	3	EA	$ 1,500	1.50	$ 6,750
	Miscellaneous Piping and Appurtenances	1	LS	$ 5,000	1.00	$ 5,000
					Division 15 - Mechanical Subtotal	**$ 135,000**
Div 16	Electrical					
	Main Switchboard	1	LS	$ 10,000	1.00	$ 10,000
	MCC	1	LS	$ 35,000	1.00	$ 35,000
	VFDs	3	EA	$ 25,000	1.68	$ 126,000
	Instrumentation	1	LS	$ 15,000	1.00	$ 15,000
	PLC and SCADA Programming	1	LS	$ 25,000	1.00	$ 25,000
	Site Electrical	1	LS	$ 25,000	1.00	$ 25,000
	Generator, 300 kW	1	LS	$ 100,000	1.00	$ 100,000
					Division 16 - Electrical Subtotal	**$ 336,000**
					Project Subtotal	**$ 1,616,000**
					Overhead and Profit, 15%	**$ 242,400**
					Adjusted Construction Subtotal	**$ 1,858,000**

Project: Madrone PS Improvements
Client: City of Millbrae
'Planning Level Cost Estimate

6.5 mgd Improvements - with 14" FM						
Division	Title	Quantity	Unit	Unit Cost	Install Adj	Cost
Div 1	General					
	Mobilization/Demobilization, 8%	1	LS	$ 148,000	1.00	$ 148,000
					Division 1 General Subtotal	**$ 148,000**
Div 2	Sitework					
	14" parallel FM	4900	LF	$ 210	1.00	$ 1,029,000
	14 to 14 inter connection vault	1	LS	$ 25,000	1.00	$ 25,000
	Bypass Pumping	1	LS	$ 100,000	1.00	$ 100,000
					Division 2 Sitework Subtotal	**$ 1,154,000**
Div 3	Concrete					
	Wall Modifications	1	LS	$ 25,000	1.00	$ 25,000
					Division 3 Concrete Subtotal	**$ 25,000**
Div 4	Masonry - Not Used					
					Division 4 - Masonry Subtotal	**$ -**
Div 5	Metals - Not Used					
					Division 5 Metals Subtotal	**$ -**
Div 6	Wood and plastics - Not Used					
					Division 6 Wood and Plastics Subtotal	**$ -**
Div 7	Thermal and Moisture Protection - Not Used					
					Division 7 Thermal and Moisture Protection Subtotal	**$ -**
Div 8	Doors and Windows - Not Used					
					Division 8 Doors and Windows Subtotal	**$ -**
Div 9	Finishes					
	Paint	1	LS	$ 5,000	1.00	$ 5,000
					Division 9 - Finishes Subtotal	**$ 5,000**
Div 10	Specialties					
	Warning Signs	3	EA	$ 50	1.00	$ 150
					Division 10 Specialties Subtotal	**$ 150**
Div 11	Equipment					
	110 HP Pumps	3	EA	$ 48,000	1.68	$ 242,000
					Division 11 Equipment Subtotal	**$ 242,000**
Div 12	Furnishings - Not Used					
					Division 12 Furnishings Subtotal	**$ -**
Div 13	Special Construction - Not Used					
					Division 13 Special Construction Subtotal	**$ -**
Div 14	Conveying Systems - Not Used					
					Division 14 Conveying Systems Subtotal	**$ -**
Div 15	Mechanical					
	Demolish Existing Pumps and Suction Piping	1	LS	$ 22,500	1.00	$ 22,500
	14" piping, suction side	1	LS	$ 20,000	1.00	$ 20,000
	14" plug valves	3	EA	$ 3,500	1.50	$ 15,750
	14" elbow	2	EA	$ 2,500	1.50	$ 7,500
	12" discharge piping	30	LF	$ 800	1.00	$ 24,000
	12" plug valve	3	EA	$ 2,500	1.50	$ 11,250
	12" check valve	3	EA	$ 1,200	1.50	$ 5,400
	12 x 14 Wye	3	EA	$ 2,500	1.50	$ 11,250
	Wall Penetration	3	EA	$ 600	1.50	$ 2,700
	Pipe supports	1	LS	$ 2,500	1.00	$ 2,500
	Restrained Flexible Coupling	3	EA	$ 1,500	1.50	$ 6,750
	Miscellaneous Piping and Appurtenances	1	LS	$ 5,000	1.00	$ 5,000
					Division 15 - Mechanical Subtotal	**$ 135,000**
Div 16	Electrical					
	Main Switchboard	1	LS	$ 10,000	1.00	$ 10,000
	MCC	1	LS	$ 35,000	1.00	$ 35,000
	VFDs	3	EA	$ 19,000	1.68	$ 95,760
	Instrumentation	1	LS	$ 15,000	1.00	$ 15,000
	PLC and SCADA Programming	1	LS	$ 25,000	1.00	$ 25,000
	Site Electrical	1	LS	$ 25,000	1.00	$ 25,000
	Generator, 200 kW	1	LS	$ 75,000	1.00	$ 75,000
					Division 16 - Electrical Subtotal	**$ 280,800**
					Project Subtotal	**$ 1,990,000**
					Overhead and Profit, 15%	**$ 298,500**
					Adjusted Construction Subtotal	**$ 2,289,000**

