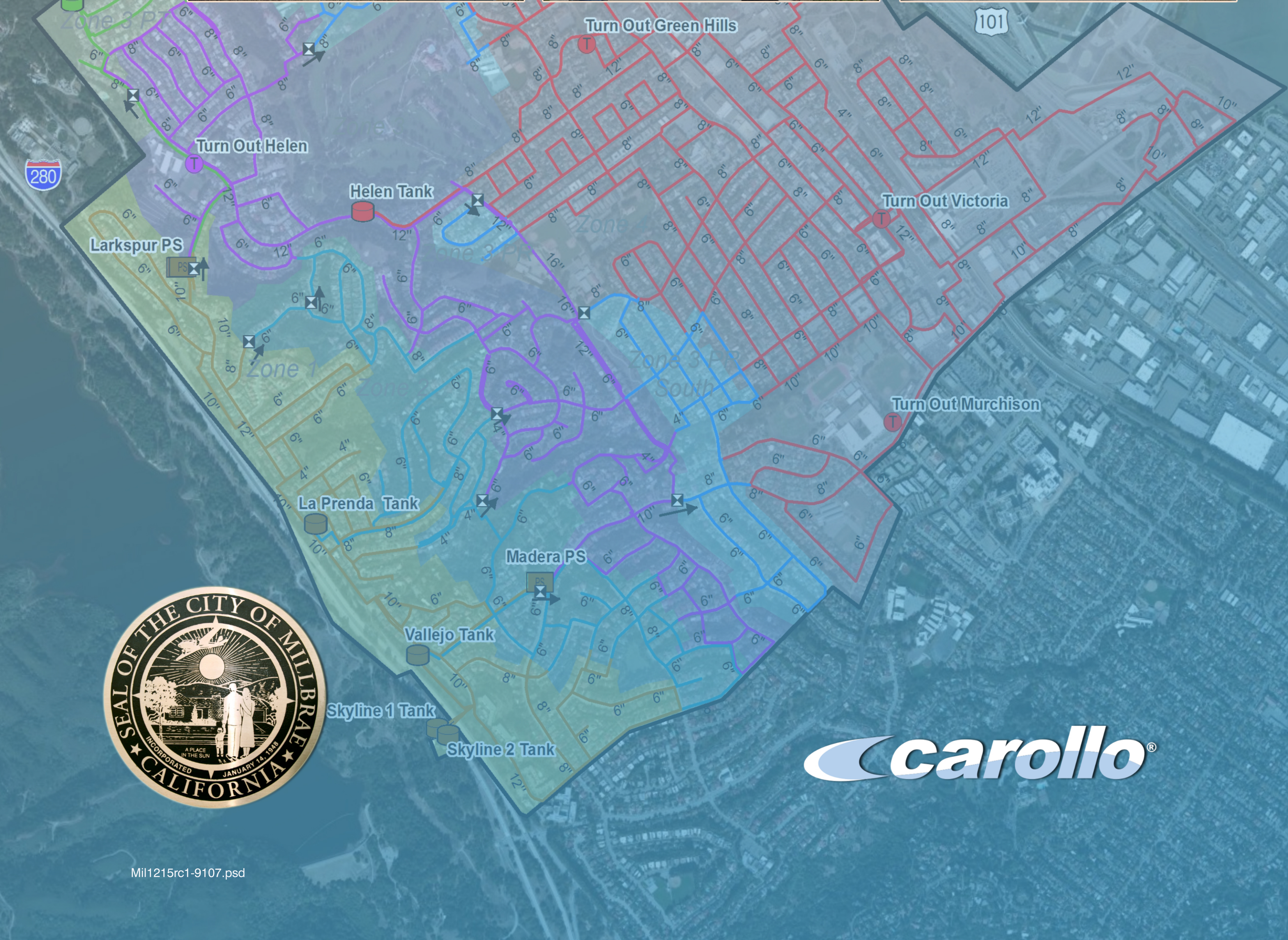
December 2015

# WATER MASTER PLAN
## final report

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12/7/2015

**CITY OF MILLBRAE**

**WATER MASTER PLAN**

**FINAL REPORT**

**DECEMBER 2015**

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**CITY OF MILLBRAE**

**WATER MASTER PLAN – FINAL REPORT**

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| | |
|---|---|
| ABAG | Association of Bay Area Governments |
| AC | Asbestos cement |
| ADD | Average day demand |
| Afy | Acre-feet per year |
| AWWA | American Water Works Association |
| BART | Bay Area Rapid Transit |
| BCA | Boone, Cook & Associates |
| CCF | Hundred cubic feet |
| CDPH | California Department of Public Health |
| CI | Cast iron |
| CIP | Capital improvement plan |
| City | City of Millbrae |
| CP | Concrete pipe |
| DI | Ductile iron |
| ECR | El Camino Real |
| FF | Fire flow |
| FY | Fiscal year |
| fmsl | Feet above mean seal level |
| Fps | Feet per second |
| GALV | Galvanized |
| GI | Galvanized iron |
| gpcd | Gallons per day per capita |
| Gpm | Gallons per minute |
| Gsf | Gallons per square foot |
| GS | Galvanized steel |
| HGL | Hydraulic grade line |
| Hp | Horsepower |
| IDSE | Initial Distribution System Evaluation |
| KJ | Kennedy/Jenks Consultants |
| MDD | Maximum day demand |
| MG | Million gallons |
| Mgd | Million gallons per day |
| MinDD | Minimum day demand |
| MMD | Maximum month demand |
| MSA | Millbrae Station Area |
| MSASP | Millbrae Station Area Specific Plan |
| NA | Not available |
| NC | Normally closed |
| NIS | Not in service |
| NO | Normally open |

| | |
|---|---|
| PG&E | Pacific Gas and Electric Company |
| PHD | Peak hour demand |
| PL | Pressure logger |
| PRV | Pressure reducing valve |
| psi | Pounds per square inch |
| PVC | Polyvinyl chloride |
| RWS | Regional Water System |
| sf | Square foot |
| SFIA | San Francisco International Airport |
| SFPUC | San Francisco Public Utilities Commission |
| SOS | Supply outage scenario |
| TM | Technical Memorandum |
| UFW | Unaccounted-for water |
| USGS | United States Geological Services |
| WMP | Water master plan |
| WS | Wooden stave |
| WTP | Water treatment plant |

# ES.0 EXECUTIVE SUMMARY

## ES.1 Study Area

The City of Millbrae (City) is located on the San Francisco Peninsula, 15 miles south of downtown San Francisco in the county of San Mateo. The City encompasses an area of approximately 3.2 square miles and is bounded on the east by San Francisco International Airport (SFIA) and Bay Shore Freeway, on the south by the City of Burlingame, on the north by the City of San Bruno, and on the west by Interstate 280 and the San Francisco State Fish and Game Refuge, which includes the San Francisco Public Utilities Commission (SFPUC) San Andreas Lake and Reservoir. The study area for this planning document is defined as City's water service area, which is coterminous with the City limits.

## ES.2 Water System Overview

The City's distribution system is divided into four major pressure zones and includes approximately 75 miles of public water mains, 12 pressure reducing valve (PRV) stations, 6 storage tanks, and 2 pump stations. The City serves approximately 6,500 service connections. The water system is supplied through five connections with SFPUC's Regional Water System (RWS).

The City's existing pressure zone boundaries, water mains, and major distribution system facilities are shown on Figure ES.1.

## ES.3 Water Demands

Annual water deliveries from SFPUC in the past ten years are presented on Figure ES.2 (data presented based on a fiscal year). The water serves a range of customer types including single-family homes, multi-family homes, commercial, institutional/government, irrigation, and fire service.

A decreasing trend in water deliveries since fiscal year (FY) 2005-2006 is evident from Figure ES.2. The water deliveries in FYs 2010-2011 and 2011-12 were about the same at nearly 2,400 afy, the lowest amount of water purchased since FY 2002-2003. The City's 2012 Average Day Demand (ADD), which is defined as the total water delivered over the entire year divided by the number of days in the year, was 2.14 million gallons per day (mgd).

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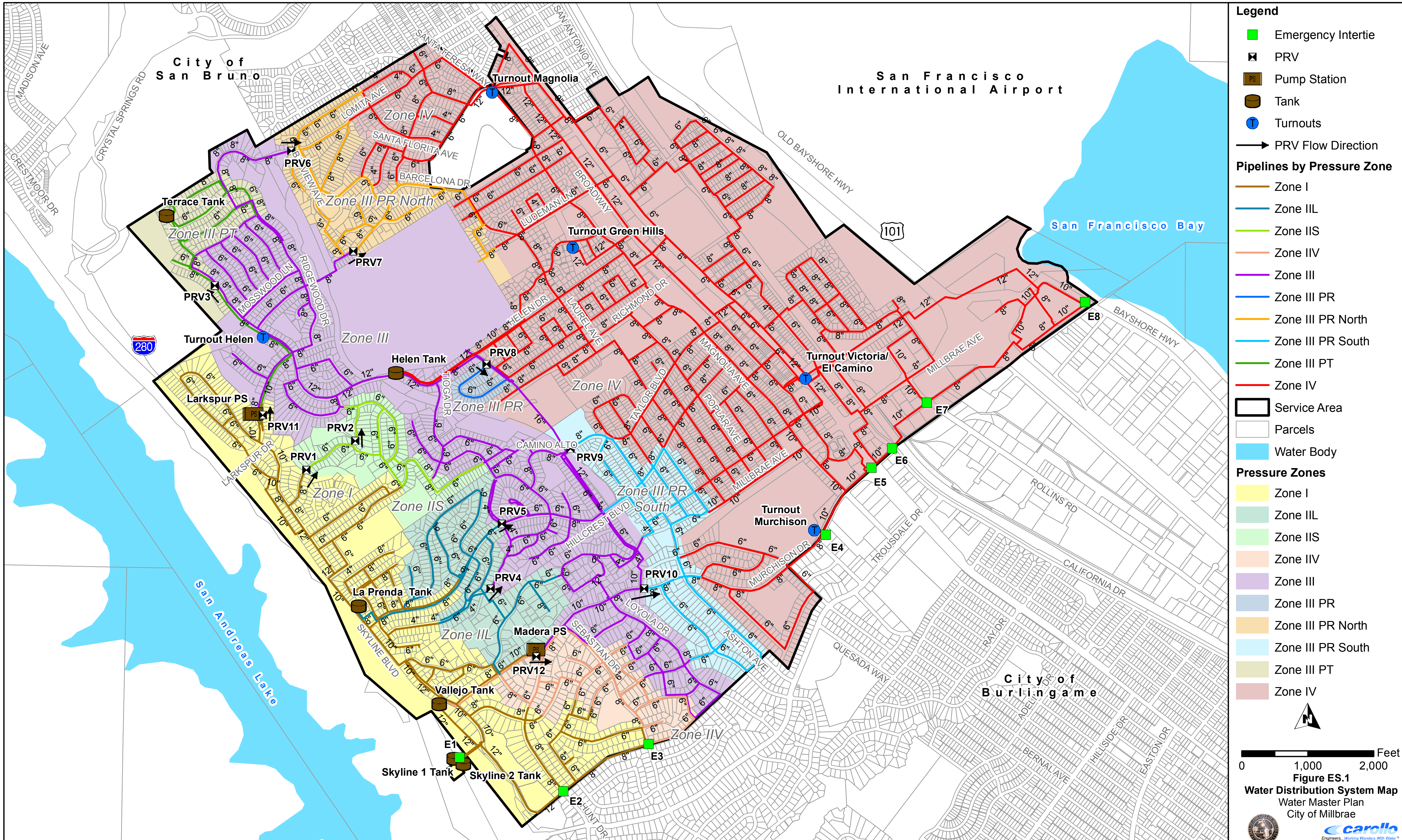

Figure ES.1
Water Distribution System Map
Water Master Plan
City of Millbrae

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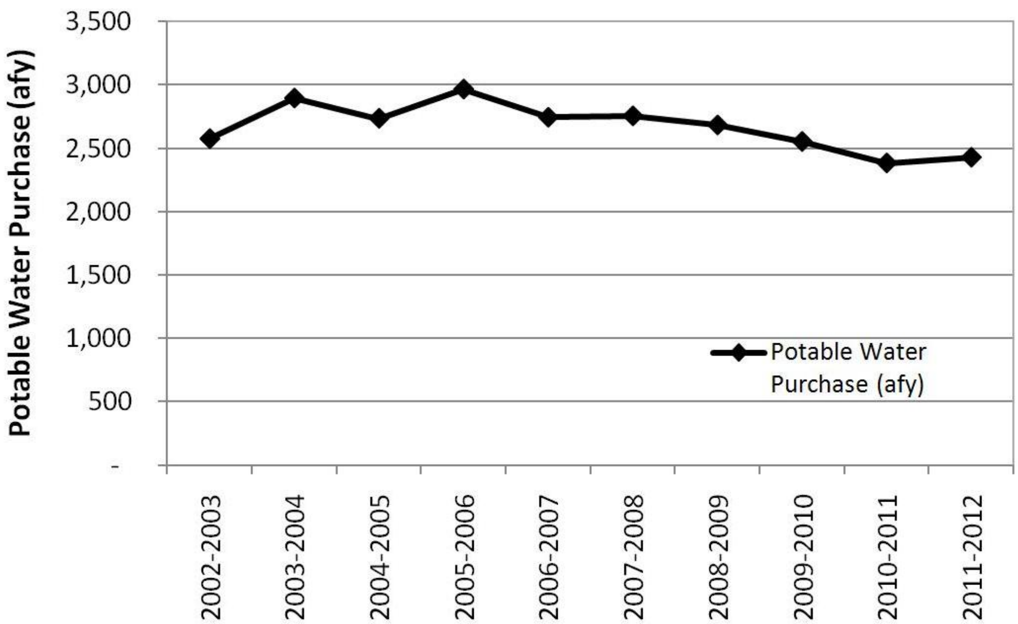


**Figure ES.2 Historical Annual Water Deliveries**

### ES.3.1 Peaking Factors

Peaking factors are used to scale average annual demands to reflect seasonal and hourly demand variations. This is typically accomplished in two steps. First, average annual demands are scaled up to maximum or peak day demands using a 'daily peaking factor' and then to peak hourly demands using an 'hourly peaking factor'. As peaking factors directly affect the sizing of water mains and distribution system facilities, selection of appropriate factors are crucial.

The previous hydraulic model used a maximum day factor of 2.0 for all customer classes. This was the same factor proposed in the 1983 water master plan and appears to be consistent with the typical peaking factors reported for comparable water systems in the same climatic conditions.

Maximum day peaking factors are typically functions of land use and climate. Service areas with high ratio of industrial/commercial to residential, little landscape areas, and cool climate with low evapotranspiration tend to have relatively low peak day consumptions. For the Bay Area, the maximum day peaking factors could range from as low as 1.4 for a diverse land use area with a large industrial component to as high as 2.8 for affluent residential areas with large landscapes. Given Millbrae's residential nature, a high maximum day peaking factor would be expected. However, due to relatively low level of landscapes within residential lots, a mid-range peaking factor of 2.0 appears to be reasonable. Hence, the maximum day peaking factor is estimated to be around 2.0.

The City's hydraulic model includes separate patterns for residential, commercial and irrigation usages. By applying the diurnal patterns to the estimated Maximum Day Demand

(MDD), the Peak Hour Demand (PHD) peaking factor was derived. The seasonal and hourly peaking factors for various categories are summarized in Table ES.1.

**Table ES.1 Summary of Peaking Factors**
**Water Master Plan**
**City of Millbrae**

| Customer Class | Max Day PF | Hourly PF | Combined PF |
|---|---|---|---|
| Residential | 2.0 | 1.66 | 3.32 |
| Commercial (1) | 2.0 | 1.75 | 3.50 |
| Irrigation | 2.0 | 1.82 | 3.64 |

Note:
1. To be applicable to both commercial and institutional/government customer classes.

### ES.3.2 Water Demand Summary

Besides the Millbrae Station Area (MSA), the city does not currently have any formal specific plans for new development or redevelopment in the future or a future land use plan. This coupled with growth uncertainties stemming from the recent economic recession makes accurate demand projections a difficult task. The City's projected water demands include several elements, as described in detail in the main body of this Master Plan. A summary of the existing and future demands are presented in Table ES.2. In addition to the projected average demands, Table ES.2 includes estimates for the ADD, MDD, and PHD through year 2035. Based on these projections, it is anticipated that the City's year 2035 ADD, MDD, and PHD will approach 3.04 mgd, 6.08 mgd, and 9.80 mgd, respectively.

**Table ES.2 Water Demand Summary**
**Water Master Plan**
**City of Millbrae**

| Year | ADD (mgd) | MDD (mgd) | PHD (mgd) |
|---|---|---|---|
| Existing (2012) | 2.14 | 4.28 | 6.85 |
| Future (2035) | 3.04 | 6.08 | 9.80 |

## ES.4 System Evaluation

The capacity analysis of the City's water distribution system consisted of the following:

- **Emergency Improvement Alternatives Analysis:** The City's water distribution system is broken up into two independent systems. Pressure Zone Groups I, II, and III are served by the Harry Tracy Water Treatment Plant (WTP), whereas Zone IV is served by multiple turnouts on the Hetch Hetchy Aqueduct. Pressure Zone Groups I, II, and III are hydraulically disconnected from Zone IV.

Lack of redundant supplies within each of the independent systems is problematic because it makes the City vulnerable to potential outages of the Harry Tracy WTP and/or the Hetch Hetchy aqueduct. The problem is more evident for Zone IV (unlike Pressure Zone Groups I, II, and III), because no storage or receiving intertie with neighboring cities is available for use during emergencies.

Carollo developed and evaluated several emergency improvement alternatives that allow the upper and lower zones to provide supply during an emergency situation where one of the two sources may be out of service. Ultimately, the City selected a hybrid of two alternatives identified in the TM. The main features of the selected emergency improvement alternative are briefly discussed below:

- New Skyline Tank**:** Based on discussion with City staff, it was determined that the Vallejo tank would be eliminated in the future to simplify operations. Furthermore, it was assumed that the Skyline and La Prenda tanks would be replaced in lieu of seismic retrofits. Several options were considered based on these premises, and the City's preferred option was to consolidate all storage at the Skyline Tank site.
- New Transmission Main/PRVs from Skyline Tank: In order to adequately convey water from the new consolidated Skyline Tank to Pressure Zone Groups I, II, III, and IV, 7,000 feet of new transmission main would be constructed along Vallejo Drive, Madera Way, Ashton Avenue, and Millbrae Avenue. Water from the transmission main would enter Pressure Zone Groups II and III through two new PRV stations. Water could be conveyed to Zone IV through a normally closed PRV station in the event of an outage at the Hetch Hetchy Aqueduct. The connection to Zone IV would be at the intersection of Millbrae Avenue and Palm Avenue.
- New Booster Pump Station/Transmission Main: In the event of an outage at the Harry Tracy WTP, a new booster pump station and approximately 900 feet of new transmission main was proposed near the Green Hills Turnout, which would pump water from Zone IV into Pressure Zone Group III. In accordance with the supply outage scenario criteria, the pump station would be sized to provide a firm capacity equal to the future 2035 ADD for Zones I, II, and III (1.31 mgd, or 910 gpm). For reliability purposes, it is recommended that an additional 910 gpm spare pump be installed at this location, for a total capacity of 1,820 gpm. The spare pump could also be used in the event of an outage at the Harry Tracy WTP under MDD conditions.
- PRV Station: A new PRV station was also proposed to provide an additional connection from Pressure Zone Group III to Zone IV. The new PRV station would connect to the existing 10-inch diameter pipeline on Helen Drive.

- **Supply Analysis:** The water supply requirements for the City under existing and future demand conditions were determined by comparing the available water supplies with the projected water demands. This is accomplished by comparing the projected MDD to the reliable water supply capacity for the Pressure Zone Groups with storage (PHDs are met through storage). For pressure zone groups without storage (i.e., Zone IV), the supply capacity must be capable of meeting the PHD.

The supply analysis considers both normal and emergency operating conditions. Based on this analysis, the City will have sufficient supply capacity under normal operating conditions to meet the future (year 2035) demand condition, and to provide for emergency operating conditions after the emergency improvements are constructed.

- **Storage Analysis:** The City currently has four active storage tanks with a combined volume of 2.1 million gallons (MG). The purpose of these tanks are to address three components; (1) operational equalization storage to meet peak hour demands (PHDs), (2) fire flow storage (see ) and (3) emergency storage.
  - Operational Storage: The City's operational storage requirement is estimated to be 1.04 MG and 1.34 MG for existing (2012) and future (2035) demand conditions, respectively.
  - Fire Storage Requirements: The required fire storage is determined based on the single greatest fire flow requirement (flow and duration) within each pressure zone group. The governing land use within is general commercial and public facility with a fire flow requirement of 2,000 gpm for 2 hours resulting in 0.24 MG of fire flow storage.
  - Emergency Storage Requirements: The governing storage requirement for emergency operating conditions is 72-hours of the MinDD outage scenarios govern for the emergency storage requirement. As shown, the Group IV emergency storage requirement (2.4 MG existing, 3.4 MG future) is larger than the combined emergency storage needs of Groups I, II and III (1.8 MG existing, 2.6 MG future). This is key because the recommendations in this Master Plan will use the higher number for sizing of storage tanks for the Emergency Scenarios.

  The storage analysis concluded that the current storage is sufficient to meet future (2035) operational and fire storage needs and that the emergency storage, which is the largest component, creates deficiencies in each pressure zone group. To address emergency deficiencies, several alternative improvements were developed. Based on the results of the seismic evaluation of the City's storage tanks, which concluded that each tank will need to be retrofitted or replaced, and to simplify operations, the City chose to consolidate all storage in the system into a new tank that will be located at the existing Skyline Tanks site. Therefore, it is recommended that the City construct a new 5 MG tank at the site of the existing skyline storage facility. The new reservoir will provide the City with sufficient storage through the year 2035.

- **Distribution System Analysis:** The distribution system analysis consisted of system pressure analysis, fire flow analysis, and pipeline velocity analysis for the City's water distribution system under both existing and future conditions based on the evaluation criteria defined in the main body of the Master Plan. Improvement projects were identified in order to mitigate system deficiencies (primarily for fire flow conditions).

- Booster Pump Stations: In the future system MDD/PHD scenario, the hydraulic model indicates that the City's existing booster pump stations (Madera and Larkspur) may not be able to prevent reservoir draining in the proposed consolidated Skyline Tank when operating under the standard "time-of-use" control strategy. The primary reason for this is that following the implementation of the proposed improvements, more flow will bleed down from Zone I to the lower zones (primarily Zone III) to address low pressure conditions. In order to address this potential issue, the City could either (1) implement a non time-of-use based control strategy during high demand periods, such as the MDD condition, (2) provide additional booster pump capacity at the Larkspur pump station in the future to allow for the continued use of a time-of-use control strategy even during the highest demand periods in the future, or (3) Implement major transmission improvements within Zone III to prevent water from bleeding down into Zone III during high demand conditions.

  For the purposes of this Master Plan, it was assumed that the City would be able to pump during the day for future peak demand conditions, thereby eliminating the need to implement major transmission system improvements in Zone III (which would be difficult to construct) or to upsize the existing booster pump stations.

Figure ES.3 provides a graphical illustration of the improvements recommended to mitigate capacity deficiencies in the existing water system and the improvements to meet future demand as identified by the hydraulic analysis.

### ES.4.1 Project Prioritization

The proposed projects provide the City with a list of improvements that will increase system reliability and correct capacity deficiencies in the distribution system. When fully implemented, the capital projects will enhance the distribution of water during maximum demand conditions through the year 2035.

Prioritizing the required capital improvements for the City's water distribution system is an important aspect of this Master Plan. The improvement projects were prioritized based on the following criteria:

1. Implementing storage and transmission improvements to provide adequate storage volume, to allow for the abandonment of seismically deficient storage tanks, and to allow for the transfer of water from Zones I, II, and III to Zone IV, which is susceptible to supply interruptions in the Hetch Hetchy Aqueduct.
2. Addressing capacity deficient pipelines that are undersized for fire flow demand conditions received the highest priority, and implementing rezoning improvements to address fire flow deficiencies in the high areas of certain pressure zones.
3. Implementing transmission improvements to allow for the movement of water from Zone IV to Zones I, II, and III. These improvements can be phased further out into the future, because the new Skyline Tank will provide emergency storage for Zones I, II, and III. In addition, the City does have emergency interconnections within Zones I, II,

and III that could also be utilized in the event of a supply outage in at the Harry Tracy WTP.

The projects were phased into the following four phases:

- Phase 1: Years 2014 through 2020
- Phase 2: Years 2021 through 2025
- Phase 3: Years 2026 through 2030
- Phase 4: Years 2031 through 2035

Each improvement project was assigned to one of the four phases based on the three project prioritization criteria above. Projects that meet the first prioritization criteria were grouped in the earlier phases, whereas projects that meet the second and third prioritization criteria were grouped in the later phases. The projects shown in Figure ES.4 are color coded according to phase, which reflects their priority

## ES.5 Capital Improvement Plan (CIP)

A summary of the capital project costs is presented in Chapter 8.0 of the Master Plan. Chapter 8.0 provides detailed information related to the projects, a description of the project, identifies facility size, the capital improvement cost, and the recommended phase in which the project would be implemented. The CIPs are prioritized based on their urgency to mitigate existing deficiencies and for servicing anticipated growth.

The implementation phases are separated into 5-year increments. Each project is itemized by phase in Chapter 8.0 and a summary by facility type and phase is provided in Table ES.3. As shown in Table ES.3, the CIP is front loaded in Phase 1 with roughly $10 million dollars worth of CIP projects (over half of the proposed CIP). This is due to the need to construct the new storage tank at Skyline and associated transmission main in the near term.

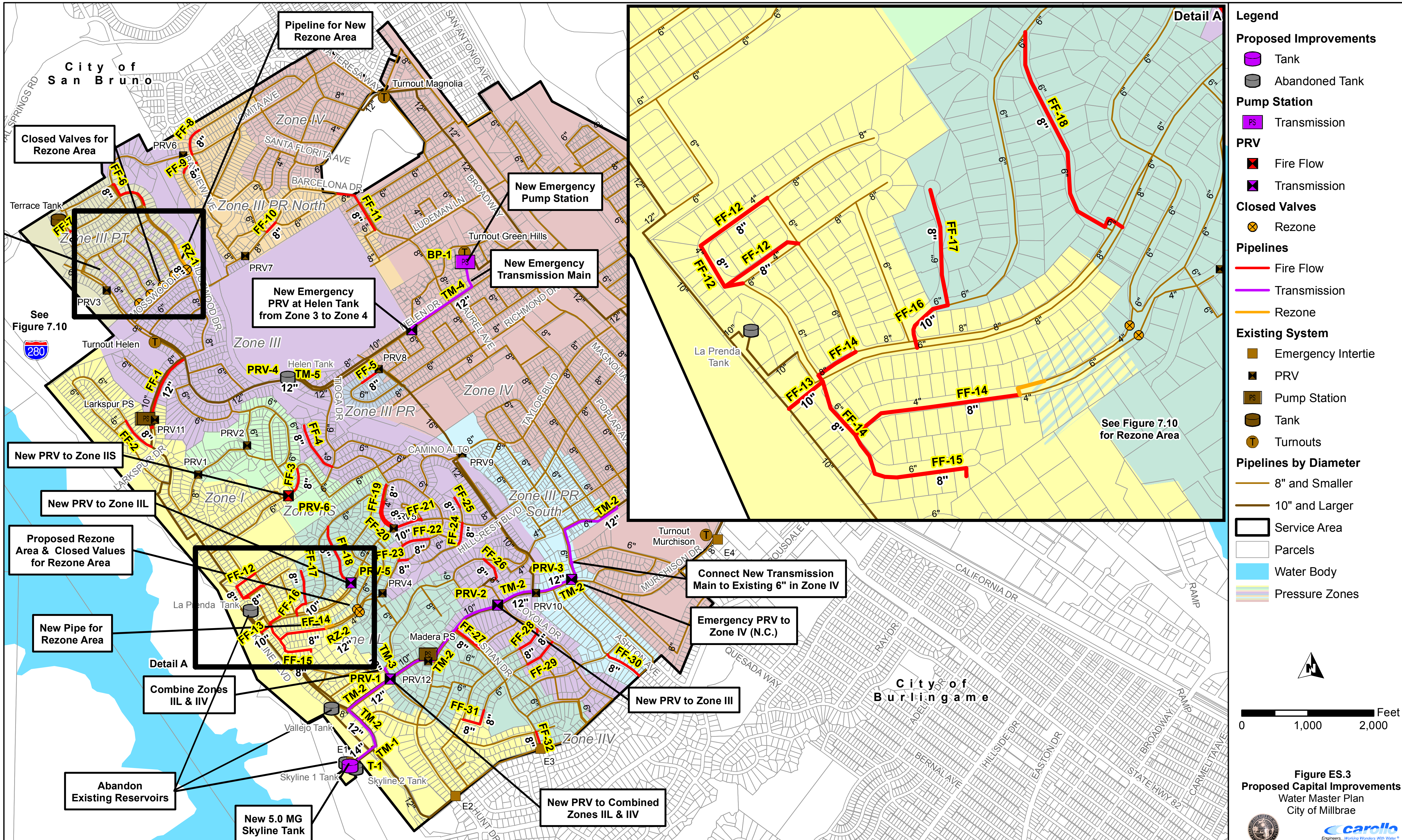


**Figure ES.3**
**Proposed Capital Improvements**
Water Master Plan
City of Millbrae

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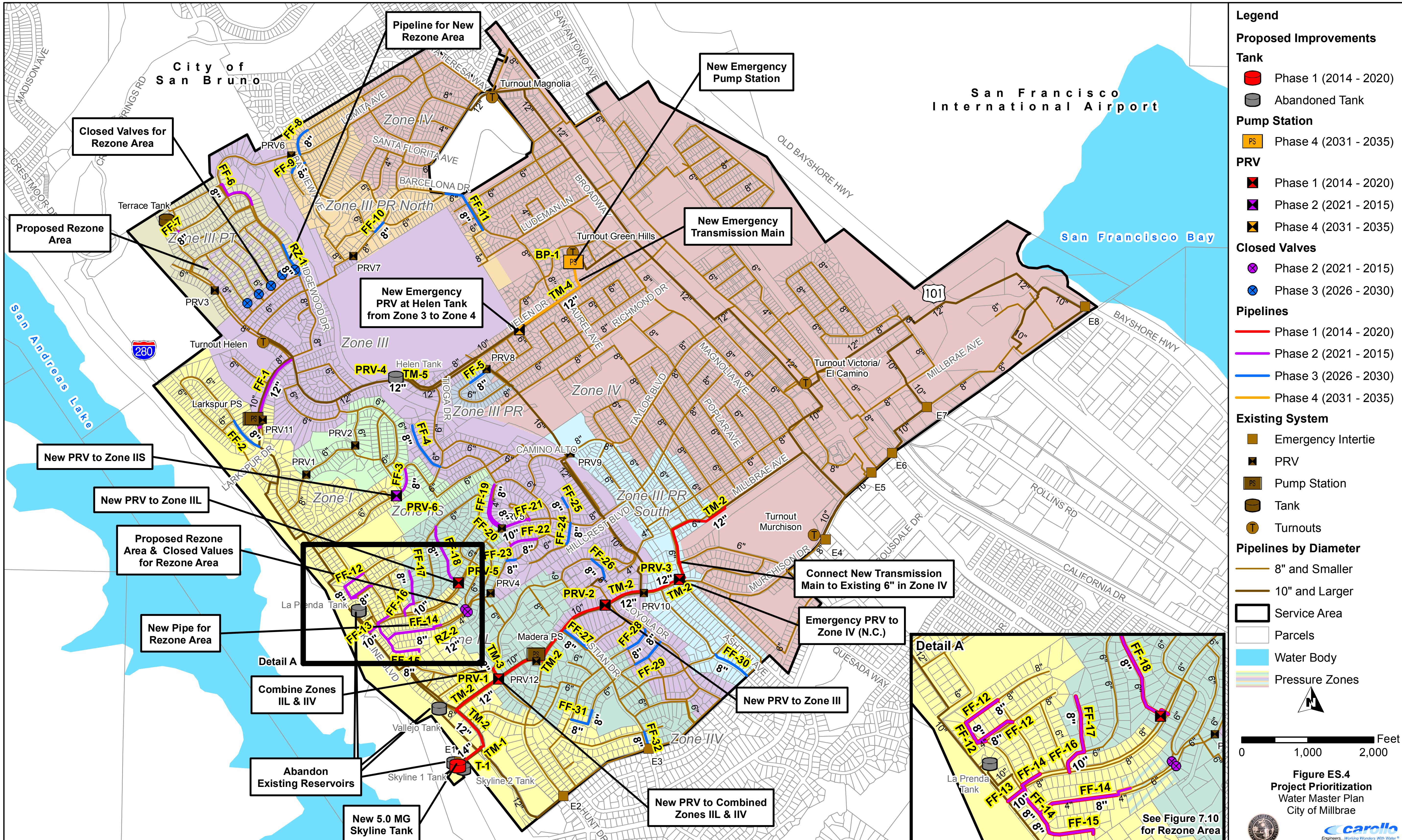


Figure ES.4
Project Prioritization
Water Master Plan
City of Millbrae

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**Table ES.3 Summary of Capital Costs by Phase**
**Water Master Plan**
**City of Millbrae**

| Improvement Type | Implementation Phase 2014-20 ($, mill.) | 2021-25 ($, mill.) | 2026 - 30 ($, mill.) | 2031- 35 ($, mill.) | Total ($, mill.) |
|---|---|---|---|---|---|
| Storage Tank, Booster Pumps, and PRVs | 7.65 | 0.08 | 0.00 | 0.70 | **8.43** |
| Transmission Pipelines | 2.43 | 0.00 | 0.00 | 0.51 | **2.94** |
| Distribution Mains (FF Imp) | 0.00 | 2.57 | 1.95 | 0.00 | **4.52** |
| Rezone Improvements | 0.00 | 0.06 | 0.10 | 0.00 | **0.16** |
| **Total** | **10.08** | **2.71** | **2.05** | **1.21** | **16.06** |

Notes:
1. Costs are based on ENR CCI 20 City average of 9,750 (April 2014).

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# 1.0 INTRODUCTION

## 1.1 Study Area and Background

The City of Millbrae (City) is located on the San Francisco Peninsula, 15 miles south of downtown San Francisco in the county of San Mateo. The City encompasses an area of approximately 3.2 square miles and is bounded on the east by San Francisco International Airport (SFIA) and Bay Shore Freeway, on the south by the City of Burlingame, on the north by the City of San Bruno, and on the west by Interstate 280 and the San Francisco State Fish and Game Refuge, which includes' the San Francisco Public Utilities Commission (SFPUC) San Andreas Lake and Reservoir. The study area for this planning document is defined as City's water service area, which is coterminous with the City limits, as shown on Figure 1.5.

The City was incorporated in San Mateo County in 1948 and has developed into a suburban residential community with a population of 21,532 (2010 US Census). The City's land use is already well established and it is essentially "built-out" with the exception of the Millbrae Station Area development, the area surrounding the Multi-Model Bay Area Rapid Transit (BART)/Caltrain/SamTrans terminal (KJ, 2011). No infill development or other redevelopments are expected to occur in the future. The impacts of Millbrae Station Area development on the City's water demands are estimated as part of this study. The updated demand estimates are used to evaluate the City's water supply needs and the sizing of the City's water system facilities, such as storage and booster stations.

## 1.2 Study Purpose

The City retained Carollo Engineers, Inc. (Carollo) on November 14, 2012 to prepare this Water Master Plan (WMP) to develop a planning guide for upgrading and improving the City's water distribution system and its reliability.

This planning effort included hydraulic model update and validation, system analysis under a range of operating conditions, and seismic evaluation of City's storage tanks. The report concludes with a summary of system recommendations and a capital improvement plan (CIP) that includes planning-level project cost estimates. This document was prepared in collaboration with City staff on various tasks.

This planning document builds upon the previous master plan (BCA, 1983) and the hydraulic model that was developed in or around 2006 as part of Stage 2 Disinfectants and Disinfection Byproducts Rule's Initial Distribution System Evaluation (IDSE) requirement.


**Figure 1.1**
**City of Millbrae Water Service Area (Study Area)**
Water Master Plan
City of Millbrae

## 1.3 Report Organization

This report is divided into the following eight sections, which are briefly described below.

**Section 1: Introduction**. This section provides a description of study area and project background and objectives.

**Section 2: Water Demands**. This section describes historical and future populations, existing and future demands, and peaking factors and diurnal patterns.

**Section 3: Existing System Description**. This section describes the water distribution system including pressure zones, water mains, supply connections, emergency interties, pump stations, storage tanks, and pressure reducing valve stations.

**Section 4: Hydraulic Model Update**. This section provides a discussion of the hydraulic model update and validation.

**Section 5: Evaluation Criteria**. This section provides a description of the recommended criteria for performance evaluation of the City's water distribution system.

**Section 6: Seismic Assessment of Storage Tanks**. This section presents visual observations of storage tanks, seismic evaluation results, and retrofit alternative recommendations. In addition, preliminary cost estimates of the proposed retrofit alternatives are provided.

**Section 7: System Evaluation**. This section presents evaluation results for the water mains, storage tanks, pumping, and pressure reducing valve station capacities to meet future water demands under various normal and emergency operating conditions. The required improvements to address these deficiencies are presented in this section.

**Section 8: CIP**. This section presents cost assumptions and planning-level CIP costs. The recommended projects are summarized and grouped by project type and phasing.

## 1.4 References

Reference documents used for the preparation of this report are listed in Appendix A.

## 1.5 Acknowledgments

Carollo wishes to acknowledge and thank all City staff for their support and assistance in the preparation of this WMP. Special thanks go to:

- Khee Lim, City Engineer.
- Jim Harrington, Public Works Supervisor.
- Craig Centis, Public Works Superintendent.

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# 2.0 WATER DEMANDS

This section describes historical and future populations, historical and future water demands and losses, and peaking factors used for the analysis of the water distribution system.

## 2.1 Historical and Future Populations

Historical populations through 2010 and future projections through 2035 are shown on Figure 2.1. Historical populations are from United States Census Bureau (US Census), while future projections are from Association of Bay Area Governments (ABAG) 2009 projections as presented in the 2010 Urban Water Management Plan (KJ, 2011). This information is also listed in Table 2.1.

As shown, population has grown rapidly since the City's incorporation in 1948 through 1970 and has been relatively flat since 1970. The ABAG projects that the City will grow by about 5,200 people from 2010 to 2035. This is equivalent to an annual growth rate of 0.9 percent. However, the estimated future populations may not be materialized as projected.

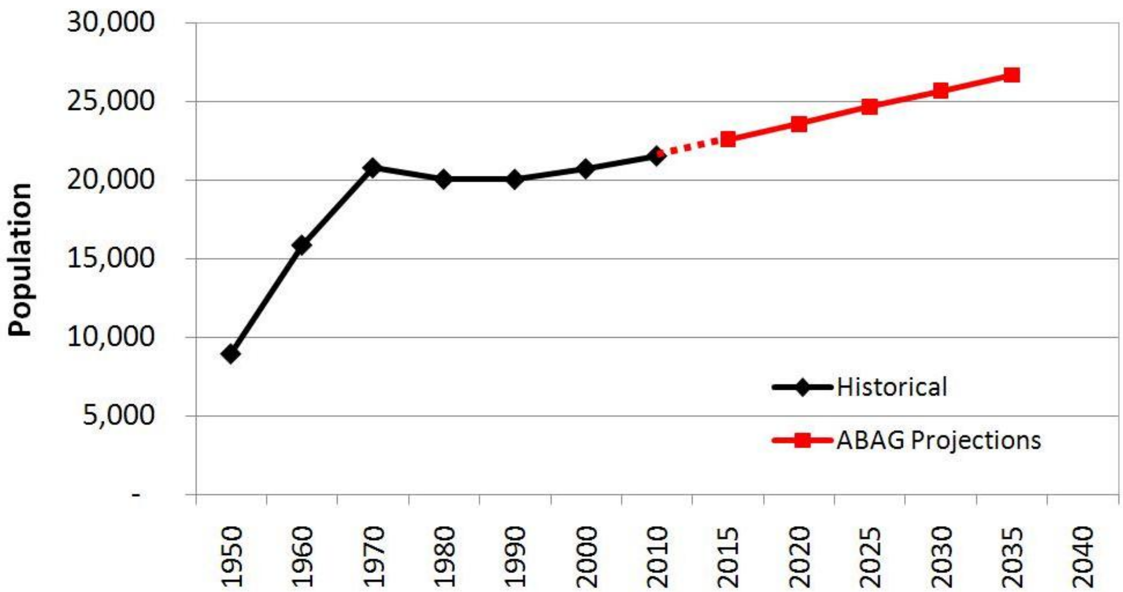



**Figure 2.1 Historical and Future Population Projections by ABAG**

| Table 2.1 | Historical and Future Population Projections<br>Water Master Plan<br>City of Millbrae | |
|---|---|---|
| **Year** | **Population** | **Source** |
| 1950 | 8,972 | 1983 WMP |
| 1960 | 15,873 | 1983 WMP |
| 1970 | 20,781 | 1983 WMP |
| 1980 | 20,058 | 1983 WMP |
| 1990 | 20,048 | US Census |
| 2000 | 20,718 | US Census |
| 2010 | 21,532 | US Census |
| 2015 | 22,600 | ABAG |
| 2020 | 23,600 | ABAG |
| 2025 | 24,700 | ABAG |
| 2030 | 25,700 | ABAG |
| 2035 | 26,700 | ABAG |

## 2.2 Historical Water Demands

Annual water deliveries from SFPUC in the past ten years are presented on Figure 2.2 (data presented based on a fiscal year). The water serves a range of customer types including single-family homes, multi-family homes, commercial, institutional/government, irrigation, and fire service.

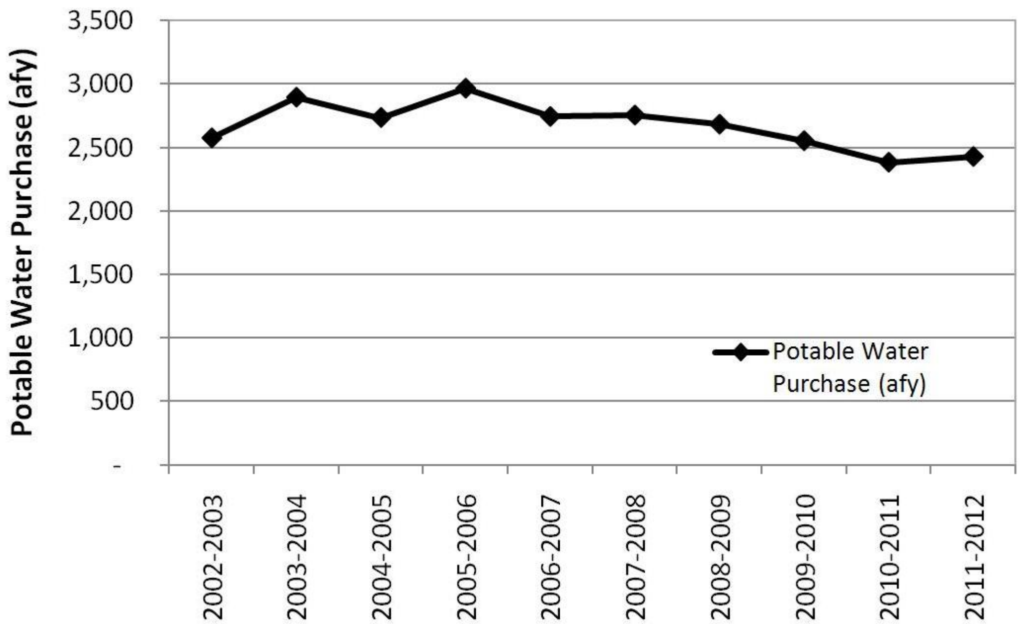



**Figure 2.2 Historical Annual Water Deliveries**

A decreasing trend in water deliveries since fiscal year (FY) 2005-2006 is evident from Figure 2.2. The water deliveries in FYs 2010-2011 and 2011-12 were about the same at nearly 2,400 afy, the lowest amount of water purchased since FY 2002-2003.

The City provided bimonthly billing records for calendar years 2011 and 2012. An analysis of these records of nearly 6,500 connections indicated that the water demands in 2011 and 2012 were 2,241 afy and 2,318 afy, respectively. The breakdown of water demands in 2011 and 2012 by customer class are graphically presented on Figure 2.3. This information is also listed in Table 2.2.

As shown, the residential demands including single and multi families made up the majority of the total demands at nearly 72 percent. Commercial and institutional/government demands made up approximately 16 and 4 percents, respectively.