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APPENDIX E

Pair-Wise Comparison Method

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Appendix E. Pair-Wise Comparison Method

Pair-Wise Comparison Method:

Used to develop factor importance weights for use in a weighted matrix.

If Factor A is:	Then, Factor A is:	Then, Factor B is:
Much more important than Factor B	5	1
More important than Factor B	4	2
Equal in importance to Factor B	3	3
Less important than Factor B	2	4
Much less important than Factor B	1	5

Pair-Wise Comparison:

Factor vs. Factor	Institutional Issues/ Public Acceptance	Implementation Time	SSO Reduction	Ease of Operation & Maintenance	Longevity/Sustainability	Total	Normalized Weight
Institutional Issues/Public Acceptance	-	2	2	4	2	10	**6**
Implementation Time	4	-	2	4	1	11	**6**
SSO Reduction	4	4	-	5	3	16	**9**
Ease of Operation & Maintenance	2	4	5	-	1	12	**7**
Longevity/Sustainability	4	5	3	5	-	17	**10**

Note: Normalized Totals become the Factor Weights on a scale from 1 to 10, with 10 being the most favorable.

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APPENDIX F

Flow Monitoring Plan

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WEST YOST ASSOCIATES
Consulting Engineers

TECHNICAL MEMORANDUM

DATE: June 24, 2014 Project No.: 478-06-13-03

TO: Khee Lim, City of Millbrae

CC: Sophia Belloli, Hanson Bridgett

FROM: Lani Good, P.E., R.C.E. C73677

REVIEWED: Jon Wells, P.E., R.C.E. C67782

SUBJECT: 2014/2015 Recommended Flow Monitoring Plan

INTRODUCTION

This Technical Memorandum (TM) recommends temporary flow monitor and rain gage locations for data gathering during the 2014/2015 wet weather season in support of the Wet Weather Alternatives Analysis for the City of Millbrae (City).

The data collected will be used to identify and prioritize specific areas of the City's collection system for rehabilitation/replacement in order to reduce rainfall-dependent inflow and infiltration (RDII) as well as to validate the City's RDII reduction efforts.

PREVIOUS FLOW MONITORING

During the winter of 2010/2011, the City contracted with V&A Engineering (V&A) for a wet weather flow monitoring and Inflow/Infiltration study. In the winter of 2010/2011, gross-level flow monitoring data was collected for large basins across the City by installing ten temporary flow monitoring locations and two rain gauges. The results of the study were presented to the City in the *Millbrae Flow Monitoring and I&I Report, August 2011*. This report was used to calibrate the hydraulic model that was used for analyze capacity of the collection system for the City's Capacity Assurance Report (CAR). In 2012/2013, twelve flow monitoring locations were identified. The flow monitors for these studies were generally located to collect validation data for the capacity projects identified in the CAR. However, due to limited precipitation events, this second round of flow monitoring was not conducted.

This flow data captured in the winter of 2010/2011 was of high value in developing and calibrating the hydraulic model for average dry weather flow (ADWF) and peak dry weather flow (PDWF) conditions. However, the precipitation events captured during these studies had

relatively small magnitudes, which added higher levels of imprecision when using this data to project the 10-year, 24-hour design storm.

RECOMMENDED FLOW MONITORING PROGRAM

This section presents the recommended temporary flow monitoring plan for the 2014/2015 wet weather season. The flow monitors and rain gages are estimated to be installed in mid-November, 2014, and will remain in service for a period of approximately 120 days. Flow monitors will be capable of monitoring in surcharge and reverse-flow conditions. The flow and precipitation data will be collected at a 5 minute intervals.