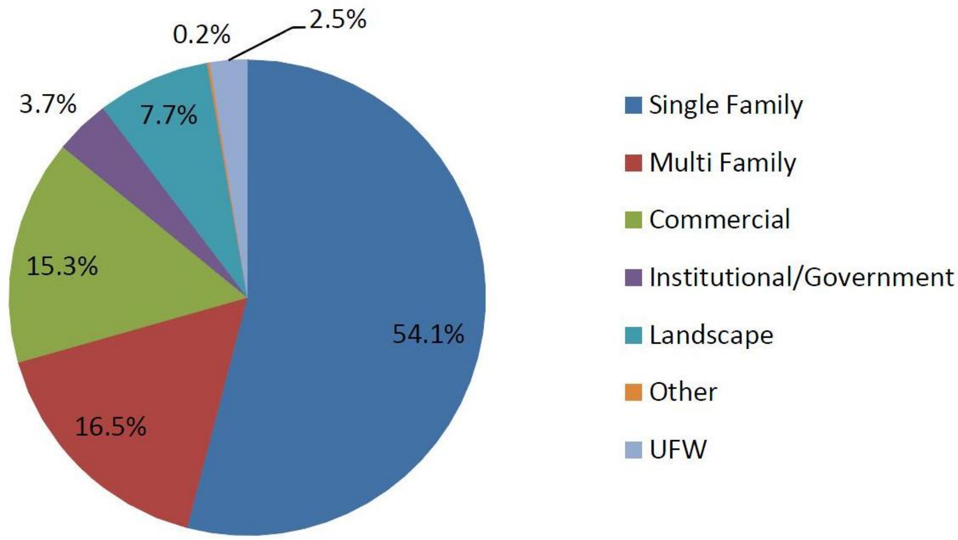



**Figure 2.3 City of Millbrae 2012 Water Demands Breakdown**

| Table 2.2 Water Demands by Customer Class<br>Water Master Plan<br>City of Millbrae | | | |
|---|---|---|---|
| **Customer Class** | **Billing Designations** | **2011 Demands (afy)** | **2012 Demands (afy)** |
| Single Family | Residential | 1,240 | 1,286 |
| Multi Family | Apartment, Duplex | 384 | 393 |
| Commercial | Bars/Taverns, Commercial, Commercial Bus, Restaurants | 382 | 364 |
| Institutional/Government | City of Millbrae, Government, Churches | 85 | 89 |
| Landscape | Irrigation, Sprinkler/Irrigation | 149 | 182 |
| Other | Fire, Temporary | 0 | 4 |
| **Total** | | **2,241** | **2,318** |

## 2.3 Unaccounted-for Water

The difference between water production (i.e., the purchased water) and the metered water is defined as unaccounted-for water (UFW), or unmetered water. UFW may be attributed to leaking pipes, unmetered or unauthorized water use, inaccurate meters, or other events causing water to be withdrawn from the system and not measured. Specific events that cause water loss include tank overflows, hydrant flushing, street cleaning, system flushing, and fire fighting. The term is used here to refer to unspecified system losses as well as unmetered demands that are known.

The water loss for well operated distribution systems is often less than ten percent. Typically, as distribution systems age, water loss increases. The water losses through the distribution system in the FY 2009-10 were 152 afy or about 6 percent (KJ, 2011). Comparisons of metered and purchased water volumes indicate that the water losses in 2011 and 2012 were about 7.6 percent and 2.5 percent, respectively.

| Table 2.3 Unaccounted-for Water<br>Water Master Plan<br>City of Millbrae | | | | |
|---|---|---|---|---|
| **Year** | **Total Water Purchase (afy)** | **Total Metered Water (afy)** | **UFW (afy)** | **UFW (%)** |
| **2011** | 2,426 | 2,241 | 185 | **7.6%** |
| **2012** | 2,378 | 2,318 | 60 | **2.5%** |

## 2.4 Peaking Factors

Peaking factors are used to scale average annual demands to reflect seasonal and hourly demand variations. This is typically accomplished in two steps. First, average annual demands are scaled up to maximum or peak day demands using a ‘daily peaking factor’ and then to peak hourly demands using an ‘hourly peaking factor’. As peaking factors directly affect the sizing of water mains and distribution system facilities, selection of appropriate factors are crucial.

This section provides discussions on the selection of appropriate peaking factors for performance evaluation and sizing of the City’s water distribution system.

### 2.4.1 Seasonal Peaking

Because daily demands or water deliveries are not recorded, an analysis of maximum day peaking factor was not performed. The previous hydraulic model used a maximum day factor of 2.0 for all customer classes. This was the same factor proposed in the 1983 water master plan and appears to be consistent with the typical peaking factors reported for comparable water systems in the same climatic conditions.

Maximum day peaking factors are typically functions of land use and climate. Service areas with high ratio of industrial/commercial to residential, little landscape areas, and cool climate with low evapotranspiration tend to have relatively low peak day consumptions. For the Bay Area, the maximum day peaking factors could range from as low as 1.4 for a diverse land use area with a large industrial component to as high as 2.8 for affluent residential areas with large landscapes.

Given Millbrae’s residential nature, a high maximum day peaking factor would be expected. However, due to relatively low level of landscapes within residential lots, a mid-range peaking factor of 2.0 appears to be reasonable. Examples of other Bay Area regions with similar daily peaking factor are Foothill Area of City of Hayward, Contra Costa Water District, City of Pleasanton, and residential areas within City of Milpitas.

The assumed daily peaking factor of 2.0 was further verified through an analysis of monthly peaking factors. Figure 2.4 presents monthly water supplies and Table 2.4 shows the maximum month peaking factors in the last 3 years. As shown, the highest maximum month peaking factor in the last three years was about 1.56. The maximum day peaking factors are typically 20 percent higher than the maximum month peaking factors. Hence, the maximum day peaking factor is estimated to be around 2.0.

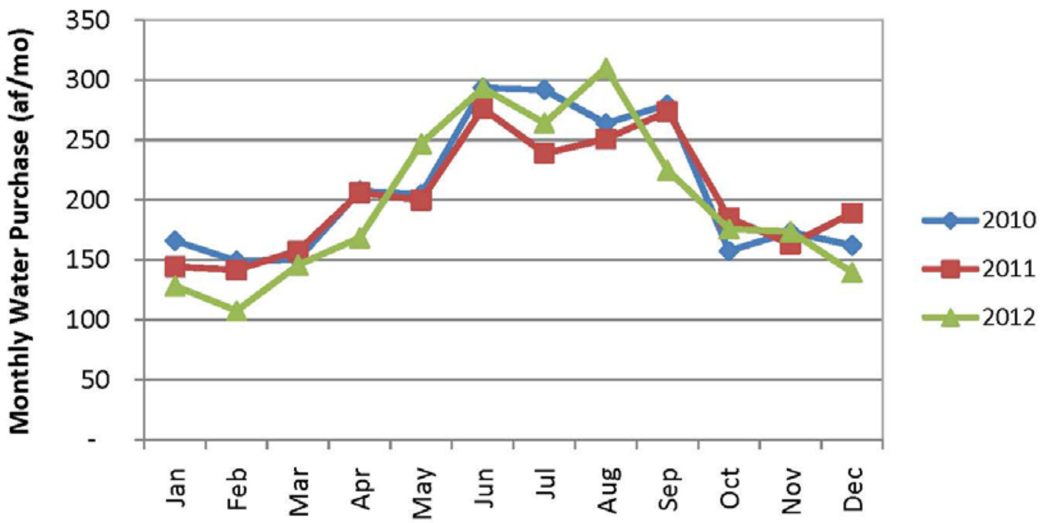



**Figure 2.4 Monthly Water Deliveries in the Last Three Years**

**Table 2.4 Summary of Monthly Peaking Factors**
**Water Master Plan**
**City of Millbrae**

| Year | Annual Water Supply (afy) | Peak Month Water Supply (af/mo) | Monthly Peaking Factor |
|---|---|---|---|
| 2010 | 2,498 | 294 | 1.41 |
| 2011 | 2,426 | 276 | 1.37 |
| 2012 | 2,378 | 310 | 1.56 |

### 2.4.2 Hourly Peaking

As shown in Figure 2.5, Figure 2.6 and Figure 2.7, the model includes separate patterns for residential, commercial and irrigation usages. The irrigation pattern for the Green Hills Country Club and Capuchino High School in the old model was applied to all customers designated as "irrigation" or "sprinkler/irrigation" in the billing database. Commercial pattern was also used for institutional/government customer class. The seasonal and hourly peaking factors for various categories are summarized in Table 2.5.

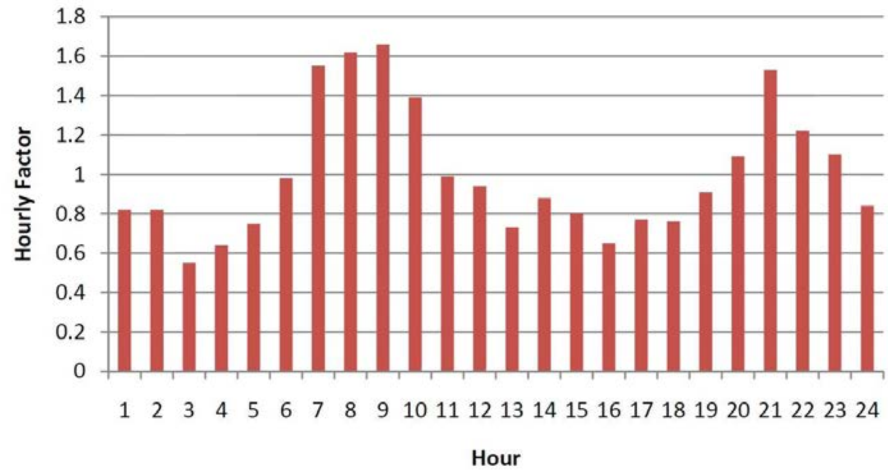



**Figure 2.5 Residential Diurnal Pattern**

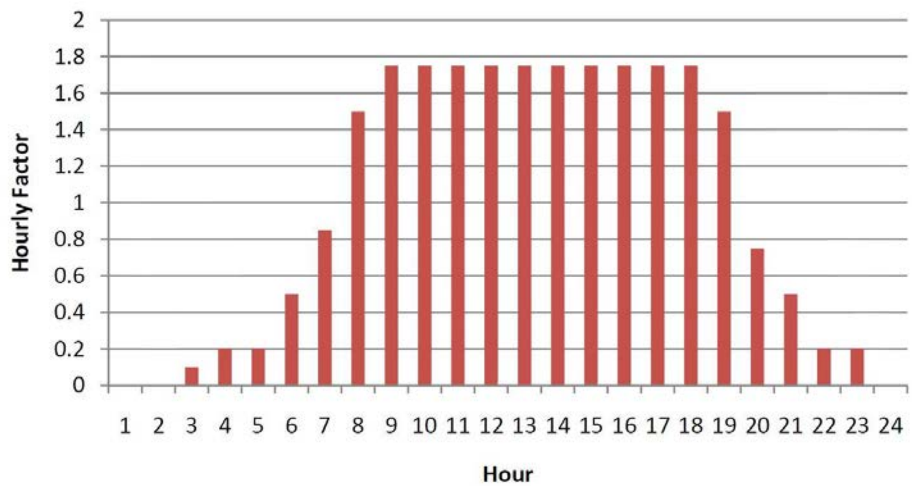



**Figure 2.6 Commercial Diurnal Pattern**

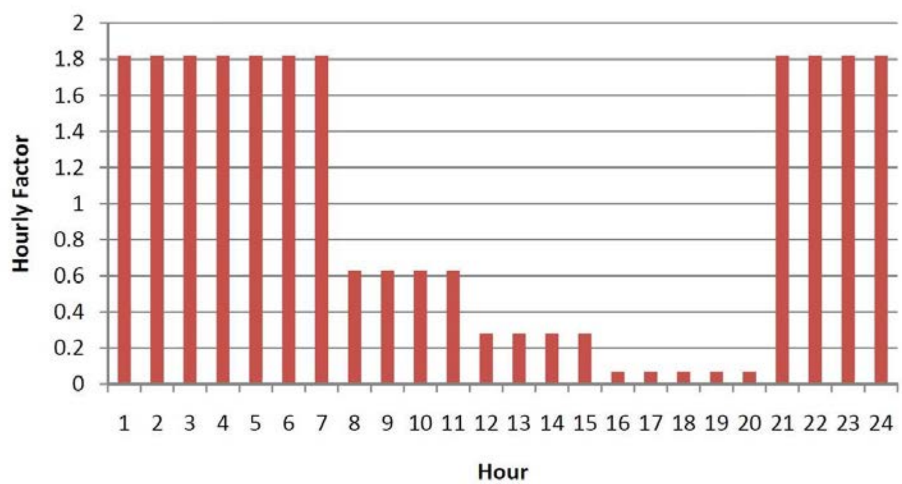



**Figure 2.7 Irrigation Diurnal Pattern**

| Table 2.5 Summary of Peaking Factors<br>Water Master Plan<br>City of Millbrae | | | |
|---|---|---|---|
| **Customer Class** | **Max Day PF** | **Hourly PF** | **Combined PF** |
| Residential | 2.0 | 1.66 | 3.32 |
| Commercial (1) | 2.0 | 1.75 | 3.50 |
| Irrigation | 2.0 | 1.82 | 3.64 |

Note:
1. To be applicable to both commercial and institutional/government customer classes.

## 2.5 Future Water Demands

Besides the Millbrae Station Area (MSA), the city does not currently have any formal specific plans for new development or redevelopment in the future or a future land use plan. This coupled with growth uncertainties stemming from the recent economic recession makes accurate demand projections a difficult task. This section describes the methodology to develop future demand projections and results.

### 2.5.1 Demand Projections Methodology

The 2010 Urban Water Management Plan projected water demands to increase to about 3,400 afy by year 2035 (KJ, 2011). This estimate was based on the estimated target per capita water use of 113 gallons per day per capita (gpcd) and the ABAG population projections.

To comply with the requirements of Water Conservation Act of 2009 (known as SB X7-7), the Urban Water Management Plan has established a per capita water use goal of 113 gpcd by 2020.

The City's per capita water use has consistently decreased since 2006 and is averaging approximately 96 gpcd in 2012. This drop in per capital water use can be attributed to several factors including climate, water conservation, and the economic recession. While it is difficult to determine the impact of each factor, the per capita water use is anticipated to recover as the economic conditions in the San Francisco Bay Area improve. For the purpose of projecting the ultimate water demand in this master plan, it is anticipated that the City's per capita water use will recover to the City's water conservation target of 113 gpcd. The City's historical and target per capita water use values are shown on Figure 2.8.

The other factor affecting the Urban Water Management Plan's 2035 demand estimate is population projections. While the ABAG estimates may not materialize as projected, they are believed to provide some cushion in water demands, which is generally desired for conservative master planning.

Therefore, the Urban Water Management Plan's demand projection for year 2035 (i.e., 3,400 afy) was assumed to be the City's ultimate water demand in this master plan. This is about 1,000 afy or 42 percent more than the existing demands of 2,400 afy in 2012. The estimated future growth is expected to occur due to the:

- Millbrae Station Area developments.
- El Camino Real (ECR) corridor commercial and mixed use redevelopment.
- Densification of very low-density and low density residential areas.
- Increase in the existing per capita water use.

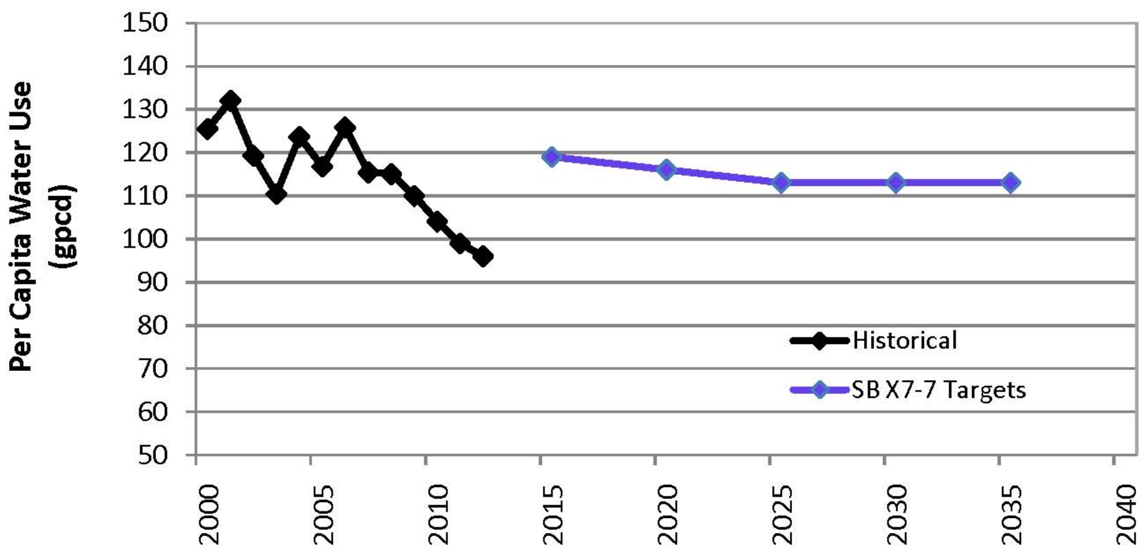



**Figure 2.8 Historical and Target Per Capita Water Use**

The following sections describe the methodologies to allocate the estimated increase in future demands to the above areas and the geographical distribution of demands within each area.

### 2.5.2 Millbrae Station Area Developments

With the exception of MSA, no new specific plan developments are currently planned within the City. The MSA planning area is composed of approximately 116 acres of land near BART/CalTrain Station at the southern edge of the City. As shown on Figure 2.9, the area is generally bounded by the Burlingame City limits on the south; the Millbrae Avenue/U.S. 101 freeway interchange on the east; El Camino Real and Broadway on the west; and Victoria Avenue, the City's public works storage yard and the Highline Canal on the north (Millbrae, 1998).

The Millbrae Station Area Specific Plan (MSASP), adopted in 1998 as part of the citywide general plan update, divided the planning area into 13 distinct sites with various land use types and maximum densities. The planned land use within these areas included office buildings, “flagship” hotels, multi-family residential developments, general commercial and parking areas. These sites are also shown on Figure 2.9.

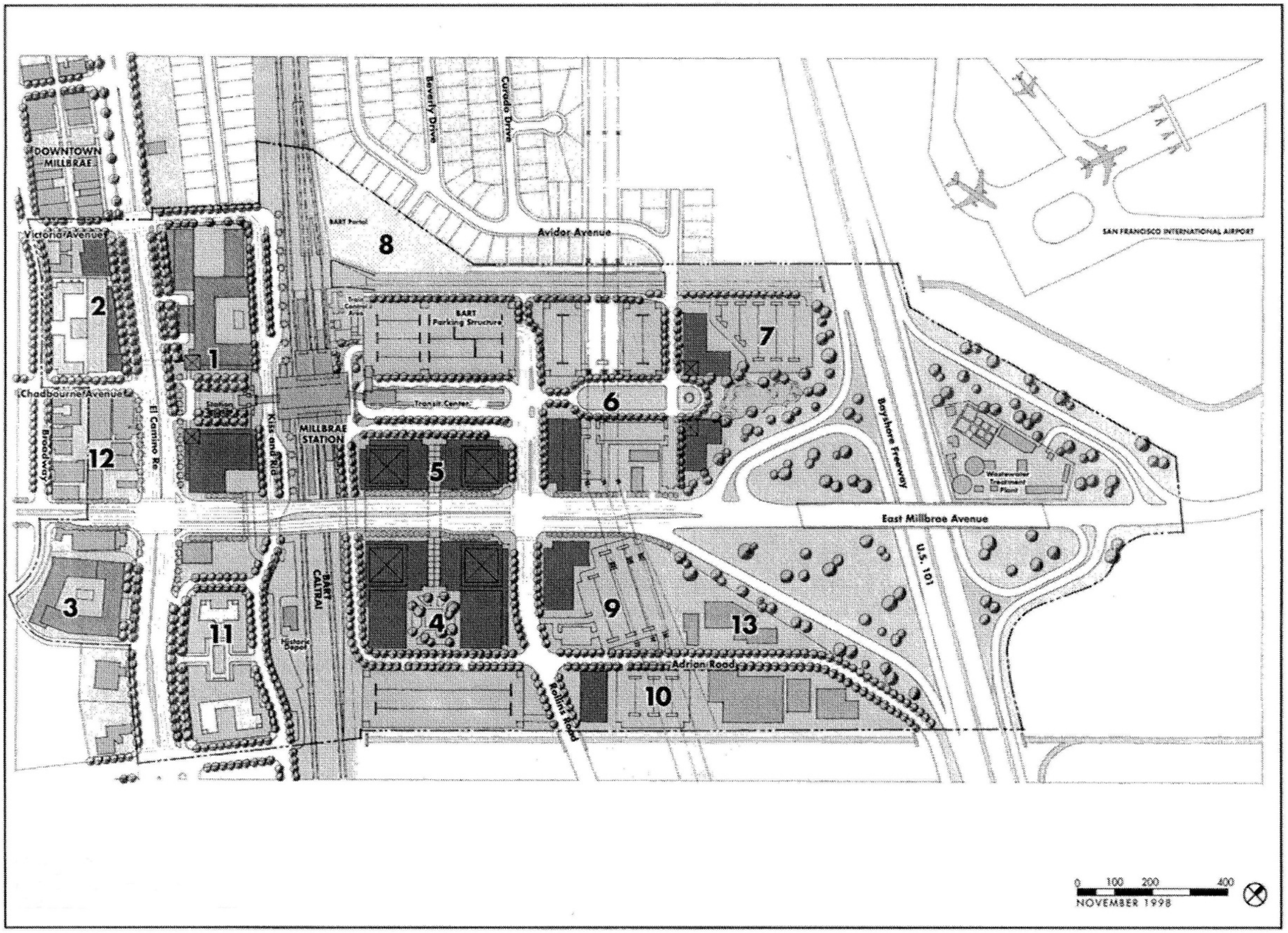
Based on the information presented in the MSASP, the average daily water demand generated by the proposed developments within these 13 sites had been estimated at about 0.475 mgd (Millbrae, 1998). The specific plan did not include site-specific demand estimates.

A cursory review of the planning area’s aerial indicates that since 1998 when the initial estimate was made, two of the sites (Sites 2 and 3) have been developed. Moreover, the development plan for several sites (Sites 5, 6 and 7) has changed since the MSASP was developed. Therefore, MSA water demands were estimated for each site as part of this master plan using the following assumptions:

- Per capita water demand of 70 gpcd was applied to residential units and nursing home occupants. This number is the “per capita water use” for single-family and multi-family residential units in 2012.
- Average residential density was assumed to be 2.7 persons per unit per Housing Element of the General Plan (adopted in 2006).Water demand factor of 2,500 gpd per acre for office buildings and general commercial (Carollo, 2008).
- Hotel water demand factor of 130 gpd per room (Carollo, 2011).

As summarized in Table 2.6, using the above assumptions, the water demand resulting from future developments within the Millbrae Station Area was estimated at about 196,200 gallon per day or approximately 220 afy. This is about ten percent of the existing annual supply. It is not known at this time at what future dates these development would be implemented (if at all). This demand will be distributed throughout the MSA per demands breakdown presented in Table 2.6.

The increase in City’s population within MSA is estimated at about 450 people. This estimate assumes that only Site 11 would be developed into a residential community and that it would include approximately 170 units, as planned originally.