The rainfall and flow monitoring data will be used to:

1. **Confirm large-basin I&I rates**. Previous flow monitoring and hydraulic modeling studies relied on small-magnitude storm data (often with low levels of soil saturation) to project the design storm conditions summarized in the City's 2012 Capacity Assurance Report (CAR). If adequately-sized storms are captured in 2014/2015, these storms will be used to validate the calibration of the CAR hydraulic model.
2. **Quantify I&I in subbasins**. Because of drought conditions occurring during the 2012/2013 and 2013/2014 wet weather seasons, only gross-scale flow monitoring of large basins within the collection system has occurred. To ensure a sustainable cos/benefit ratio for the rehabilitation efforts recommended in the Wet Weather Alternatives Evaluation, more intensive flow monitoring should be performed in 2014/2015 to further prioritize rehabilitation among subbasins.
3. **Validate RDII reduction efforts**. Due to the inherent variability of weather and ground saturation conditions, it is difficult to quantitatively determine the success of rehabilitation efforts by simply comparing the hydrograph prior to and following rehabilitation (rehab). Instead, a control method approach is necessary to provide flow and rainfall data for comparable subbasins with similar rainfall patterns to serve as control points for validating RDII reduction efforts. By monitoring pre-rehab and post-rehab flows for a rehab basin and a similar non-rehabilitated control basin, the effects of storm intensity, duration, and ground saturation conditions can be considered. The subbasins being compared must have similar construction and physical condition and must be near enough to each other to be subject to the same rainfall.

Flow Monitors

West Yost Associates (West Yost) has reviewed the City's previous flow monitoring activities, the June 2014 Wet Weather Alternatives Analysis, and the City's graphic information system (GIS) information to determine appropriate temporary flow monitor locations. The temporary flow monitors will be area-velocity meters and will record wastewater flow data throughout the 2014/22015 wet weather season.

Site Selection Criteria

Temporary flow monitor sites are located to:

- Isolate subbasins with high RDII,

- Identify subbasins for collection system rehabilitation,
- Identify subbasins of similar size and location to serve as control basins for ongoing RDII reduction validation efforts,
- Meet minimum drainage basin size and flow requirements, and
- Avoid interruption from pumping station cycles.

Recommended Locations

The Madrone and Hillcrest basins have been identified as a priority for rehabilitation. Seven subbasins from these areas have been specifically identified for flow monitoring and potential RDII reduction projects in the preferred alternative selected in the Wet Weather Alternatives Analysis. Additional basins have been identified for monitoring to provide RDII information for future planning and for use as control basins in RDII reduction validation efforts. To capture the flow both entering and exiting these subbasins, the seventeen flow monitoring sites will be needed. These recommended flow monitoring locations are described in Table 1 and shown in Figure 1.

Table 1. 2014/2015 Flow Monitoring Sites

Meter Site	Location Description	Manhole ID	Sewer Diameter, in	Notes
1	515 Santa Teresa Way	603089	6	Flow from Madrone Subbasin 1
2	Behind 423 Lomita Ave	603045	6	Flow from Madrone Subbasin 2
3	516 Cypress Ave	603053	6	Flow from Madrone Subbasin 3
4	Alley Behind 195 El Camino Real	318002A	6	Flow from Hillcrest Subbasin 1
5	Millbrae/Elder Intersection	217003	8	Flow from Hillcrest Subbasin 2
6	10 La Cruz Ave	314002	18	Flow from Hillcrest Subbasin 3
7	Barclay/Magnolia Intersection	314013	10	Flow from Hillcrest Subbasin 4
8	861 Taylor Blvd	313051	6	Flow from Hillcrest Subbasin 8 (Probable Control Basin[1])
9	898 Hillcrest Blvd	313106	6	Flow from Hillcrest Subbasin 7
10	900 El Camino Real	410008	10	Flow from Broadway Subbasin 2
11	224 Park Blvd	603037	6	Flow from Madrone Subbasin 4
12	Helen/Lynwood Intersection	504021	6	Flow from Helen Subbasin 4
13	1100 Millbrae Ave	217011	6	Flow from Hillcrest Subbasin 5
14	100 Minorca Way	317024	6	Flow from Hillcrest Subbasin 6 (Probable Control Basin[1])
15	East of Madrone PS	111002	6	Flow from Madrone Subbasin 9
16	540 Helen Dr	508042	8	Flow from Helen Basin
17	Helen/Tioga Intersection	508040	6	Flow from Tioga Basin

Note: [1] Any basin in this phase of flow monitoring that is not rehabilitated may be used as a control basin.