Source: Millbrae Station Area Specific Plan

Figure 2.9 Millbrae Station Area Development Illustrative Plan

**Table 2.6 Millbrae Station Area Development Water Demand Projection**
Water Master Plan
City of Millbrae

| Area No. | Lot Area (ac) | Total Office (sf) | Hotel (rooms) | Residential (units) | Retail and Restaurants (sf) | Average Demand (gpd) |
|---|---|---|---|---|---|---|
| Site 2 (151 El Camino Real) | 2.0 | | | 120 | 25,000 | 14,830(6) |
| Site 3(1) (88 S Broadway) | 2.2 | | 500 | | | 15,520(6) |
| **Subtotal (Developed Sites)** | **4.2** | | **500** | **120** | **25,000** | **30,350** |
| Site 1 | 5.0 | 200,000 | 500 | | 50,000 | 79,300 |
| Site 1 Alt. | 5.0 | 300,000 | 233 | | 50,000 | 50,400 |
| Site 4 | 7.3 | 450,000 | | | | 25,800 |
| Site 5(2) | 2.4 | 560,000 | | | 10,000 | 32,700 |
| Site 6(2) | 5.2 | 140,000 | | | 7,300 | 8,500 |
| Site 7(2) (BART Parking Lot) | 5.6 | | | | | 900 |
| Site 8(3) | 2.1 | | | | | 8,800 |
| Site 9 | 3.4 | 75,000 | | | | 4,300 |
| Site 10 | 2.0 | 40,000 | | | | 2,300 |
| Site 11 | 4.4 | | | 170 | 25,000 | 33,600 |
| Site 12(4) | 1.3 | | | | | - |
| Site 13(4) | 4.4 | | | | | - |
| **Subtotal (Undeveloped Sites)** | **47.3** | **1,565,000** | **500** | **170(5)** | **92,300** | **196,200** |

<u>Source</u>: The reported quantities, except for Sites 5, 6 and 7, are from Millbrae Station Area Specific Plan (Table 3-1).

1. The development appears to be a condominium complex and not a hotel as was originally planned.
2. Demands were estimated per a more recent conceptual plan.
3. The site was planned to include a nursing home with 125 beds.
4. No specific development had been proposed for this site.
5. Future residential population is estimated at 170 units x 2.6 persons/unit = 442 persons.
6. Actual consumptions from Nov-Dev 2011 to Nov-Dec 2012. The actual developments may be different from planned.

### 2.5.3 El Camino Real (ECR) Corridor Redevelopment

It is anticipated that the City's commercial district along ECR corridor will be redeveloped into a heavy commercial/mixed use area in the future. While no specific plan is available for this area at this time, future redevelopment along ECR is anticipated to increase water demands. For the purpose of estimating the existing water duty factor for this area, the ECR corridor is roughly defined to include parcels along ECR immediately to the east of it, parcels between the ECR and the Broadway Street and the public right of ways of the vicinity area. This area, shown on Figure 2.10, is about 86 acres.

An analysis of 2012 billing database indicates that this area is a mixed-use of commercial and residential land use with the total average annual demand of about 200,000 gpd, of which approximately 64 percent is commercial and the remaining is mostly residential. The water duty factor for this area is therefore estimated at about 2,350 gpd/ac. It is assumed that this water duty factor will be increased to 3,000 gpd/ac in the future. This will result in future demand increase of about 65 afy by 2035. This demand increase will be evenly distributed in the ECR corridor area.

### 2.5.4 Densification of Residential Areas

Since the early 2000s, the City's population density has been gradually increasing. As 'empty nesters' have sold houses and down sized, larger families have taken up residence in the City. Although no hard evidence exists to confirm the increase in water demand that has occurred, according to the City's Planning Department, this change is believed to have increased the size of the households. Furthermore, the City expects to remove the ban on second dwelling units that has been in place since 1980s. While a flood of applicants would be expected, the associated demand increase is difficult to quantify. Given the existing population demographic of the City, and their desire to have multi-generation families on the same residential lot, it is anticipated that this change in the City ordinance will increase the density of water demands.

The methodology to estimate the overall demand increase due to densification is based on the anticipated population growth estimated to occur between 2012 and 2035 that is not currently anticipated to occur within the planned future developments and redevelopments (i.e. MSA, and ECR redevelopments). This methodology is summarized in Table 2.7. As shown, it is anticipated that the City's water demand will increase by approximately 530 afy by 2035. This is an increase of approximately 22 percent over the existing demands. This demand will be evenly distributed within the very low-density and low-density residential areas as defined by the City's Land Use Plan (Millbrae, 1998).

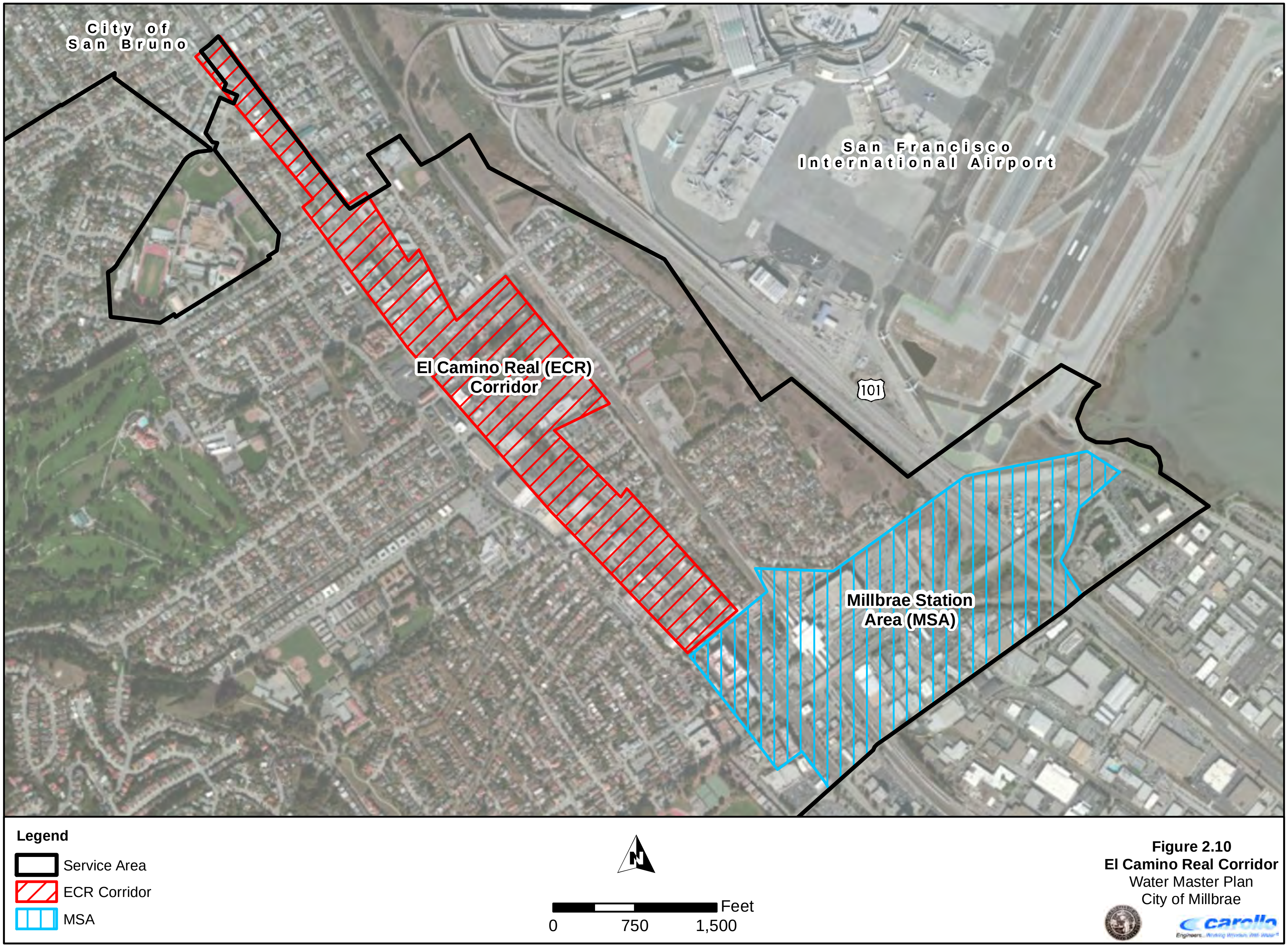



**Figure 2.10**
**El Camino Real Corridor**
Water Master Plan
City of Millbrae

| Table 2.7 Water Demand Projections from Densification<br>Water Master Plan<br>City of Millbrae | | |
|---|---|---|
| **Description** | **Value** | **Source** |
| 2012 population | 22,100 | US Census |
| 2035 population | 26,700 | ABAG |
| Total population increase | 4,600 | - |
| MSA population increase | 450 | 170 units @ 2.6 persons/unit |
| Population increase from densification | 4,150 | - |
| **Water demand increase (afy)** | **530** | **4,150 persons @ 113 gpcd** |

### 2.5.5 <u>Per Capita Water Use Recovery</u>

The combined increase in water demands associated with MSA developments (220 afy), ECR corridor redevelopments (65 afy), and densification within very low-density and low-density areas (530 afy) is estimated at about 815 afy. To arrive at the Urban Water Management Plan's demand projection of 3,400 afy by year 2035, approximately 185 afy of water demand must be allocated elsewhere. This remaining demand is due to the uncharacteristically low per capita water use at the present time (i.e., 96 gpcd in 2012). As described earlier, it is anticipated that per capita water use will be increased in the future concurrent with the economic recovery. Therefore, the remaining 185 afy of water demands will be evenly distributed throughout the City.

### 2.5.6 <u>Summary of Future Demands</u>

A summary of future water demand and its components are presented in Table 2.8. As shown, densification of very low and low-density residential areas makes up about 16 percent of the water demands in 2035. The MSA developments, per capita water use recovery and ECR corridor redevelopments account for 6 percent, 5 percent, and 2 percent of the future demands, respectively.

Water demand projections are also presented graphically on Figure 2.11. While the timeline for future growth is not known at this time, it is anticipated that the rate of growth will be increased with the economic recovery over time.

| **Table 2.8** | **Summary of Future (Year 2035) Water Demand<br>Water Master Plan<br>City of Millbrae** | |
|---|---|---|
| **Description** | **Demand (afy)** | **Fraction (%)** |
| Existing (2012) Demand | 2,400 | 71% |
| MSA Developments | 220 | 6% |
| ECR Corridor Redevelopments | 65 | 2% |
| Densification | 530 | 16% |
| Per Capita Water Use Recovery | 185 | 5% |
| **Future (2035) Demand** | **3,400** | **100%** |

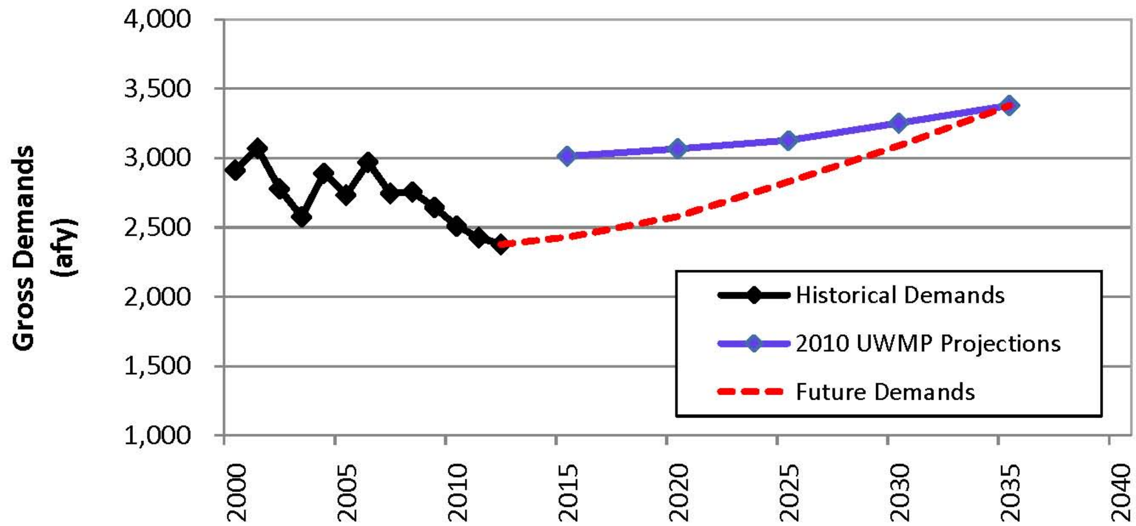



**Figure 2.11 Future Water Demands Projection**

## 3.0 EXISTING SYSTEM DESCRIPTION

The City's distribution system is divided into four major pressure zones and includes approximately 75 miles of public water mains, 12 pressure reducing valve (PRV) stations, 6 storage tanks, and 2 pump stations. The City serves approximately 6,500 service connections. The water system is supplied through five connections with SFPUC's Regional Water System (RWS).

The City's existing pressure zone boundaries, water mains, and major distribution system facilities are shown on Figure 3.1. A more detailed description of City's water system components are provided in this section.

### 3.1 Pressure Zones

Due to its topographic setting, the City's water system is divided into four major and four minor pressure zones. A major pressure zone is defined as a zone that either is served directly from a supply source or has a dedicated storage reservoir, while minor zones are those that solely rely on PRVs from zones with higher elevations.

Zone I is the highest in elevation, and zone elevations decrease in numerical order to Zone IV. Zones I and III serve 1 and 3 minor zones, respectively. The minor zones are served through one or two PRVs. The City's pressure zones are summarized in Table 3.1 and shown on Figure 3.1.

**Table 3.1 Pressure Zones Summary**
**Water Master Plan**
**City of Millbrae**

| Major Pressure Zones | Approximate HGL (fmsl) |
|---|---|
| Zone I | 685 ft(1) |
| Zone II | 610 ft(1) |
| Zone III | 430-460 ft(3) |
| Zone IV | 280-300 ft(4) |
| **Minor Pressure Zones(5)** | |
| Zone III PT | 540 ft |
| Zone III PR North | 365-375 ft |
| Zone III PR | 280 ft |
| Zone III PR South | 285-290 ft |

Notes:
1. Top water elevation of Skyline tanks.
2. Top water elevation of Vallejo and La Prenda tanks.
3. Varies based upon the Harry Tracy transmission main's HGL. The reported range is an estimate.
4. Varies based upon the Hetch Hetchy aqueduct's HGL. The reported range is an estimate.
5. The HGL for minor pressure zones are estimated from the elevation of the PRV(s) serving each zone and the pressure setpoint of the PRV(s) as indicated in the City's PRV Maintenance Records.

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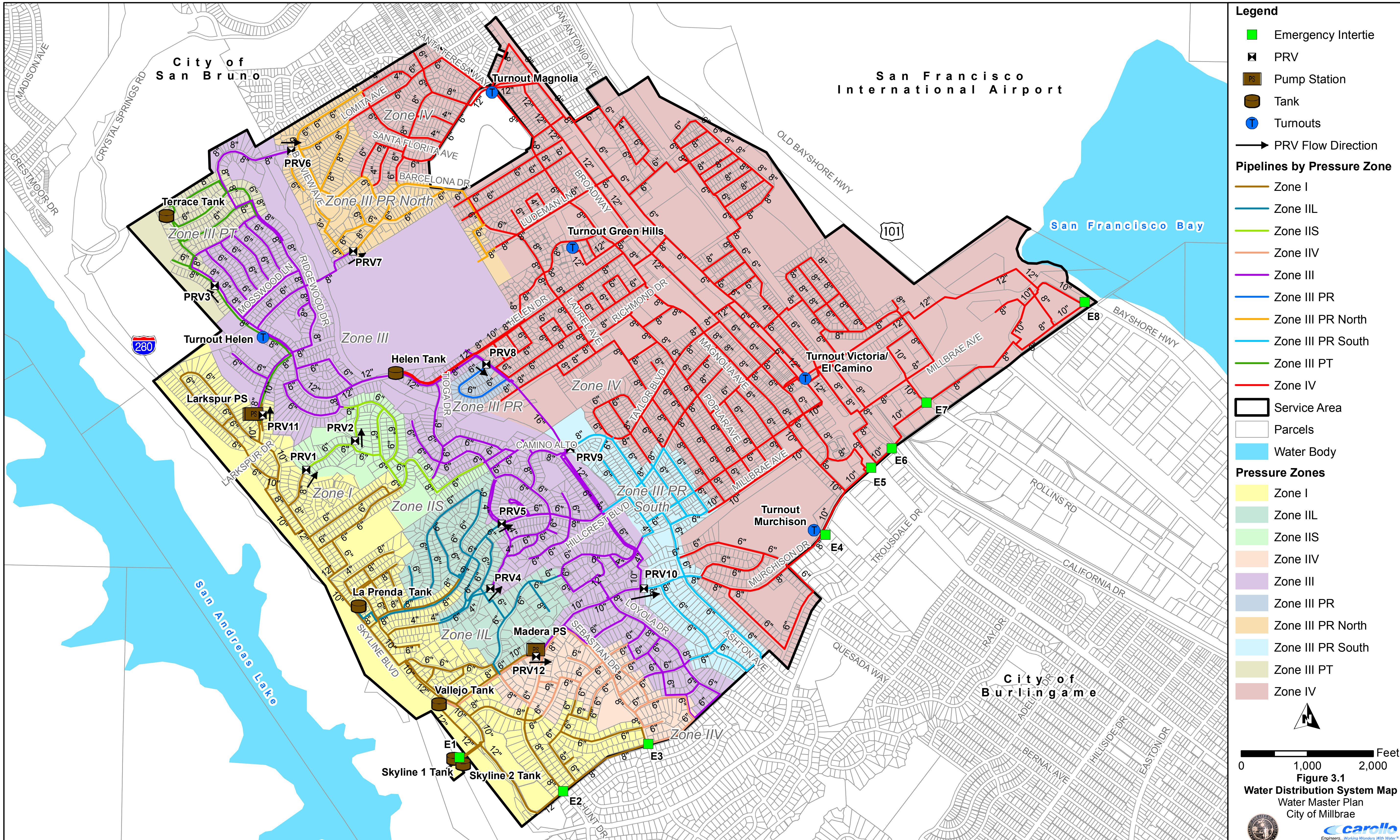


**Figure 3.1**
**Water Distribution System Map**
Water Master Plan
City of Millbrae

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A simplified hydraulic schematic of the City's water distribution system is depicted on Figure 3.2, while a brief description of the system's hydraulics is provided in the following paragraphs.

The City's water system is effectively operated as two systems with no connections between the two. One system includes pressure zones I, II and III and their minor zones and is supplied from Harry Tracy Water Treatment Plant's 30-inch diameter aqueduct via a turnout located on Helen Avenue (Helen Turnout). The second system includes pressure zone IV and is supplied through SFPUC's 60-inch diameter Hetch Hetchy aqueduct via four turnouts. The hydraulic grade lines (HGLs) for the Harry Tracy transmission main and Hetch Hetchy aqueduct are approximately 430-460 and 280-300 feet above mean sea level (fmsl), respectively.

Zone III is directly served through the Harry Tracy aqueduct with no pump station or storage tank. Two pump stations, Madera and Larkspur, pump water from this zone to the most elevated Zone I. These pump stations are operated during the night and are controlled through the water level in the Skyline tanks. Zone I in turn serves Zone II via two PRVs (Tuolumne Court and Tuolumne Drive PRVs) and the minor Zone III PT via the Helen PRV. Zone II has two dedicated storage tanks, La Prenda and Vallejo, which are fed during daytime from Skyline tanks. Zone III also serves three minor zones: Zone III PR South, Zone III PR and Zone III PR North.

## 3.2 Water Mains

The City's distribution system consists of approximately 75 miles of public water mains ranging from 2 to 16 inches in diameter. The majority of pipes are 6 and 8 inches in diameter (about 49 and 26 percent, respectively). Figure 3.3 shows the size distribution of public water mains as indicated in the City's GIS database. As shown, cast iron (CI) is the most common pipe material with 69 percent. Figure 3.4 shows the material distribution of public water mains as indicated in the City's GIS database. As shown, nearly half of the City's pipelines are 6-inch in diameter.

No information was readily available on the installation year of the water mains. It is reported that several portions of the water system are approximately 50 years old (KJ, 2011).