Field investigations of each proposed flow and precipitation monitoring site will be performed at the onset of the program, and field adjustments will be made as necessary, in consultation with the City. The City will provide all permits for conducting the flow monitoring program, locate manholes, provide access to public facilities for rain gauges, and will assist in traffic control if necessary.

Recommended Rain Gauge Locations

Rainfall on the peninsula typically moves from north to south, with higher elevations generally receiving more rainfall than lower elevations. Therefore, temporary rain gages are located in both high and low elevations, and in both north and south basins of the service area.

Rain gages will be tipping buckets with dedicated data loggers. The data loggers will record the time when each 0.01 inch of rainfall occurs at the location of the tipping bucket, and will be checked periodically by field crews during the flow monitoring program.

Site Selection Criteria

Up to four temporary rain gages will be installed in the service area to accurately quantify rainfall during the 2014/2015 wet weather season. The rain gages will be installed at publicly-owned locations on flat roofs in locations suitably open to the elements (with no tree cover) that limit public access and disturbance.

Recommended Locations

The following four rain gauge locations are recommended:

1. Capuchino High School – to capture rain in the flatter portions of the Madrone basin. Madrone Pump Station is an alternate location.
2. Taylor Middle School - to capture rain in the center of the City.
3. Meadows Elementary School - to capture rain in the higher elevations.
4. Potable Water Tank at 450 Skyline Blvd. – one of the sites of the City's potable water distribution system storage tanks may also serve as a fourth potential rain gauge location to capture rainfall in the hills.

FIGURE 1

City of Millbrae
Wet Weather Study and Alternatives Analysis

Proposed Flow Monitoring Locations

Not to Scale

Legend

- Flow Meter
- Rain Gauge
- Manhole
- Pump Station
- Force Main
- Gravity Main
- Streets
- City Boundary
- Subbasin
- Sub-Basins Improved for Alt 2 and Alt 3
- Sub-Basins Improved for Alt 2

WEST YOST ASSOCIATES
Consulting Engineers

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APPENDIX G

Detailed Project Costs

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Appendix G. Alternative 3 Estimated Project Costs				
Project Name and Description	Unit	$/Unit	QTY	Total
Rainfall-Dependent Inflow/Infiltration Reduction Planning Projects				
Smoke Testing - Broadway	LF	$1.25	11,898	$15,000
Smoke Testing - Madrone	LF	$1.25	7,353	$10,000
Flow Monitoring & Modeling	YR	$130,000	7	$910,000
Planning Project Total				**$935,000**
Rainfall-Dependent Inflow/Infiltration Reduction Capital Projects				
Madrone Subbasins 1 & 2 Sewer Rehab				
Manhole Rehabilitation	EA	$5,500	71	$391,000
Upper&Lower Lateral Replacement	EA	$6,050	367	$2,220,000
8-inch Rehabilitation	LF	$110	14,889	$1,638,000
Project Subtotal				*$4,249,000*
30% Contingency				$1,275,000
Construction Subtotal				*$5,524,000*
Design, Admin., CM, etc.(30% of Construction Subtotal)				$1,657,000
Capital Total				**$7,181,000**
Madrone Subbasin 3 Sewer Rehab				
Manhole Rehabilitation	EA	$5,500	73	$402,000
Upper&Lower Lateral Replacement	EA	$6,050	360	$2,178,000
8-inch Rehabilitation	LF	$110	13,195	$1,451,000
Project Subtotal				*$4,031,000*
30% Contingency				$1,209,000
Construction Subtotal				*$5,240,000*
Design, Admin., CM, etc.(30% of Construction Subtotal)				$1,572,000
Capital Total				**$6,812,000**
Hillcrest Subbasin 4 Sewer Rehab				
Manhole Rehabilitation	EA	$5,500	82	$451,000
Upper&Lower Lateral Replacement	EA	$6,050	338	$2,045,000
8-inch Rehabilitation	LF	$110	15,883	$1,747,000
Project Subtotal				*$4,243,000*
30% Contingency				$1,273,000
Construction Subtotal				*$5,516,000*
Design, Admin., CM, etc.(30% of Construction Subtotal)				$1,655,000
Capital Total				**$7,171,000**
Hillcrest Subbasins 1 & 2 Sewer Rehab				
Manhole Rehabilitation	EA	$5,500	54	$297,000
Upper&Lower Lateral Replacement	EA	$6,050	318	$1,924,000
8-inch Rehabilitation	LF	$110	11,815	$1,300,000
Project Subtotal				*$3,521,000*
30% Contingency				$1,056,000
Construction Subtotal				*$4,577,000*
Design, Admin., CM, etc.(30% of Construction Subtotal)				$1,373,000
Capital Total				**$5,950,000**
RDII Reduction Projects CAPITAL TOTAL				**$27,114,000**
Consent Decree Obligation Projects				
Madrone Pump Station Improvements				
Upsize to 5.0 mgd	LS	$960,000	1	*$960,000*
30% Contingency				$288,000
Construction Subtotal				*$1,248,000*
Design, Admin., CM, etc.(30% of Construction Subtotal)				$374,000
Capital Total				**$1,622,000**