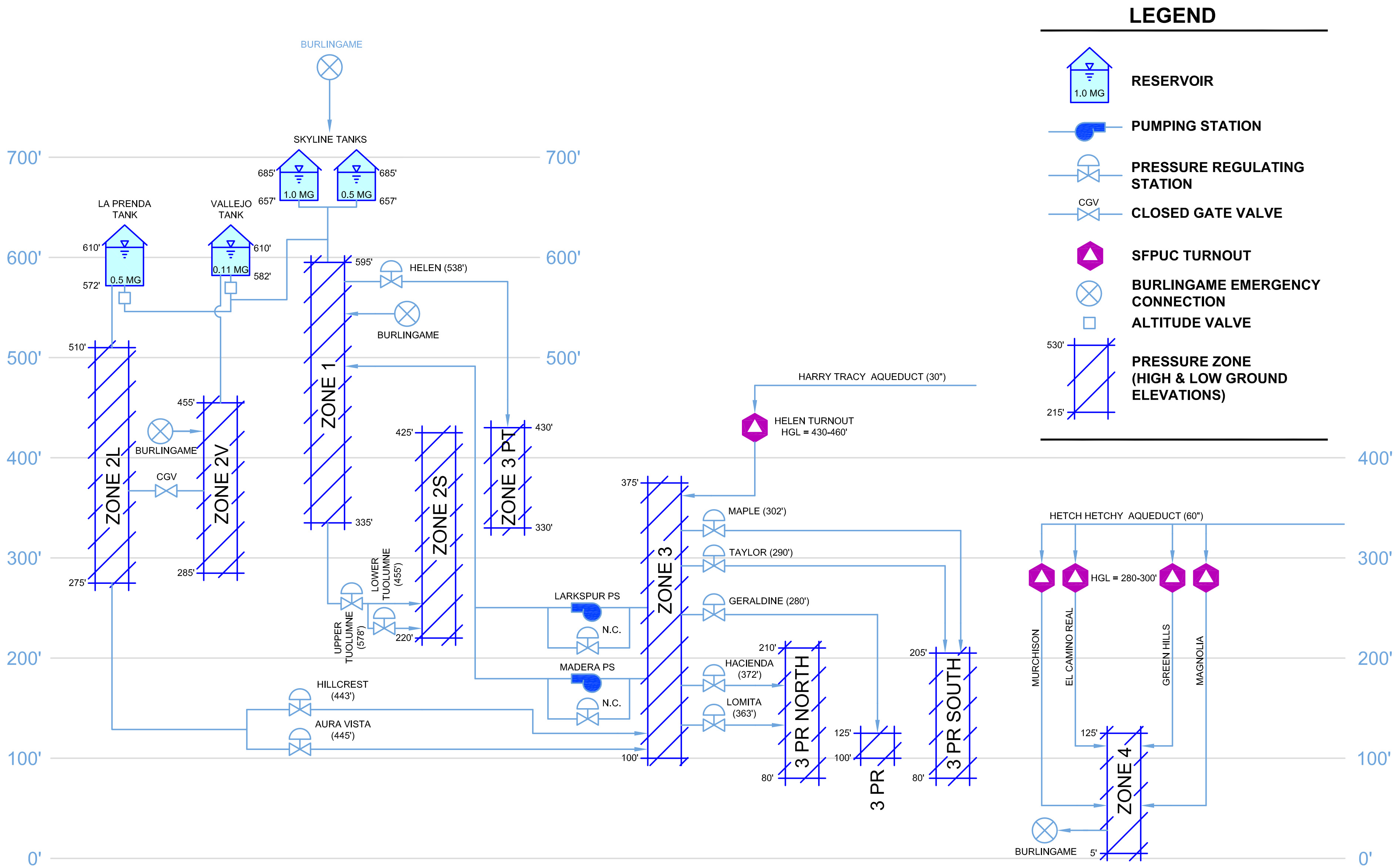


**Figure 3.2**
**Hydraulic Profile Schematic**
Water Master Plan
City of Millbrae

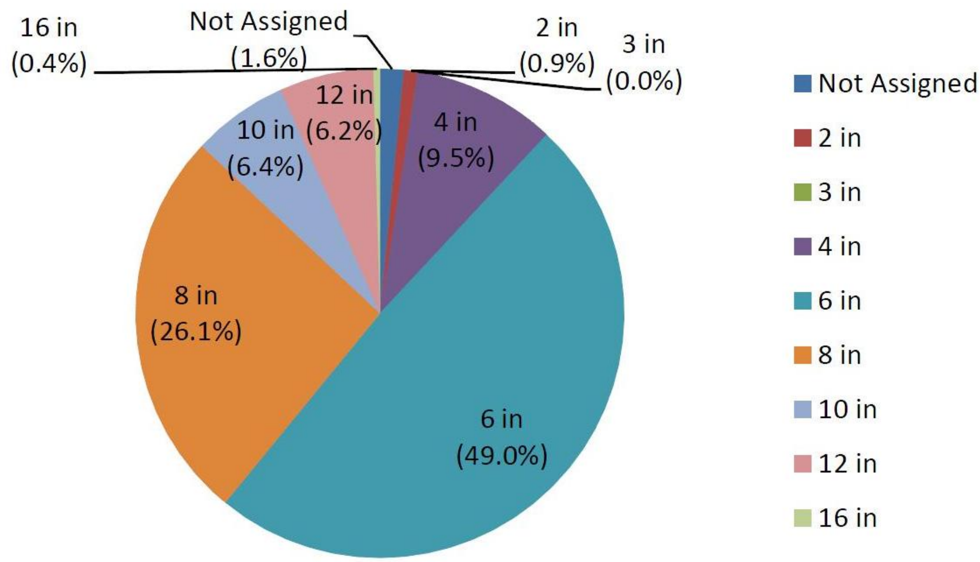


**Figure 3.3 Distribution of Public Main Water Pipes by Size**

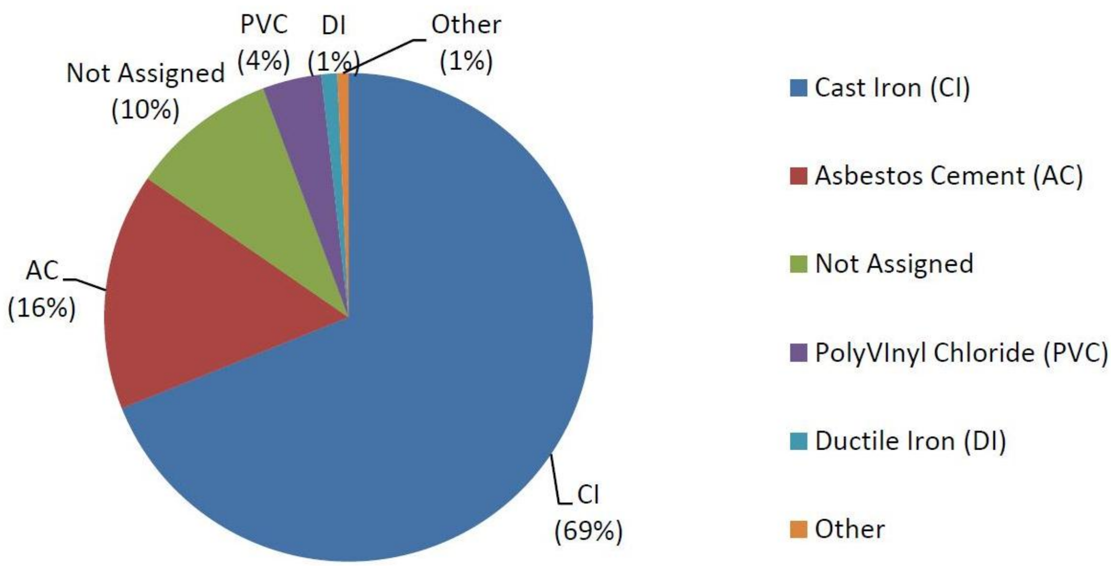


**Figure 3.4 Distribution of Public Main Water Pipes by Material**

The counts of water main breaks from 1985 though 2013 are summarized in Table 3.2, with their locations shown on Figure 3.5. As shown, the number of breaks has generally declined over time. This is due to the implementation of main replacement and upgrade program in recent years.

However, as summarized in Table 3.2, there was an increase in main breaks in the period of 2010-2013 as compared to the period of 2005-2009. This is primarily associated with a significant pipeline failure event that occurred on December 12 and 13, 2013. Over the course of a twenty hour period, seven water main breaks were reported and repaired by City staff and contractors called in to assist City staff with the repairs. The main breaks were isolated within a single pressure zone (Zone 3). In order to help identify the potential cause of the main break incident, the City contracted with Carollo to conduct an analysis of the pipeline failures and provide an opinion on their potential causes. The results of this analysis were inconclusive. However, six of the seven main breaks did occur on cast iron pipe that is believed to be 50 years old or older. For this reason, it was recommended that the City conduct a pipeline condition evaluation and develop an asset management program that prioritizes the replacement of older cast iron pipe.

A list of historical main break locations by address since 1985 is provided in Appendix B.

**Table 3.2 Water Main Breaks Summary (1985-2013)**
**Water Master Plan**
**City of Millbrae**

| Period | No. of Main Breaks |
|---|---|
| 1985-1989 | 46 |
| 1990-1994 | 38 |
| 1995-1999 | 36 |
| 2000-2004 | 16 |
| 2005-2009 | 4 |
| 2010-2013 | 11 |
| **Total** | **144** |

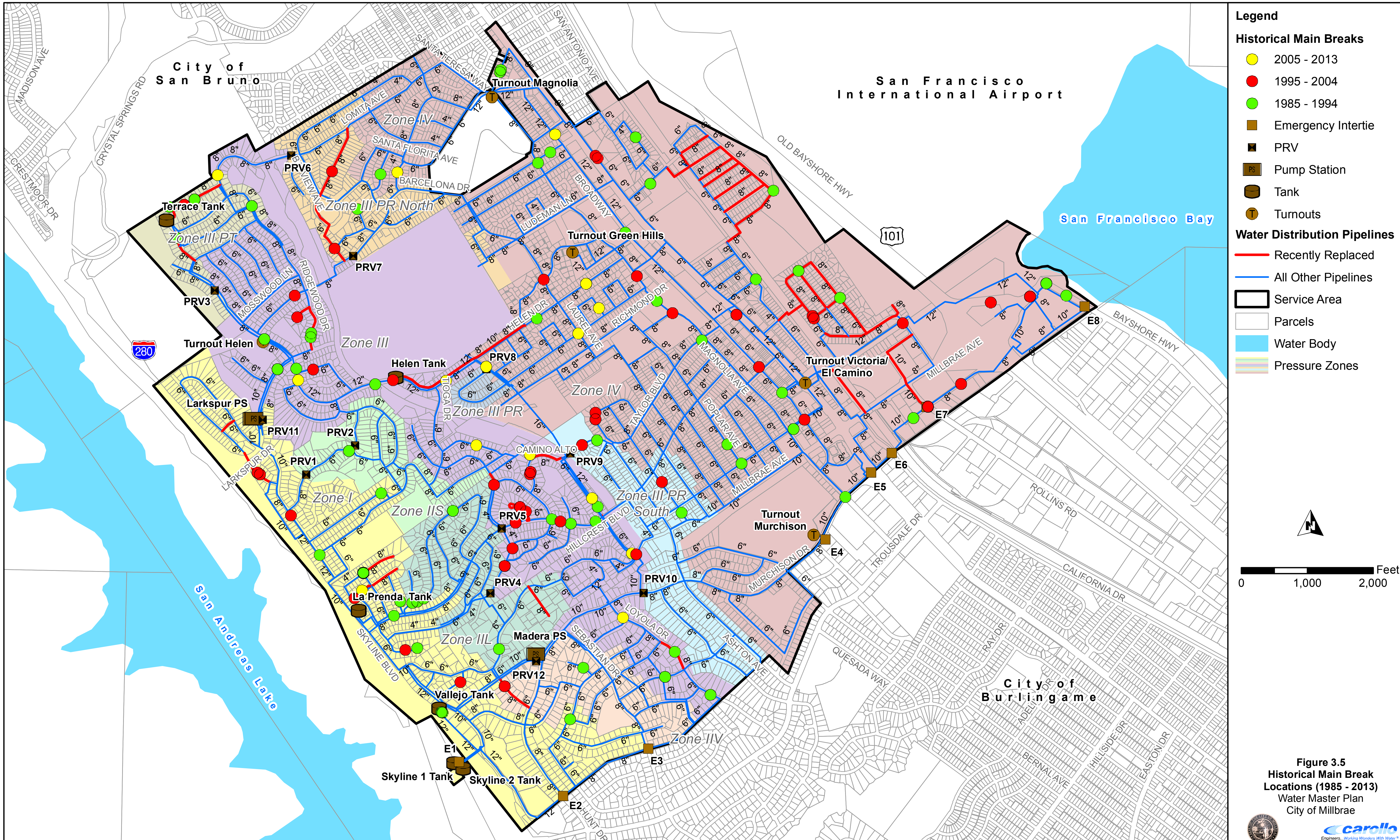


**Figure 3.5**
**Historical Main Break Locations (1985 - 2013)**
Water Master Plan
City of Millbrae

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## 3.3 Supply Connections

The City exclusively purchases potable water from SFPUC's RWS through eight (8) water meters at five (5) turnout locations. Zones I through III and their subzones are served through three 6-inch diameter meters at the Helen turnout (also known as Meadows). Zone IV is served through Murchison, El Camino Real (also known as Victoria), Green Hills and Magnolia turnouts. The turnout locations are shown on Figure 3.1 with their characteristics summarized in Table 3.3. The City's supply guarantee from SFPUC is 3.15 mgd (KJ, 2011).

As discussed earlier, Zones I, II, III, and their subzones solely rely on Helen turnout from Harry Tracy transmission main. Similarly, Zone IV solely relies on turnouts from Hetch Hetchy aqueduct with no ability to move water from Zone IV to higher zones and vice versa. This configuration has resulted in reduced system reliability.

**Table 3.3 SFPUD Supply Connections**
**Water Master Plan**
**City of Millbrae**

| Turnout | Address | No. of Meters | Meter Size (inch) | Capacity (gpm) | Zones Served | Source |
|---|---|---|---|---|---|---|
| Helen (Meadows) | 1327 Helen Dr | 3 | 6 | 4,500 | I, II & III | Harry Tracy |
| Murchison | Murchison Dr & Ogden Dr | 1 | 4 | 1,000 | IV | Hetch Hetchy |
| El Camino Real (Victoria) | 195 El Camino Real | 1 | 10 | 5,000 | IV | Hetch Hetchy |
| Green Hills | 301 Green Hills Dr | 2 | 4 | 2,000 | IV | Hetch Hetchy |
| Magnolia/Park Place | Magnolia Ave and Park Blvd | 1 | 4 | 800 | IV | Hetch Hetchy |

## 3.4 Emergency Interties

In addition to the water purchased from SFPUC, the City has eight (8) emergency interties with the City of Burlingame. The location of these interties and the reported pressures across each intertie are summarized in Table 3.4. The intertie locations are also shown on Figure 3.1.

As shown, only three of these connections (E1, E2 and E3) can serve Millbrae without a need for pumping. E1 and E2 serve Zone I and E3 serve Zone II. Other zones including Zone IV cannot be served from Burlingame.

**Table 3.4 Emergency Interties with City of Burlingame[1]**
**Water Master Plan**
**City of Millbrae**

| Map ID | Location | Main Size (inch) | Burlingame Pressure (psi) | Millbrae Pressure (psi) | Zones Served |
|---|---|---|---|---|---|
| **Two-way interties** | | | | | |
| E1 | Skyline Tank Site | 10, 12 | Tank Level | Tank Level | I |
| E2 | Frontera @ Murchison | 12 | 48 | 48 | I |
| **To Millbrae only** | | | | | |
| E3 | Sebastian @ Murchison | 8 | 92 | 60 | II |
| **To Burlingame only** | | | | | |
| E4 | Ogden @ Murchison | 10 | 60 | 90 | IV |
| E5 | El Camino @ Murchison | 10 | 76 | 116 | IV |
| E6 | California @ Murchison | 10 | 78 | 118 | IV |
| E7 | Rollins @ Adrian | 8 | 80 | 120 | IV |
| E8 | Bay shore [2] | 10 | 80 | 120 | IV |

Notes:
1. Information provided by City staff.
2. Located across from Westin Hotel.

## 3.5 Pump Stations

The City currently owns and operates two pump stations, Madera Pump Station and Larkspur Pump Station, to pump water from zone III to zone I. Each pump station has three (2+1) constant-rate vertical pumps with the design head and flow of 360 gpm and 323 ft. The pumps are Flowserve Byron Jackson pumps with their manufacturer pump curve presented in Appendix C. Neither pump currently has a backup power generator. A summary of pump station characteristics is presented in Table 3.5.

The pumps are operated automatically during nighttime generally between the hours of 9:30 PM and 7:30 AM to fill Skyline tanks. This has been implemented due to an agreement with Pacific Gas and Electric Company (PG&E) to minimize power use during the day. If the Skyline tank level falls below 12 ft during the day, pumps will automatically be started. If the Skyline tank level should reach 26.6 at any time of day or night, any running pumps will automatically be stopped. The sequence of events for City's pump controls is included in Appendix C.

| Table 3.5 | Pump Stations<br>Water Master Plan<br>City of Millbrae | | | | |
|---|---|---|---|---|---|
| **Pump Station[(1)]** | **From Zone** | **To Zone** | **No. of Pumps[(2)]** | **Break Horsepower (hp)** | **Rated Capacity (gpm @ ft)** |
| Madera | III | I | 2+1 | 115 | 3 x 360 @ 323 |
| Larkspur | III | I | 2+1 | 115 | 3 x 360 @ 323 |

Notes:
1. The pump stations do not have backup power generator.
2. All six pumps are identical Flowserve Byron Jackson pumps.

## 3.6 Storage Tanks

The City currently owns six steel water tanks, but only operates four of them. The Terrace and Helen tanks were decommissioned from service due to inadequate hydraulic grade line or operational difficulty. These tanks could potentially be demolished and rebuilt in the future. Two of the tanks, Skyline 1 and 2, with a combined capacity of 1.5 Million Gallons (MG) serve zone I, while the other two tanks, La Prenda and Vallejo, with a combined capacity of 0.6 MG, serve Zone II. Zones III and IV do not have local storage tanks. SFPUC's San Andreas and Crystal Spring Reservoirs effectively serve as storage for these zones. A summary of storage tanks characteristics is provided in Table 3.6.

| Table 3.6 | Summary of Storage Tanks<br>Water Master Plan<br>City of Millbrae | | | | | |
|---|---|---|---|---|---|---|
| **Tank** | **Zone Served** | **Base Elevation (fmsl)** | **Maximum Water Level (ft)** | **Top Water Level Elevation (fmsl)** | **Diameter (ft)** | **Volume (MG)** |
| Skyline 1 | I | 657 | 28 | 685 | 55 | 1 |
| Skyline 2 | I | 657 | 28 | 685 | 80 | 0.5 |
| La Prenda | II | 572[1] | 38 | 610[1] | 48 | 0.5 |
| Vallejo | II | 582 | 28 | 610 | 26 | 0.11 |
| **Total** | | | | | | **2.1** |
| Terrace | NIS[2] | 194 | 30 | 224 | NA | 0.22 |
| Helen | NIS[2] | 403 | 32 | 435 | 38 | 0.25 |

Source: City's hydraulic schematic and model
Notes:
1. Elevations were confirmed by City staff.
2. Not in service.

The City operates two altitude valve stations located at La Prenda and Vallejo tank sites. The purpose of these valve stations is to control the tanks inflow. A summary of City's altitude valve stations is presented in Table 3.7. The recent maintenance records of these valves are presented in Appendix C.

**Table 3.7 Summary of Altitude Valve Stations**
**Water Master Plan**
**City of Millbrae**

| Station | Location | Zone Served | No. of Valves | Valve Size (in) | Outlet Pressure (psi) |
|---|---|---|---|---|---|
| La Prenda | Tank site | II | 2 | 8, 10 | NA |
| Vallejo | Tank site | II | 1 | 6 | NA |

Source: City's PRV maintenance records (Appendix C)

## 3.7 Pressure Reducing Valve Stations

The City currently owns and operates 12 PRV stations as shown on Figure 3.1. Two of these stations, Madera and Larkspur, located at or near the pump station sites serve as pump station bypass and are normally closed, while the other 10 stations are normally in operation. Each station regulates the outlet pressure through up to three valves with the purpose of supplying water to lower elevation pressure zones. A summary of City's pressure regulating stations is presented in Table 3.8.

**Table 3.8 Pressure Regulating Stations**
**Water Master Plan**
**City of Millbrae**

| Map ID | Station | Location | From Zone | To Zone | No. of Valves | Size (in) | Pressure (psi) | Normal Status |
|---|---|---|---|---|---|---|---|---|
| PRV1 | Tuolumne Drive (Upper) | 1320 Tuolumne Dr | I | II | 2 | 2, 6 | 60 | Open |
| PRV2 | Tuolumne Court (Lower) | 1166 Tuolumne Ct | I | II | 1 | 6 | 60 | Open |
| PRV3 | Helen (Terrace) | NA | I | III PT | 3 | 2, 4, 6 | 94 | Open |
| PRV4 | Aura Vista | Aura Vista Dr and Mullins Ct | II | III | 1 | 4 | 75 | Open |
| PRV5 | Hillcrest | Hillcrest Blvd & El Bonito Way | II | III | 1 | 6 | 60 | Open |
| PRV6 | Lomita | Lomita Ave & Bayview Ave | III | III PR North | 3 | 2, 4, 6 | 85 | Open |
| PRV7 | Hacienda | NA | III | III PR North | 3 | 2, 4, 6 | 80 | Open |
| PRV8 | Geraldine | Geraldine Dr & Anita Ln | III | III PR | 2 | 2, 6 | 74 | Open |
| PRV9 | Taylor | 850 Taylor Dr | III | III PR South | 2 | 2, 6 | 75 | Open |
| PRV10 | Maple (Murchison) | Maple Pl & Murchison Dr | III | III PR South | 2 | 2, 6 | 52 | Open |
| PRV11 | Larkspur | In pump station | I | III | 1 | 8 | 44 | Closed |
| PRV12 | Madera | Across from pump station | I | III | 2 | 2, 6 | 110 | Closed |

Source: PRV maintenance records (Appendix C)

# 4.0 HYDRAULIC MODEL UPDATE

This section includes a discussion of the update of the hydraulic model that was prepared as part of a previous study in or around 2006. A number of modifications were made to update and validate this model. These steps included updating the elevations, pipelines, pressure zone boundaries, facility setpoints and demands. The hydraulic model update and validation steps are further described in this section.

## 4.1 Hydraulic Model Update

The City's existing hydraulic model was prepared around 2006 by RMC Water and Environment (RMC). While no documentation of the existing model was available, based on the review of the model itself, it was concluded that the model ran properly, meaning without warnings and errors, and that the pressures were within normal ranges. However, further review of the model indicated that the elevations in some areas were greatly different from the publically available sources such as those from United States Geological Services (USGS) and the County of San Mateo. Moreover, City staff indicated that there had been several pipelines implemented since 2006. Therefore, the following steps were taken to update the model:

- <u>Ground elevations update</u>: The elevations for all model nodes were updated using publically available high and moderate resolution elevation data from USGS. This process showed that the elevations in the existing model deviated from the revised elevations by up to 60 feet in some areas. Revised elevations were applied using linear interpolation to all nodes within the model. The USGS and County elevations were in close agreement.
- <u>Pipelines and pressure zone boundary update</u>: The City staff provided the location, extent, size and material of the new pipelines built or replaced in recent years, which were then added to the model. These pipelines were mostly from PVC material. A Hazen-William roughness coefficient (C factor) of 130 were used for these pipelines. In addition, the pressure zone III PR North boundaries were updated per information obtained from the City.
- <u>Facility settings update</u>: The downstream pressure settings for all PRVs were obtained from the City (Appendix C) and updated in the model accordingly. In addition, the pump curves for all six pumps were adjusted based on the recent pump tests conducted in December 2012. The test results indicated that the pumps total dynamic head (TDH) had been reduced by about 40 to 75 feet at the tested flow rates. The recent pump test reports are presented in Appendix D.
- <u>Demands update</u>: Because a lot has changed since the last model update, particularly with increased water awareness, water conservation, and price sensitivity in the recent economic downturn, it was necessary to update the demands to reflect the current

conditions. For this reason, the 2012 billing database was geo-coded and used in the model to reflect the current demands aggregate and distribution throughout the City.

The hydraulic modeling software $H_2$OMAP Water® has an option of assigning ten different demand sets for each model node where each set can have a dedicated diurnal pattern. The updated model used three of the ten demand sets. Demand 1 was used for existing single and multi-family residential demands. Demand 2 was used for existing commercial, government, and institutional demands. Demand 3 was used for existing landscape irrigation demands. Specific land-use based diurnal patterns as presented in Section 2.4 were used in the hydraulic model. The remaining demand sets in the model will be reserved for future demands.

## 4.2 Hydraulic Model Validation

The model validation was performed to compare the hydraulic model simulation of the pressures and tank levels with those measured in the field over a 24-hour period, hereinafter referred to as “validation day”. This section describes the data gathering task, validation process, and results.

### 4.2.1 Data Gathering

The required field data were collected through the City’s Supervisory Control and Data Acquisition (SCADA) system, manual field measurements by City staff, and through the installation of temporary pressure loggers (PLs). Fire flow tests were not conducted as part of this model validation task.

Six PLs were distributed throughout the City within zones I, III, III PR North, III PR South, and IV. The objective was to obtain information on the pressures within the City particularly in zones without dedicated storage tanks. Due to its extent and isolation from other zones, two PLs were installed in Zone IV. A data-gathering plan was prepared and submitted to the City to communicate the location of PLs and the required data from the City’s SCADA system. The Model Validation Data Gathering Plan is presented in Appendix D.

The field tests were completed from January 3 to January 5, 2013. Temporary PLs were set to collect data every 5 minutes and were installed at the selected fire hydrants for the duration of the field testing. The location of these PLs are shown on Figure 4.1.

Simultaneously, tank level data from the City’s SCADA system was recorded with 5-minute intervals. In addition, meter readouts at the five turnout locations were recorded manually On January 3, 4 and 5 at around 11:00 AM. The pumps running status (i.e., on/off times) during the field collection period were also obtained from the SCADA. These information are presented in Appendix D.