Appendix G. Alternative 3 Estimated Project Costs				
Project Name and Description	Unit	$/Unit	QTY	Total
Gravity Sewer Capacity Upgrade - Capuchino High School Vicinity				
12-inch Remove & Replace	LF	$206	1,488	$307,000
15-inch Remove & Replace	LF	$257	413	$106,000
Project Subtotal				*$413,000*
30% Contingency				$124,000
Construction Subtotal				*$537,000*
Design, Admin., CM, etc.(30% of Construction Subtotal)				$161,000
Capital Total				**$698,000**
Gravity Sewer Capacity Upgrade - Richmond Drive/Anita Drive				
10-inch Remove & Replace	LF	$172	2,086	$359,000
12-inch Remove & Replace	LF	$206	666	$137,000
12-inch Microtunneling	LF	$264	535	$141,000
Project Subtotal				*$637,000*
30% Contingency				$191,000
Construction Subtotal				*$828,000*
Design, Admin., CM, etc.(30% of Construction Subtotal)				$248,000
Capital Total				**$1,076,000**
Gravity Sewer Capacity Upgrade - Aviador Avenue and East Millbrae Drive				
18-inch Remove & Replace	LF	$308	957	$295,000
18-inch Jack and Bore	LF	$396	274	$109,000
Project Subtotal				*$404,000*
30% Contingency				$121,000
Construction Subtotal				*$525,000*
Design, Admin., CM, etc.(30% of Construction Subtotal)				$158,000
Capital Total				**$683,000**
Gravity Sewer Capacity Upgrade - Murchison Avenue				
12-inch Remove & Replace	LF	$206	1,244	$256,000
12-inch Microtunneling	LF	$264	194	$51,000
Project Subtotal				*$307,000*
30% Contingency				$92,000
Construction Subtotal				*$399,000*
Design, Admin., CM, etc.(30% of Construction Subtotal)				$120,000
Capital Total				**$519,000**
Structural 5 Spot Repairs (6 to 10-inch)				
Broadway Basin	EA	$6,050	22	$133,000
Helen Basin	EA	$6,050	7	$42,000
Hillcrest Basin	EA	$6,050	16	$97,000
Tioga Basin	EA	$6,050	6	$36,000
Madrone Basin	EA	$6,050	31	$188,000
Murchison Basin	EA	$6,050	8	$48,000
Project Subtotal				*$544,000*
30% Contingency				$163,000
Construction Subtotal				*$707,000*
Design, Admin., CM, etc.(30% of Construction Subtotal)				$212,000
Capital Total				**$919,000**
Structural 5 Line Replacements (8-inch Rehabilitation)				
Broadway Basin	LF	$137	290	$40,000
Helen Basin	LF	$137	51	$7,000
Hillcrest Basin	LF	$137	1,020	$140,000
Tioga Basin	LF	$137	66	$9,000
Madrone Basin	LF	$137	1,280	$175,000
Murchison Basin	LF	$137	193	$26,000

Appendix G. Alternative 3 Estimated Project Costs				
Project Name and Description	Unit	$/Unit	QTY	Total
Project Subtotal				*$397,000*
30% Contingency				$119,000
Construction Subtotal				*$516,000*
Design, Admin., CM, etc.(30% of Construction Subtotal)				$155,000
Capital Total				**$671,000**
Consent Decree Obligation Projects CAPITAL TOTAL				**$6,188,000**
ALTERNATIVE 3 RECOMMENDED PROGRAM TOTAL				**$34,237,000**

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