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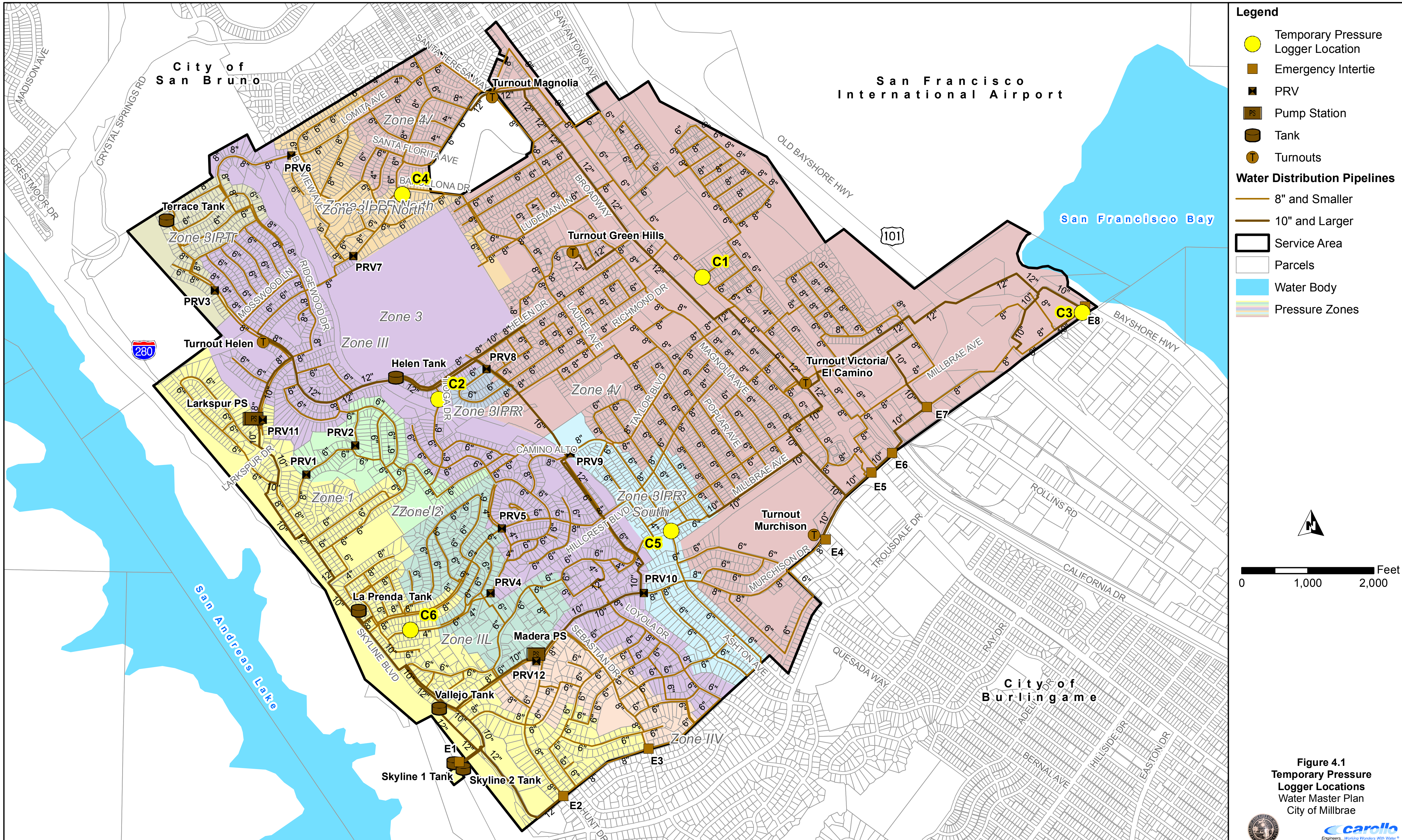


Figure 4.1
Temporary Pressure Logger Locations
Water Master Plan
City of Millbrae

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### 4.2.2 Model Validation Process

The first step to validate the model was to select a validation day over which the model results would be compared to the field measurements. Based on the availability of data, the turnout meter readouts in particular, two possible validation days were available:

- January 3 (11:00 AM) to January 4 (11:00 AM).
- January 4 (11:00 AM) to January 5 (11:00 AM).

Using the recorded meter readouts at the turnout locations and the tank levels, the water demands in these two periods were estimated at about 1.00 MG and 1.34 MG, respectively. These demands were approximately 49 and 65 percent of the average day demands (ADDs) in 2012. Given the typical minimum day demand (MinDD) to ADD ratios, the January 3-4 demand of 1.00 MG appeared to be uncharacteristically low, and therefore, January 4-5 was selected as the validation day.

For the purpose of validation, several parameters needed to be adjusted in the model. These parameters included tank initial levels, pumps on/off periods, turnout HGLs, and pressure zone demands. These adjustments are further described below.

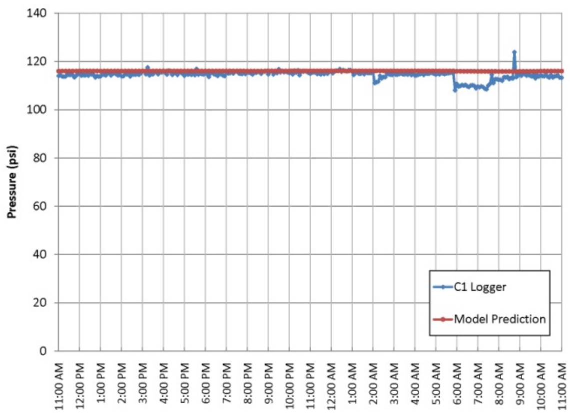
The tank initial levels and pumps on/off periods were adjusted in the model per the SCADA information (Appendix D). As shown, all pumps were off during the validation day except for Larkspur Pump No. 2 and Madera Pump No. 2. The former was running between 21:33 to 12:00 on January 4 (for about 1.5 hrs) and the latter was running from 21:31 on January 4 to 4:33 on January (5 for about 6 hrs).

Using the information from the temporary PLs in Zone III and IV, the turnout HGLs on the validation day were estimated to have been about 456 fmsl in Zone III and 300 fmsl in Zone IV. The HGLs were further fine tuned to produce the same amount of flow as actually delivered via each turnout during the validation day. Furthermore, the pressure setpoint for Murchison PRV was adjusted from 52 to 60 psi to closely simulate pressures within Zone III PR South .

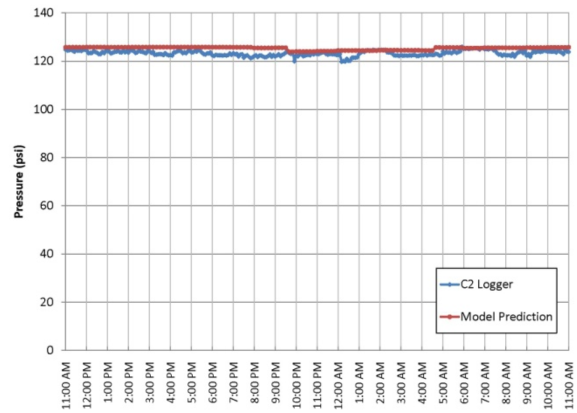
Because of the supply and demand differences at the pressure zone level, the pressure zone demands needed to be adjusted to achieve demand and supply balance. For example, the supply to Zones I-III was about 22 percent higher than the estimated demands in those zones. Subsequently, the supply to Zones IV was about 17 percent lower than the demands in that zone. A global multiplier was applied to demands within each of these pressure zones to achieve supply and demand balance.

### 4.2.3 Model Validation Results

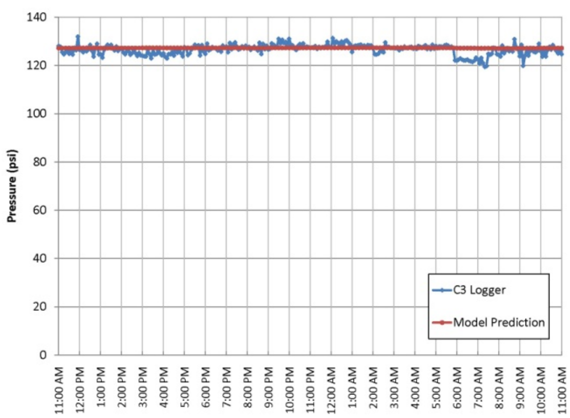
Once all the necessary adjustments were made, the model was run and the simulated pressures and tank levels were compared to field condition obtained from the SCADA. Figure 4.2 shows actual system pressures in comparison with the model predicted pressures on the validation day at four PL locations. PLs C4 and C6 malfunctioned sometimes prior to the validation day. This information is also tabulated and presented in Table 3.8. As shown, the average field pressures during the validation day are within one percent of the model predicted values.



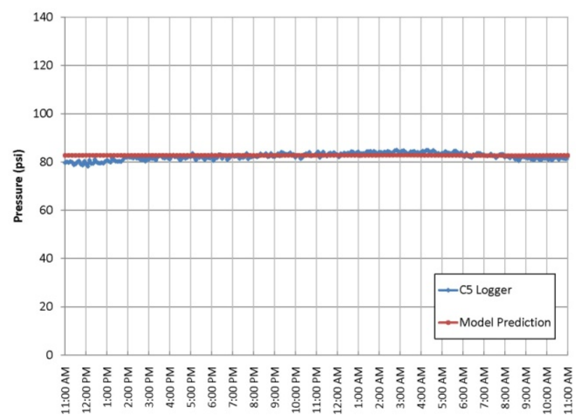

**PL C1 @ Zone IV**




**PL C2 @ Zone III**




**PL C3 @ Zone IV**




**PL C5 @ Zone III PR South**

**Figure 4.2 System Pressure Validation Results**

| Table 4.1 Comparison of Field and Model Pressures in Validation Day<br>Water Master Plan<br>City of Millbrae | | | |
|---|---|---|---|
| **Pressure Logger** | **Zone** | **Average Field Pressures (psi)** | **Model Pressure (psi)** |
| C1 | IV | 116 | 114 |
| C2 | III | 125 | 123 |
| C3 | IV | 127 | 126 |
| C4 | III PR North | NA | 103 |
| C5 | III PR South | 83 | 82 |
| C6 | I | NA | 53 |

While the field and model pressures appeared to be in general agreement, the model predicted that the La Prenda tank drained at a rate much faster than observed in the field. Subsequently, once the water level in La Prenda hit the altitude valve's low-level setpoint, the Skyline tanks filled La Prenda. This was also inconsistent with the field observations. Moreover, the water delivery through Helen turnout was measured to be 897 Hundred Cubic Feet (CCF) in the field, while the simulated delivery was only 520 CCF. These inconsistencies indicated that further adjustment of the model parameters was necessary.

LA Prenda's over draining indicated that too much flow was leaving Zone II. A plausible explanation is that the PRVs serving Zone III from Zone II (Aura Vista and Hillcrest) may have been closed or had setpoints considerably lower than those assumed. If the flows these PRVs are not restricted, the Zone III's southern demands tend to be served via the PRVs while the northern demands are served directly from the Helen turnout. This is because Zone III is stretched across the City. However, if these PRVs are to be closed or their setpoints reduced, the zone's entire demands would be served through the Helen turnout effectively increasing delivery through the Helen turnout.

To verity this explanation, flows through Aura Vista and Hillcrest PRVs were restricted in the model. Upon the adjustment, the delivery through Helen turnout was increased to 845 CCF, close to the actual delivery of 897 CCF. In addition, the La Prenda's draining did not occur and the model was able to accurately simulate tank levels observed in the field. Figure 4.3, Figure 4.4 and Figure 4.5 compare the model simulated tank levels with those observed in the field after restricting flow through Aura Vista and Hillcrest PRVs.

It is recommended that the City verify the pressure setpoints and the status of Aura Vista and Hillcrest PRVs. Restricting flows through these two PRVs would also be expected from the energy management standpoint. Because no pumping is required at the Helen turnout, the City should take advantage of the available HGL at this turnout rather than burning head through the PRVs.

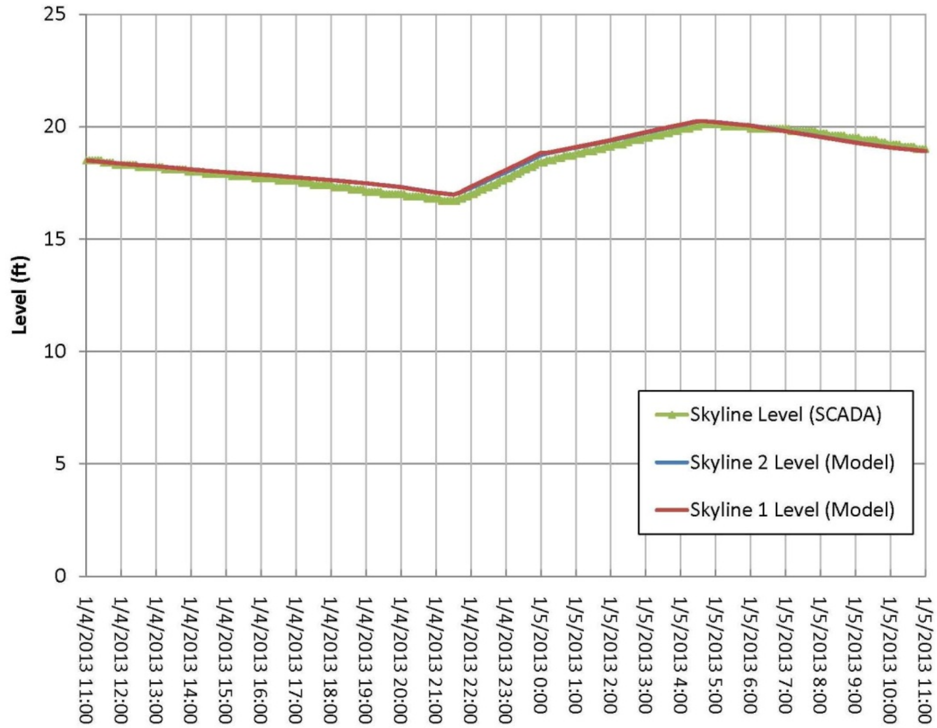



**Figure 4.3 Model Validation Results for Skyline Tanks**

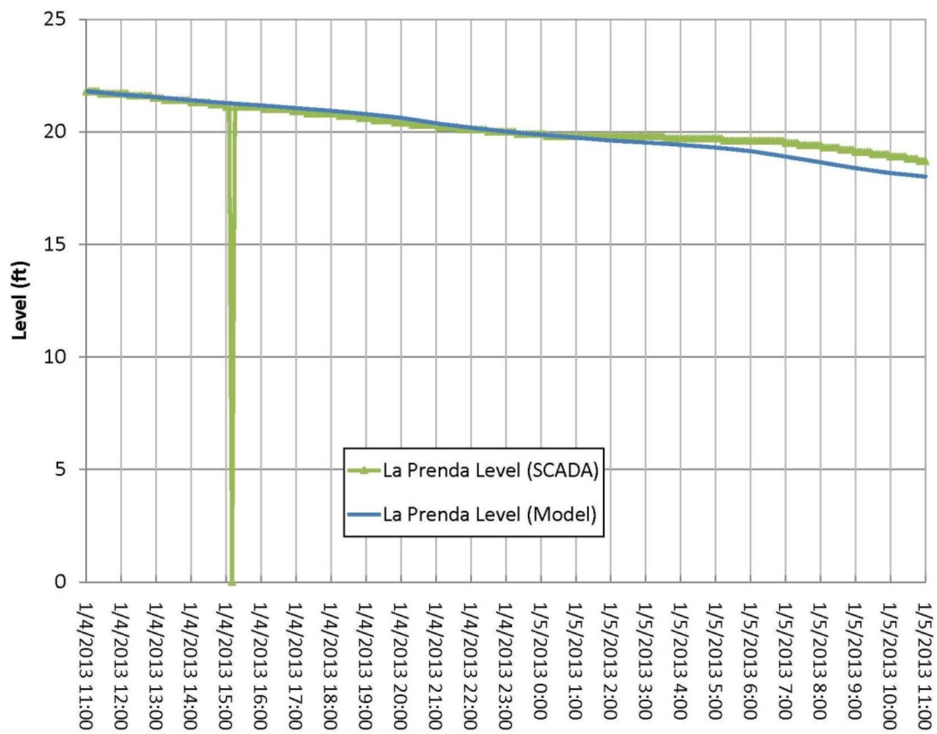



**Figure 4.4 Model Validation Results for La Prenda Tank**

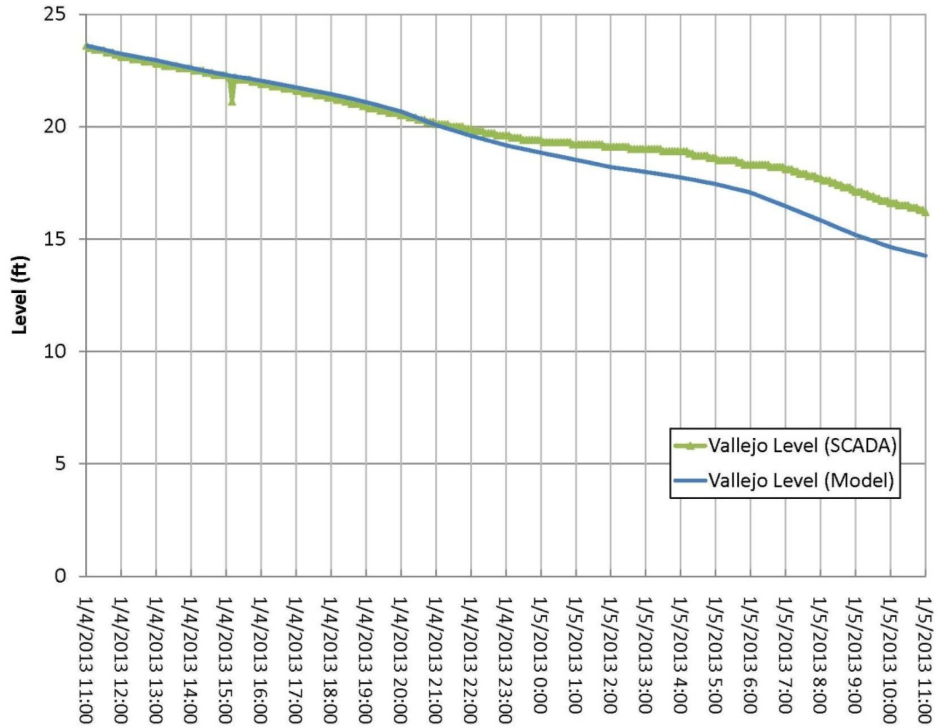



**Figure 4.5 Model Validation Results for Vallejo Tank**

# 5.0 EVALUATION CRITERIA

The City's water system will be evaluated under a range of normal and emergency operating conditions and demand scenarios, as outlined below:

Normal Operating Conditions:

- Average Day Demand (ADD).
- Peak Hour Demand (PHD).
- Maximum Day Demand plus Fire Flow (MDD+FF).

Emergency Operating Conditions:

- Harry Tracy Aqueduct Outage (24 hours), under ADD.
- Hetch Hetchy Aqueduct Outage (24 hours), under ADD.
- Harry Tracy Aqueduct Outage (72 hours), under MinDD.
- Hetch Hetchy Aqueduct Outage (72 hours), under MinDD.

Distribution system evaluation criteria are required to determine the performance of the City's water system under the range of operating conditions as discussed above to identify system deficiencies and improvement projects to address them. Under each operating condition, the capacities and performance of the water system are compared with the evaluation criteria to determine which pipelines or water facilities need to be upgraded or replaced. The evaluation criteria for water systems consist of the following categories:

- System Pressure.
- Pipeline Velocity.
- Storage Volume.
- Pump Station Capacity.
- PRV Station Capacity.

The criteria used in the 1983 master plan were reviewed and compared with typical planning criteria used in the systems of similar water utilities, local codes, engineering judgment, and commonly accepted industry standards. A list of recommended criteria used in the evaluation of the City's distribution system is presented in Table 5.1.

**Table 5.1 Distribution System Evaluation Criteria**
**Water Master Plan**
**City of Millbrae**

| Description | Value | Units |
|---|---|---|
| **Maximum Pressure** | | |
| Average Day Demand (ADD) | 125 | psi |
| **Minimum Pressure** | | |
| Peak Hour Demand (PHD) | 40 | psi |
| Maximum Day Demand (MDD) + Fire Flow | 20 | psi |
| Supply Outage Scenarios (SOS) | 20 | psi |
| **Pipeline Criteria** | | |
| Maximum Velocity with ADD | 5 | fps |
| Maximum Velocity with PHD | 7 | fps |
| Maximum Velocity with MDD + FF and SOS | 10 | fps |
| Pipelines Within Pump Stations | 10 | fps |
| Hazen-Williams C-factor | 130 | n/a |
| Minimum Size for Pipeline Replacement | 8 | Inches |
| **Fire Fighting Capabilities** | | |
| Residential | 1,500 | gpm for 2 hours |
| General Commercial & Millbrae Station Area SP | 2,000 | gpm for 2 hours |
| Public Facilities | 2,000 | gpm for 2 hours |
| Industrial and Utilities | 2,000 | gpm for 2 hours |
| Park and Open Space | 1,000 | gpm for 2 hours |
| **Storage Volume** | | |
| Operational | Varies | |
| Fire Fighting | Highest zone fire flow requirement | |
| Emergency | Varies | |
| **Pump Stations/PRV Stations** | | |
| For zones with storage, the facility has to meet the MDD of the zone it serves(1). | | |
| For zones without storage, the facility has to meet the PHD or MDD+FF of the zone it serves, whichever is greater. | | |

Notes:
1. With the largest single pump/valve out of service.

## 5.1 System Pressures

Minimum system pressures are evaluated under different conditions: Peak Hour Demand (PHD), Maximum Day Demand (MDD) plus fire flow and outage scenarios. Maximum system pressures are evaluated under Average Day Demand (ADD).

The minimum pressure design criterion is 40 psi for PHD. Under MDD plus fire flow conditions and supply outage scenarios (SOS), the pressures are allowed to drop to as low as 20 psi. The maximum pressure criterion under ADD is 125 psi.

## 5.2 Pipeline Velocities

Pipeline velocities are evaluated using three different maximum velocity criteria for selected flow conditions under both existing and future demand scenarios. For transmission and distribution pipelines, a maximum velocity of 5 feet per second (fps) and 7 fps were used for average day demand and peak hour demand conditions, respectively. Fire hydrant laterals are excluded from these criteria, as higher velocities are acceptable. Under fire conditions and supply outage scenarios, velocities of up to 10 fps were allowed. Ideally, all transmission and distribution pipelines should have maximum velocities less than 7 fps in order to minimize headloss; however, higher velocities in existing pipelines is not, by itself, sufficient justification for pipeline replacement.

## 5.3 Storage Capacity

The total storage required for a water system is evaluated in three components.

- Storage for operational use.
- Storage for fire-fighting.
- Storage for emergencies.

These three components are determined for each pressure zone to evaluate the ability of the water system to meet the storage criteria on both a zone-by-zone basis, as well as a system-wide basis. These three storage requirements are discussed in more detail below.

### 5.3.1 Operational Storage

Operational storage is defined as the quantity of water that is required to meet daily fluctuations in demand beyond the quantity of water that is produced on a daily basis. It is necessary to coordinate the production rates of water sources and the available storage capacity in a water system to ensure that a continuous treated water supply is provided to the system. Water systems are often designed to produce the average flow on the day of maximum demand. Water storage is then used to supply water for peak flows that may occur throughout the day. This operational storage is replenished during off peak hours when the demand is less.

For the City, the operational storage requirements for the different pressure zone groups were estimated on a case-by-case basis by comparing diurnal demands and supplies within each group. More information regarding the required operational storage is provided in Section 0.

### 5.3.2 Fire Flow and Storage

The maximum fire flow requirements for various land use categories are presented in Table 5.1. These fire flows are based on the City's Department of Public Works requirements (Millbrae, 2005) and typical values for municipalities and discussions with the City's Fire Department.

Fire flow storage is determined based on the single greatest fire flow requirement (flow and duration) within each zone. When multiple zones are fed by the same reservoir, these zones are combined and the highest fire flow among them is used to determine the necessary storage requirement. More information regarding required fire flow storage by pressure zone group is included in Section 7.3.2.

### 5.3.3 Emergency Storage

The volume of water that is needed during an emergency is usually based on past experience and on the estimated time expected to lapse before the emergency is corrected. Possible emergencies include earthquakes, water contamination, several simultaneous fires, unplanned electrical outages, pipeline ruptures, or other unplanned events. Since the occurrence and magnitude of emergencies is difficult to predict, emergency storage criteria are based on past experience and engineering judgment. Typically, emergency storage is set as a percentage of either average day, minimum day, or maximum day demand.

As previously discussed, the following four emergency operating conditions evaluated as part of Master Plan include:

- 24-hour outage of Harry Tracy WTP under ADD conditions
- 24-hour outage of Hetch Hetchy aqueduct under ADD conditions
- 72-hour outage of Harry Tracy WTP under MinDD conditions
- 72-hour outage of Hetch Hetchy aqueduct under MinDD conditions

As described in Section 2.4, the minimum day factor (i.e., the ratio of MinDD to ADD) for the City is estimated to be about 0.65 (Table 2.8). Therefore, the 72-hour outage scenarios will require approximately 1.95 times the ADD. Hence, the 72-hour outage scenarios are the governing scenarios for calculating the emergency storage requirements.

### 5.3.4 Pump Station Capacity

The City is fortunate to be able to take advantage of the hydraulic grade lines of the SFPUC aqueducts to minimize and thus minimize pumping. The City currently has two pump stations serving zones I and II. For these zones, the pump stations must provide maximum day demands with the largest single pump out of service (also referred to as "fire capacity").

Peak hour demands of zones III and IV are served directly via SFPUC's aqueducts without any pumping.

### 5.3.5 PRV Station Capacity

There are a few zones within the City's water system that are either served solely through a PRV station or are served through a pressure reducing station in addition to a booster station or a supply source. In the latter case, the pressure reducing station may serve the zone in conjunction with the booster station, or may act as an emergency supply. For the zones where it is necessary to rely on a pressure reducing station to meet demands, the capacity is evaluated under two different scenarios.

- For pressure zones with storage (Zone II), the PRV stations should provide the maximum day demands of the zones they serve.
- For pressure zones without storage (Zones III, III PT, III PR, III PR North and III PR South), the PRV stations should provide the peak hour demands or maximum day demands plus fire flows of the zones they serve, whichever is larger.

The hydraulic model will be used to evaluate the ability of the PRV stations to satisfy the demands within each zone with the largest single PRV out of service.

# 6.0 SEISMIC ASSESSMENT OF STORAGE TANKS

Millbrae is located in a seismically active region that has a number of earthquake faults located within the immediate vicinity. The western reaches of the City is traversed by the San Andreas Fault Zone that is responsible for the creation of San Andreas Lake and the numerous sag ponds that occur along the fault. Additionally, the San Andreas Fault has an Alquist-Priolo (AP) zone associated with it that is located just to the west of the City's boundaries. Within the AP zone, the potential for fault rupture has been considered to be relatively high. In addition, the Hayward and Calaveras Faults have the potential to impart significant damage to buildings and infrastructure in the City and are also a significant concern.

To evaluate storage tanks performance against seismic events, historical dive reports and tank drawings were reviewed and a site visit to each reservoir was conducted to document field conditions and identify and upgrades that were not represented in the drawings. A seismic evaluation of the reservoirs was performed based upon the provisions set forth in the 2011 edition of AWWA D 100, Welded Carbon Steel Tanks for Water Storage. Appendix E presents the storage tanks observations, seismic evaluation results, and recommendations. A summary of findings and recommendations are presented in this section.

## 6.1 Seismic Analysis

In seismic analysis of steel tanks, three key considerations are taken into account: freeboard requirements, anchorage requirements, and tank shell stress analysis.

**Freeboard requirements**

Sloshing of the tank contents during an earthquake create waves that will induce additional loads on the tank wall and roof shells. The current design guidelines of AWWA D 100, and California Building Code require additional allowance made in the height of the tank to accommodate the sloshing wave.

Based on the analysis performed, the deficit heights for sloshing wave accommodation range from 4.5 to 12.1 feet for various tanks.

**Anchorage requirements**

High seismic demand on the tank and its contents may create overturning moments or may cause the tank to slide. To evaluate the risk of sliding or overturning a factor of safety can be calculated.

All tanks were determined to have insufficient factors of safety and require anchoring to avoid overturning or significant damage during an earthquake.

**Tank Shell Stress Analysis**

The increased stresses created in the tank due to the seismic loads are calculated, as outlined in AWWA D 100, in order to avoid excessive damage to the tank shells and roof during an earthquake. The shell stresses were analyzed assuming the “self-anchored” condition, since none of the tanks are anchored to their foundations.

In all tanks except for the Vallejo tank, the shell appears to be designed for the hydrostatic forces and does not consider seismic loads. Analysis shows the tank shells to be deficient in resisting hydrodynamic hoop tension. Therefore, during a seismic event the tank shell can be expected to sustain damage and possibly a catastrophic loss of contents.

Considering that the tanks require anchoring, tank shells were also analyzed assuming “anchored” condition (per AWWA D 100). Stress analysis of the tanks shows that all tanks, including the Vallejo tank, are deficient for compression buckling. This deficiency may cause bulging at the base, known as “elephant foot buckling” or shell floor failure.

## 6.2 Summary of Seismic Analysis Findings

This section presents the recommended alternatives based on the field inspections, and the structural analysis performed. Table 6.1 summarizes the recommended alternatives for each tank. Different retrofit recommendations for each tank are grouped together in three alternatives.

It should be noted that corrosion of the tank shell contributes to weakening and potential failure of the shell during a seismic event. If not addressed, the rate of the corrosion of the steel members will gradually accelerate. In order to remediate the corrosion of the steel tanks effectively, sand blasting the steel members, and reapplying coating is recommended.

Cost estimates for each retrofit alternative are presented in next section.

**Table 6.1 Summary of Recommended Retrofit Alternatives**
**Water Master Plan**
**City of Millbrae**

| Tank | Alternative 1 Drilled Shafts Anchors | Alternative 2 Soil Anchors | Alternative 3 Replacement of All Tanks |
|---|---|---|---|
| La Prenda | Replace Bottom 10 feet of Tank Shell, Raise Roof, Install Anchors, Apply Coating | Replace Bottom 10 feet of Tank Shell, Raise Roof, Install Anchors, Apply Coating | Replace Tank |
| Skyline 1 (North) | Replace Tank | Replace Tank | Replace Tank |
| Skyline 2 (South) | Replace Bottom 10 feet of Tank Shell, Raise Roof, Install Anchors, Apply Coating | Replace Bottom 10 feet of Tank Shell, Raise Roof, Install Anchors, Apply Coating | Replace Tank |
| Vallejo | Replace Bottom 4 feet of Tank Shell, Raise Roof, Install Anchors, Apply Coating | Replace Bottom 4 feet of Tank Shell, Raise Roof, Install Anchors, Apply Coating | Replace Tank |
| Helen | Replace Bottom 4 feet of Tank Shell, Raise Roof, Install Anchors, Apply Coating | Replace Bottom 4 feet of Tank Shell, Raise Roof, Install Anchors, Apply Coating | Replace Tank |

## 6.3 Estimate of Alternative Retrofit Costs

The estimated construction costs presented in this section are based on preliminary structural retrofit recommendations developed herein and include retrofit of the tanks for sloshing loads.

The estimated construction costs for each structure were developed based on a variety of sources. Once the initial costs were prepared, a 30 percent contingency was applied to reflect uncertainties at the pre-design stage and assumptions used in the estimating methods.

A summary of retrofit projects and the estimated costs associated with them are presented in Table 6.2. If the tank water surface elevations were lowered, the total project cost would be approximately $1,500,000 less for alternatives 1 and 2.

**Table 6.2 Comparison of Construction Cost Estimates for Retrofit Alternatives**
**Water Master Plan**
**City of Millbrae**

| Tank | Alternative 1 Drilled Shafts Anchors | Alternative 2 Soil Anchors | Alternative 3 Replacement of All Tanks |
|---|---|---|---|
| La Prenda | $1,029,500 | $876,500 | $1,888,500 |
| Skyline 1 (North) | $2,869,000 | $2,869,000 | $2,869,000 |
| Skyline 2 (South) | $1,127,000 | $1,012,500 | $2,307,500 |
| Vallejo | $445,500 | $426,500 | $815,500 |
| Helen | $643,500 | $566,500 | $1,310,000 |
| **Total** | **$6,113,500** | **$5,741,000** | **$9,190,500** |
| **Total with lowered water levels** | **$4,613,500** | **$4,241,000** | **n/a** |

## 6.4 Seismic Retrofit Conclusions

Based on the findings of the seismic analysis of the City's storage tanks, each tank will need to be retrofitted or replaced. In addition, the storage capacity evaluation and the emergency improvement alternatives analysis, indicate that the City does not have enough existing storage capacity to meet the emergency storage requirements. To address these issues, Carollo prepared an Emergency Improvements Alternatives technical memorandum (Appendix F), which identified several options to address the shortfall. Based on City staff input, it was decided that the City would construct a new Skyline Tank, to be located at the existing Skyline Tanks site, which would serve as the sole source of storage within the City's distribution system. The selected emergency improvement storage alternative is described in greater detail in Chapter 7.0.

## 7.0 SYSTEM EVALUATION

This section presents the results of the capacity evaluation of the water supply, distribution, and storage facilities. This section also presents improvements to mitigate existing system deficiencies and to serve future users. These improvements are recommended based on the system's technical requirements, cost effectiveness, and reliability.

### 7.1 Emergency Improvement Alternatives

As previously discussed, the City's water distribution system is broken up into two independent systems. Pressure Zone Groups I, II, and III are served by the Harry Tracy WTP, whereas Zone IV is served by multiple turnouts on the Hetch Hetchy Aqueduct. Pressure Zone Groups I, II, and III are hydraulically disconnected from Zone IV.

Lack of redundant supplies within each of the independent systems is problematic because it makes the City vulnerable to potential outages of the Harry Tracy WTP and/or the Hetch Hetchy aqueduct. The problem is more evident for Zone IV (unlike Pressure Zone Groups I, II, and III), because no storage or receiving intertie with neighboring cities is available for use during emergencies.

Carollo developed and evaluated several emergency improvement alternatives that allow the upper and lower zones to provide supply during an emergency situation where one of the two sources may be out of service. The results of this analysis are presented in an Emergency Improvements TM, which is provided in Appendix F for reference. Ultimately, the City selected a hybrid of two alternatives identified in the TM. The main features of the selected emergency improvement alternative are shown on Figure 7.1, and are briefly discussed below:

- **New Skyline Tank:** Based on discussion with City staff, it was determined that the Vallejo tank would be eliminated in the future to simplify operations. Furthermore, it was assumed that the Skyline and La Prenda tanks would be replaced in lieu of seismic retrofits. Several options were considered based on these premises, and the City's preferred option was to consolidate all storage at the Skyline Tank site.
- **New Transmission Main/PRVs from Skyline Tank:** In order to adequately convey water from the new consolidated Skyline Tank to Pressure Zone Groups I, II, III, and IV, 7,000 feet of new transmission main would be constructed along Vallejo Drive, Madera Way, Ashton Avenue, and Millbrae Avenue. Water from the transmission main would enter Pressure Zone Groups II and III through two new PRV stations. Water could be conveyed to Zone IV through a normally closed PRV station in the event of an outage at the Hetch Hetchy Aqueduct. The connection to Zone IV would be at the intersection of Millbrae Avenue and Palm Avenue.
- **New Booster Pump Station/Transmission Main:** In the event of an outage at the Harry Tracy WTP, a new booster pump station and approximately 900 feet of new

transmission main was proposed near the Green Hills Turnout, which would pump water from Zone IV into Pressure Zone Group III.

- **PRV Station:** A new PRV station was also proposed to provide an additional connection from Pressure Zone Group III to Zone IV. The new PRV station would connect to the existing 10-inch diameter pipeline on Helen Drive.

The emergency improvements associated with the City's preferred emergency improvement alternative were used as the basis for the development of capital improvement projects (see Section 7.5). Additional pipeline improvements were also necessary to address system pressure and fire flow deficiencies, as summarized in the following sections.

## 7.2 Supply Analysis

Table 7.1 summarizes the projected (year 2035) water demands by pressure zone group. As shown in Table 7.1, the City's projected MDD for year 2035 is estimated to be 6.08 mgd. Of the 6.08 mgd, roughly 57-percent (3.45 mgd) of the demand is associated with Pressure Zone IV. The remaining 43-percent (2.63 mgd) MDD is associated with Pressure Zone Groups I, II, and III.

**Table 7.1 Definition of Pressure Zone Groups and Future (2035) Demands**
**Water Master Plan**
**City of Millbrae**

| Group | Pressure Zones | MinDD (mgd) | ADD (mgd) | MDD (mgd) | PHD (mgd) |
|---|---|---|---|---|---|
| I | 1, 2S, 3PT | 0.25 | 0.39 | 0.78 | 1.28 |
| II | 2L, 2V | 0.12 | 0.18 | 0.36 | 0.59 |
| III | 3, 3PR, 3PR South, 3PR North | 0.48 | 0.74 | 1.49 | 2.32 |
| **Group I, II, and III Subtotal** | | **0.85** | **1.31** | **2.63** | **4.10** |
| IV | 4 | 1.12 | 1.72 | 3.45 | 5.71 |
| **Group IV Subtotal** | | **1.12** | **1.72** | **3.45** | **5.71** |
| **Total** | | **1.97** | **3.04** | **6.08** | **9.80** |

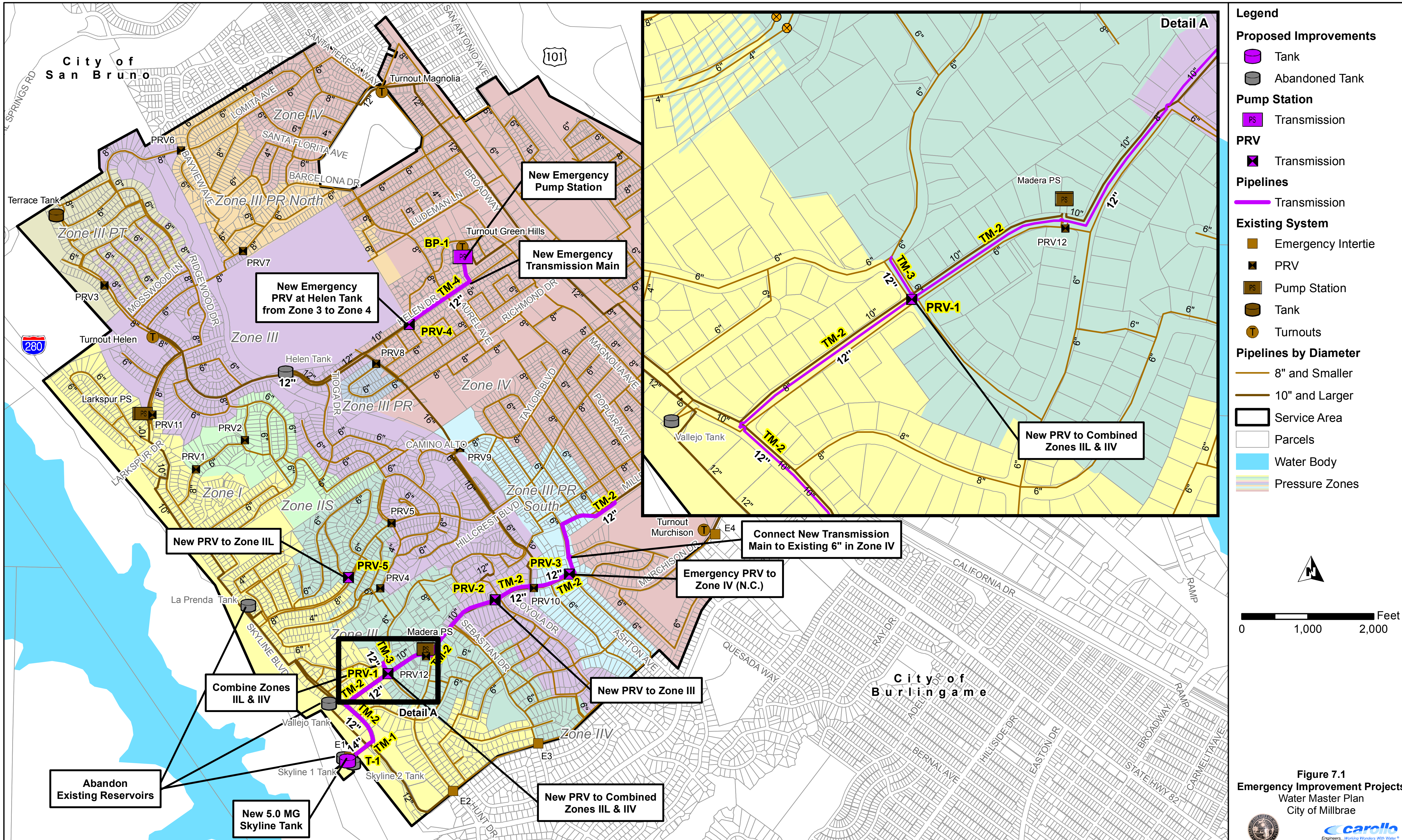



Figure 7.1
Emergency Improvement Projects
Water Master Plan
City of Millbrae

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The water supply requirements for the City under existing and future demand conditions were determined by comparing the available water supplies with the projected water demands. This is accomplished by comparing the projected MDD to the reliable water supply capacity for the Pressure Zone Groups with storage (PHDs are met through storage), as documented in Table 7.2. For pressure zone groups without storage (i.e., Zone IV), the supply capacity must be capable of meeting the PHD.

**Table 7.2 Supply Capacity Analysis**
**Water Master Plan**
**City of Millbrae**

| Supply Scenario | Demands | | | Supply Capacity | | | Excess Supply[(2)] (mgd) |
|---|---|---|---|---|---|---|---|
| | 2035 MDD (mgd) | 2035 PHD (mgd) | Required Supply[(1)] (mgd) | Harry Tracy (mgd) | Hetch Hetchy Aqueduct (mgd) | Total Supply Capacity (mgd) | |
| **Normal Operating Conditions** | | | | | | | |
| Harry Tracy Supply to Group I, II, and III | 2.63 | 4.10 | 2.63 | 6.48 | -- | 6.48 | 3.85 |
| Hetch Hetchy Supply to Group IV | 3.45 | 5.71 | 5.71 | -- | 12.67 | 12.67 | 6.96 |
| **Emergency Operating Conditions (After Emergency Improvements are Constructed)** | | | | | | | |
| Harry Tracy Out of Service | 6.08 | 9.80 | 6.08 | 0 | 12.67 | 12.67 | 6.59 |
| Hetch Hetchy Out of Service | 6.08 | 9.80 | 6.08 | 6.48 | 0 | 6.48 | 0.40 |

Notes:
1. Required supply is the 2035 MDD, except for normal operating conditions for Group IV. Under normal operating conditions, Zone IV will not have storage, and therefore the supply must be capable of meeting the PHD. Storage is available at the proposed consolidated Skyline Tank for all other supply scenarios.
2. Excess Supply = Total Supply Capacity – Required Supply.

The supply analysis considers both normal and emergency operating conditions, as described below:

- Harry Tracy Supply to Pressure Zone Groups I, II and III.
- Hetch Hetchy Supply to Zone IV.
- Harry Tracy Out of Service.

- Hetch Hetchy Out of service.

As shown in Table 7.2, the City will have sufficient supply capacity under normal operating conditions to meet the future (year 2035) demand condition, and to provide for emergency operating conditions after the emergency improvements indentified in Section 7.1 are constructed.

## 7.3 Storage Analysis

The City currently has four active storage tanks with a combined volume of 2.1 million gallons (MG). Storage capacity, design criteria, and area designation are described in Section 5.0. The purpose of these tanks are to address three components; (1) operational equalization storage to meet peak hour demands (PHDs), (2) fire flow storage (see ) and (3) emergency storage.

### 7.3.1 Operational Storage

As shown in Table 7.3, the City's operational storage requirement is estimated to be 1.04 MG and 1.34 MG for existing (2012) and future (2035) demand conditions, respectively. For more detailed information regarding how the operational storage volumes are calculated, refer to Appendix F.

**Table 7.3 Operational Storage Requirements**
**Water Master Plan**
**City of Millbrae**

| Pressure Zone Group | Existing (MG) | Future (MG) |
|---|---|---|
| Group I | 0.75 | 1.02 |
| Group II | 0.29 | 0.32 |
| Group III | 0.0(1) | 0.0(1) |
| Group IV | 0.0(1) | 0.0(1) |
| **Total Storage Needs** | **1.04** | **1.34** |

Note:
1. Operational storage is not required in Pressure Zone Group III or Group IV, because peak demands in these zones are provided by Harry Tracy WTP or the Hetch Hetchy Aqueduct.

### 7.3.2 Fire Storage Requirements

The required fire storage within each group is determined based on the single greatest fire flow requirement (flow and duration) within each group. Table 7.4 presents a summary of governing land use and corresponding fire flow and storage requirements. As shown, the governing land use within Group 1 is general commercial and public facility with a fire flow requirement of 2,000 gpm for 2 hours resulting in 0.24 MG of fire flow storage. The governing land use within Group 2 is low density residential with a fire flow requirement of 1,500 gpm for 2 hours resulting in 0.18 MG of fire flow storage. Due to the absence of existing storage facilities, the fire flow for Groups 3 and 4 were assumed to be directly supplied from Harry Tracy WTP and Hetch Hetchy aqueduct, respectively. Therefore, no fire flow storage was planned for these groups.

**Table 7.4 Fire Flow Requirements and Storage Needs**
**Water Master Plan**
**City of Millbrae**

| Pressure Zone Group | Governing Land Use(1) | Required Fire Flows(2) | Fire Flow Storage(3) (MG) |
|---|---|---|---|
| I | General Commercial/Public Facility | 2,000 gpm, 2 hrs | 0.24 |
| II | Low Density Residential | 1,500 gpm, 2 hrs | 0.18 |
| III | Public Facility | 2,000 gpm, 2 hrs | 0(4) |
| IV | General Commercial/Public Facility/MSA | 2,000 gpm, 2 hrs | 0(4) |
| **Total** | | | **0.42** |

Notes:
1. Per General Plan Land Use Map
2. Per Table 5.1
3. Assumes one fire within each group, and is based on the greatest fire flow requirement.
4. Assumes fire flow is supplied through Harry Tracy WTP or Hetch Hetchy aqueduct.

### 7.3.3 Emergency Storage Requirements

As discussed in Section 5.3.3, the 72-hour MinDD outage scenarios govern for the emergency storage requirement. Table 7.5 and Table 7.6 present estimated future MinDDs and the required emergency storage volume for each pressure zone for existing and future demand conditions, respectively. As shown, the Group IV emergency storage requirement (2.4 MG existing, 3.4 MG future) is larger than the combined emergency storage needs of Groups I, II and III (1.8 MG existing, 2.6 MG future). This is key because the recommendations in this Master Plan will use the higher number for sizing of storage tanks for the Emergency Scenarios.

| Table 7.5 | Existing (2012) Emergency Storage Needs<br>Water Master Plan<br>City of Millbrae | | | | |
|---|---|---|---|---|---|
| **Pressure Zone** | **MinDD (mgd)** | **Emergency Storage Needs (MG)** | | | |
| | | **Group 1** | **Group 2** | **Group 3** | **Group 4** |
| Zone I | 0.13 | 0.38 | - | - | - |
| Zone III PT | 0.03 | 0.08 | - | - | - |
| Zone II S | 0.02 | 0.07 | - | - | - |
| Zone II V | 0.04 | - | 0.13 | - | - |
| Zone II L | 0.04 | - | 0.11 | - | - |
| Zone III | 0.23 | - | - | 0.69 | - |
| Zone III PR/PR S/PR N | 0.12 | - | - | 0.36 | - |
| Zone IV | 0.78 | - | - | - | 2.35 |
| **Total** | **1.39** | **0.53** | **0.24** | **1.05** | **2.35** |

| Table 7.6 | Future (2035) Minimum Day Demands and Emergency Storage Needs<br>Water Master Plan<br>City of Millbrae | | | | |
|---|---|---|---|---|---|
| **Pressure Zone** | **MinDD (mgd)** | **Emergency Storage Needs (MG)** | | | |
| | | **Group I** | **Group II** | **Group III** | **Group IV** |
| Zone I | 0.18 | 0.54 | - | - | - |
| Zone III PT | 0.04 | 0.11 | - | - | - |
| Zone II S | 0.04 | 0.11 | - | - | - |
| Zone II V | 0.05 | - | 0.16 | - | - |
| Zone II L | 0.07 | - | 0.20 | - | - |
| Zone III | 0.31 | - | - | 0.93 | - |
| Zone III PR/PR S/PR N | 0.17 | - | - | 0.52 | - |
| Zone IV | 1.12 | - | - | - | 3.36 |
| **Total** | **1.97** | **0.76** | **0.36** | **1.45** | **3.36** |

### 7.3.4 Summary of Storage Requirements

Table 7.7 and Table 7.8 summarizes the required storage needs for both existing (2012) and future (2035) demand conditions, respectively. The following sections summarize the information presented in these tables. As shown, all groups are deficient and in need of additional storage. It can also be concluded that the current storage is sufficient to meet future (2035) operational and fire storage needs and that the emergency storage, which is the largest component, creates the deficiency in each group. To address emergency deficiencies, several alternative improvements were developed. These alternatives are described in Appendix F.

| Table 7.7 Existing (2012) Storage Requirements and Availability Comparison<br>Water Master Plan<br>City of Millbrae | | | | |
|---|---|---|---|---|
| **Storage Component** | **Group I** | **Group II** | **Group III** | **Group IV** |
| Emergency | 0.53 | 0.24 | 1.05 | 2.35 |
| Fire Storage Needs | 0.24 | 0.18 | 0 | 0 |
| Operational Needs | 0.75 | 0.29 | 0 | 0 |
| **Total Storage Needs** | **1.52** | **0.71** | **1.05** | **2.35** |
| Total Available Storage | 1.50 | 0.61 | 0 | 0 |
| **Surplus/Deficit** | **-0.02** | **-0.10** | **-1.05** | **-2.35** |

| Table 7.8 Future (2035) Storage Requirements and Availability Comparison<br>Water Master Plan<br>City of Millbrae | | | | |
|---|---|---|---|---|
| **Storage Component** | **Group I** | **Group II** | **Group III** | **Group IV** |
| Emergency | 0.76 | 0.36 | 1.45 | 3.36 |
| Fire Storage Needs | 0.24 | 0.18 | 0 | 0 |
| Operational Needs | 1.02 | 0.32 | 0 | 0 |
| **Total Storage Needs** | **2.23** | **0.83** | **1.45** | **3.36** |
| Total Available Storage | 1.50 | 0.50(1) | 0 | 0 |
| **Surplus/Deficit** | **-0.52** | **-0.36** | **-1.45** | **-3.36** |

Note:
1. Assuming Vallejo tank is eliminated in the future.

As previously mentioned, the City's preferred emergency improvement alternative is to combine all storage within the system in a new consolidated Skyline Tank. Table 7.9 summarizes the required storage volume for this option. As shown in Table 7.9, it is recommended that the City construct a new 5 MG tank at the site of the existing skyline storage facility. The new reservoir, in conjunction with the other emergency improvement alternatives described in Section 7.1, will provide the City with sufficient storage through the year 2035.

| Table 7.9 | Alternative Storage Requirements<br>Water Master Plan<br>City of Millbrae |
|---|---|
| **Storage Component** | **Volume (MG)** |
| Higher Zones Emergency | 2.57 |
| Lower Zone Emergency | 3.36 |
| Emergency$^{(1)}$ | 3.36 |
| Operational | 1.34 |
| Fire | 0.24 |
| **Total Storage** | **4.94** |

Note:

1. The emergency storage is the greater of the higher and lower zone emergency storage requirements.

## 7.4 Distribution System Analysis

This section presents the results of the system pressure analysis and fire flow analysis of the City's water distribution system. Recommendations to address system deficiencies are presented in Section 7.5.

In accordance with the criteria presented in Chapter 5.0, system pressure analyses were performed using the hydraulic model for MDD, PHD, and MDD plus fire flow conditions. This following summarizes the results of the analysis for existing and future demand conditions.

- **Existing System.** For each demand condition (i.e., ADD, PHD, and MDD+FF), the hydraulic model was used to identify service nodes within the distribution system with pressures that violate the established pressure criteria (Per Table 5.1). Based on these results, the following are noted:
  - Average Day Demand: For existing ADD conditions, the hydraulic model shows that 36 nodes exhibited pressures that exceed the recommended maximum pressure of 125 psi. The locations of these nodes are shown on Figure 7.2. Based on discussions with City staff and due to the very steep topography of the City, it is impractical to implement projects to rezone these areas to reduce pressures below 125 psi. Furthermore, areas where pressures exceed 80 psi are typically served by individual service connection PRVs. Therefore, no recommendations to address these high pressure areas are included in this Master Plan. However, the City could consider a rezone study in the future if it is determined that high pressures in these area are a concern.

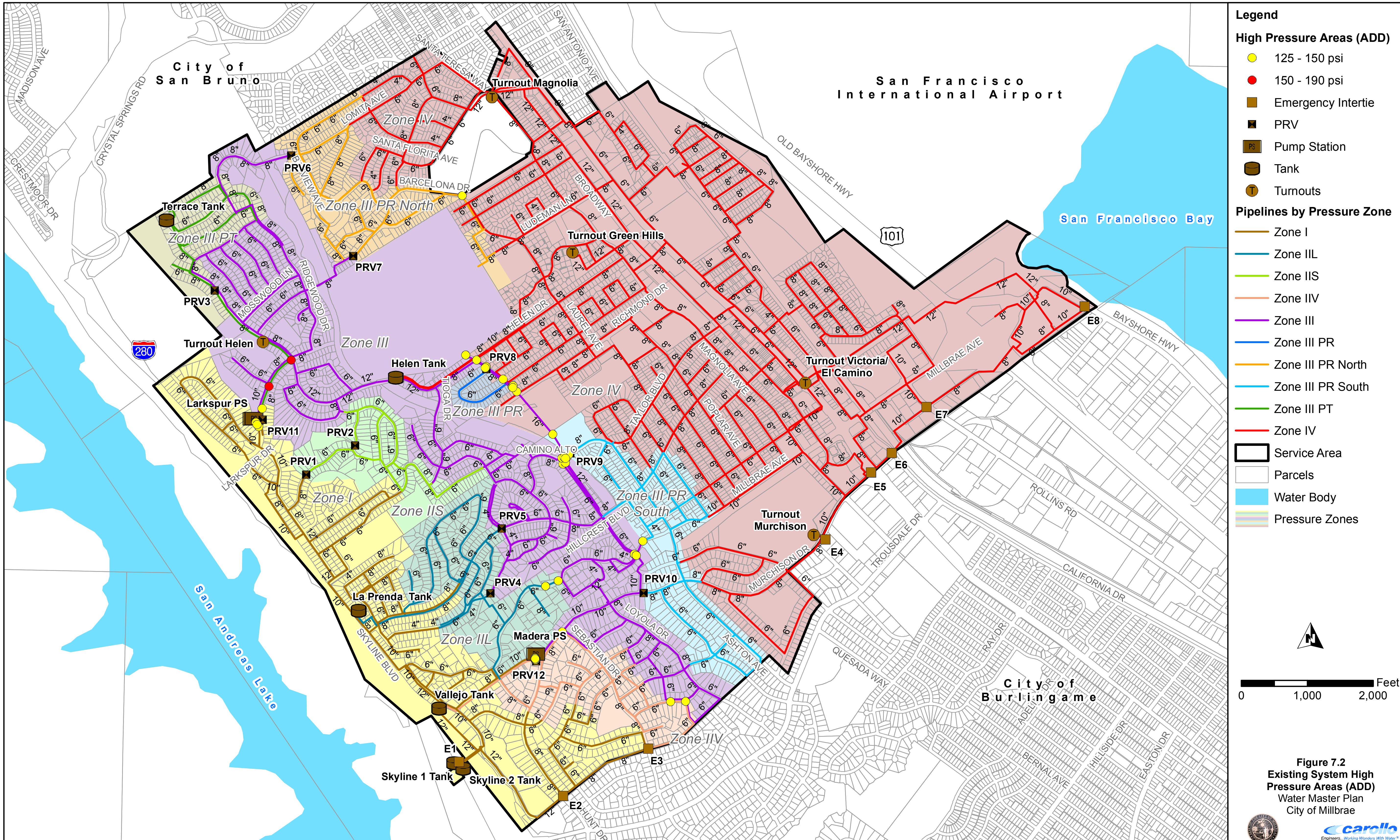


**Figure 7.2**
**Existing System High Pressure Areas (ADD)**
Water Master Plan
City of Millbrae

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- Peak Hour Demand: The hydraulic modeling results for existing PHD conditions showed that 58 nodes had pressures that violated the minimum pressure criteria of 40 psi. The locations of these nodes are shown on Figure 7.3. The deficient service nodes are primarily located in the higher elevation areas of Zone III.
- Maximum Day Demand plus Fire Flow: Hydraulic modeling results for MDD plus fire flow conditions showed that 91 hydrant nodes had residual pressures less than the minimum residual pressure criteria of 20 psi. The locations of these nodes are shown on Figure 7.4. Most of the deficient nodes are located in Zones I, II, and III, with just a few deficient nodes located in Zone IV. These deficiencies are chiefly caused by small diameter pipelines (4-inch and 6-inch diameter pipes) serving neighborhoods in the hilly area of the City that are incapable of conveying the required fire flow. In addition to the emergency improvement projects discussed in Section 7.1, several smaller diameter pipelines will need to be replaced through Zones I, II, and III to address this issue (See Section 7.5).

- **Future System.** The future system analysis was performed in a manner similar to the existing system analysis. The purpose of the future system evaluation is to verify that that the build out water demands do not create additional deficiencies within the existing distribution system. Based on the hydraulic modeling results of the future water distribution system, the following are noted:
- Average Day Demand: As would be expected, no additional high pressures were simulated in the future system hydraulic model beyond those identified in the existing system evaluation (Figure 7.5).
  - Peak Hour Demand: As shown on Figure 7.6, two additional nodes violated the minimum pressure criterion of 40 psi under PHD conditions for the future demand condition. However, neither of these two nodes will require improvement projects to address the future system deficiency, because the existing system deficiencies targeted for adjacent nodes within the system will address these two areas as well.
- Maximum Day Demand plus Fire Flow: As shown on Figure 7.7, no additional fire flow deficiencies were observed under future demand conditions beyond those identified in the existing system evaluation.
- **Supply Outage Analysis.** Following the existing system and future system analysis, improvement projects were identified to mitigate the identified system deficiencies and to ensure that the emergency improvement projects described in Section 7.1 are appropriately sized and did not lead to additional system deficiencies (see Section 7.1 for detailed information regarding the proposed improvements). Once the recommended improvements were identified and sized, the model was run under the supply outage scenarios to ensure that system pressures exceed 20 psi if the Harry Tracy WTP is out of service or if the Hetch Hetchy Aqueduct is out of service. Based on this analysis, it was confirmed that following the implementation of the recommended improvements, there were no areas in the system with service pressures below 20 psi for the supply outage scenarios.

- **Booster Pump Stations.** In the future system MDD/PHD scenario, the hydraulic model indicates that the City's existing booster pump stations (Madera and Larkspur) may not be able to prevent reservoir draining in the proposed consolidated Skyline Tank when operating under the standard "time-of-use" control strategy. The primary reason for this is that following the implementation of the proposed improvement projects identified in Section 7.5, more flow will bleed down from Zone I to the lower zones (primarily Zone III) to address low pressure conditions. In order to address this potential issue, the City could either (1) implement a non time-of-use based control strategy during high demand periods, such as the MDD condition, (2) provide additional booster pump capacity at the Larkspur pump station in the future to allow for the continued use of a time-of-use control strategy even during the highest demand periods in the future, or (3) Implement major transmission improvements within Zone III to prevent water from bleeding down into Zone III during high demand conditions.

  For the purposes of this Master Plan, it was assumed that the City would be able to pump during the day for future peak demand conditions, thereby eliminating the need to implement major transmission system improvements in Zone III (which would be difficult to construct) or to upsize the existing booster pump stations.

## 7.5 Proposed Improvements

- Figure 7.8 provides a graphical illustration of the improvements recommended to mitigate capacity deficiencies in the existing water system and the improvements to meet future demand as identified by the hydraulic analysis. Figure 7.9 shows the Future Hydraulic Profile once the improvements have been implemented. The improvements are summarized in Table 7.10 with a cross-referenced number system. The columns used in Table 7.10 refer to the following:
- <u>Figure Number</u>: Assigned number that corresponds to the Proposed Improvements Table. This is an alphanumeric number that starts with one letter indicating the type of improvement P= Pipe, T = Tank, W = Well, BP = Booster Pump and continues with a number.
- <u>Type of improvement</u>: Storage tanks, wells, pipelines, jacked steel casings, and booster pumps.
- <u>Street Description</u>: Street in which the improvement is proposed.
- <u>Limits</u>: Description of the beginning and end of a proposed pipeline project.
- <u>Ex. Size/Diameter</u>: This is the size of the existing pipeline/facility. It represents the diameter of the existing pipelines (in inches), the size of the storage reservoirs (in MG), and the size of the wells and booster stations (in gpm).
- <u>New Size/Diameter</u>: This is the size of the proposed improvement. It represents the diameter of the proposed pipelines (in inches), the size of the storage tanks (in MG), and the size of the wells and booster stations (in gpm).

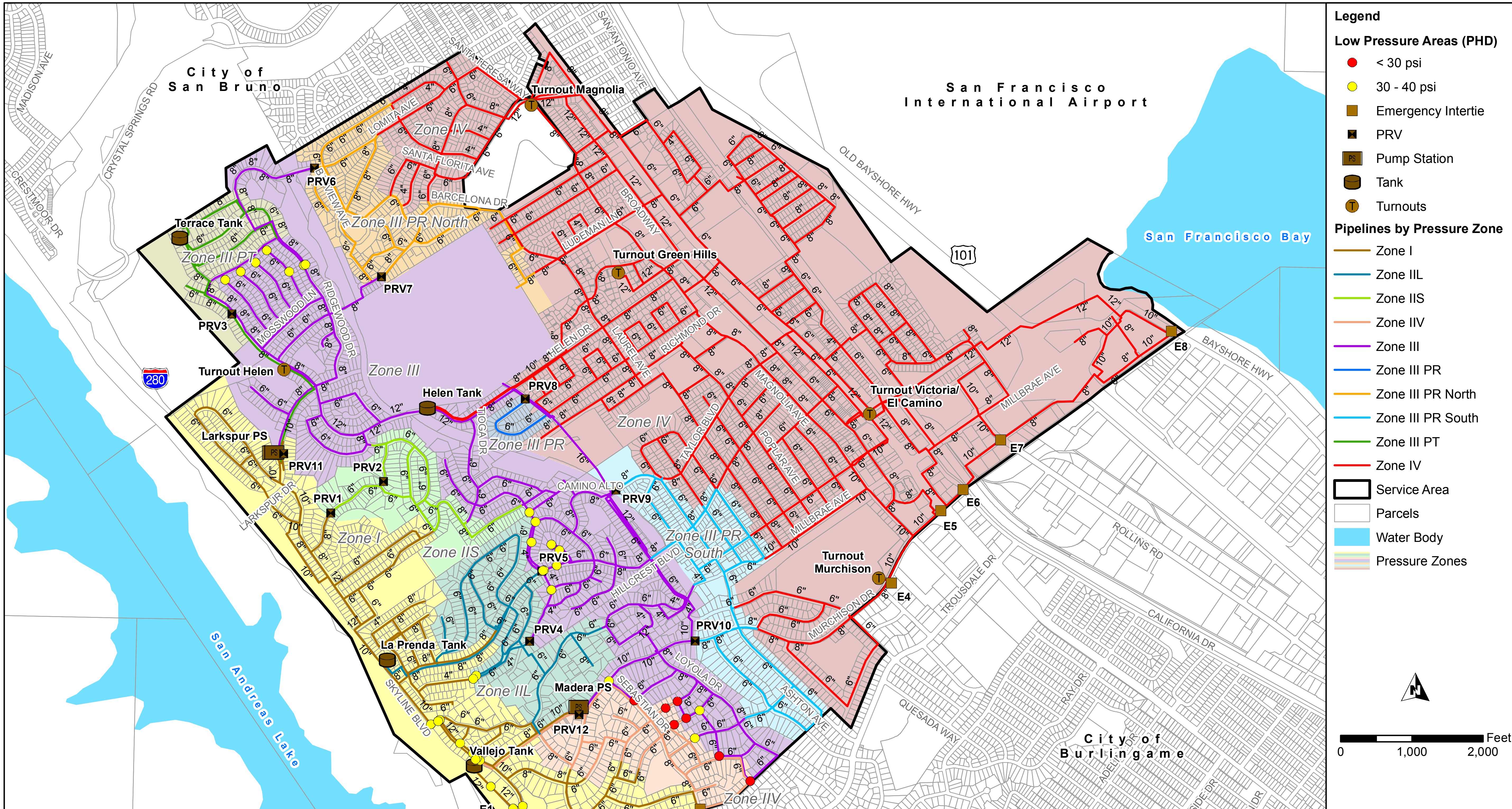


**Figure 7.3**
**Existing System Low Pressure Areas (PHD)**
Water Master Plan
City of Millbrae

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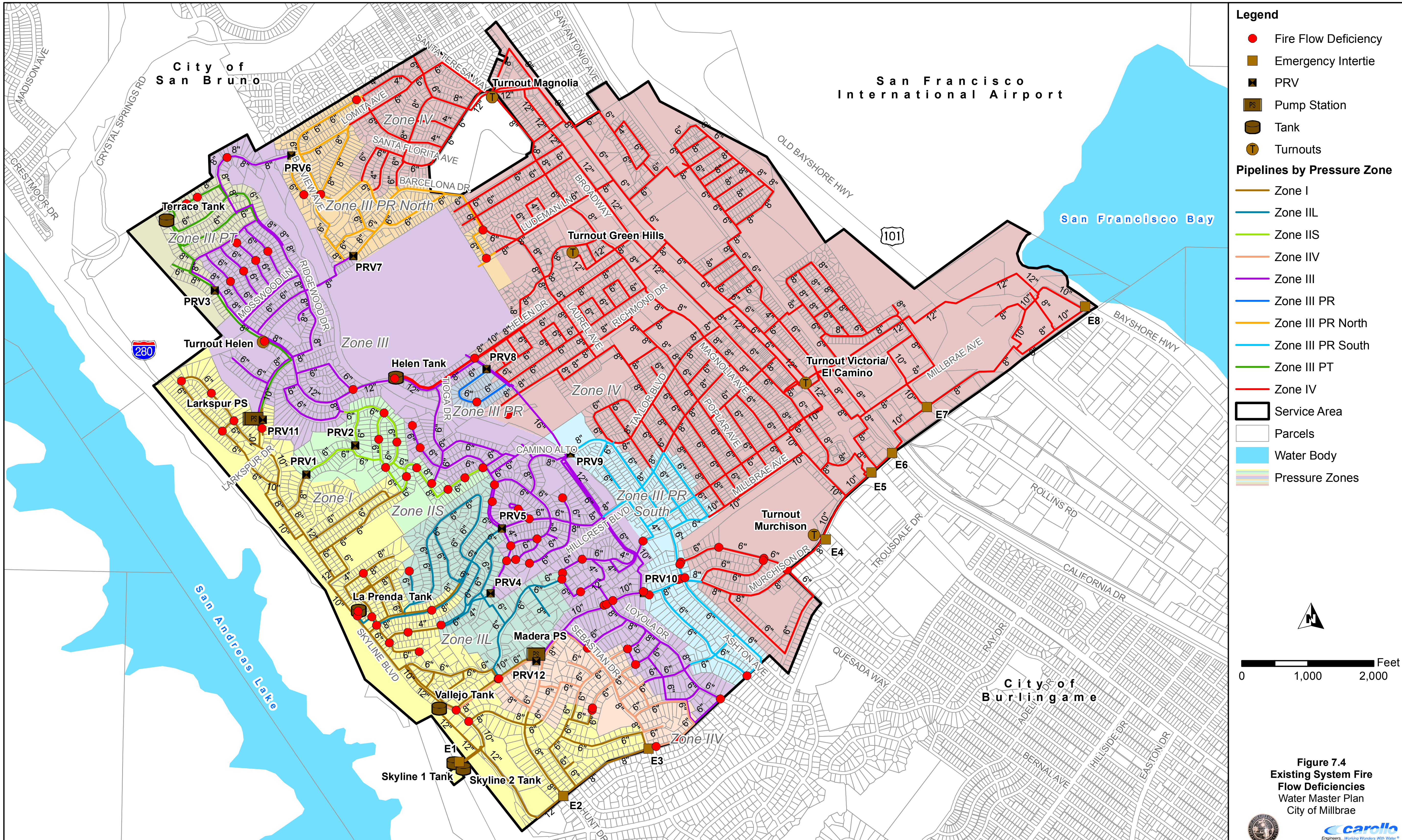


**Figure 7.4**
**Existing System Fire Flow Deficiencies**
Water Master Plan
City of Millbrae

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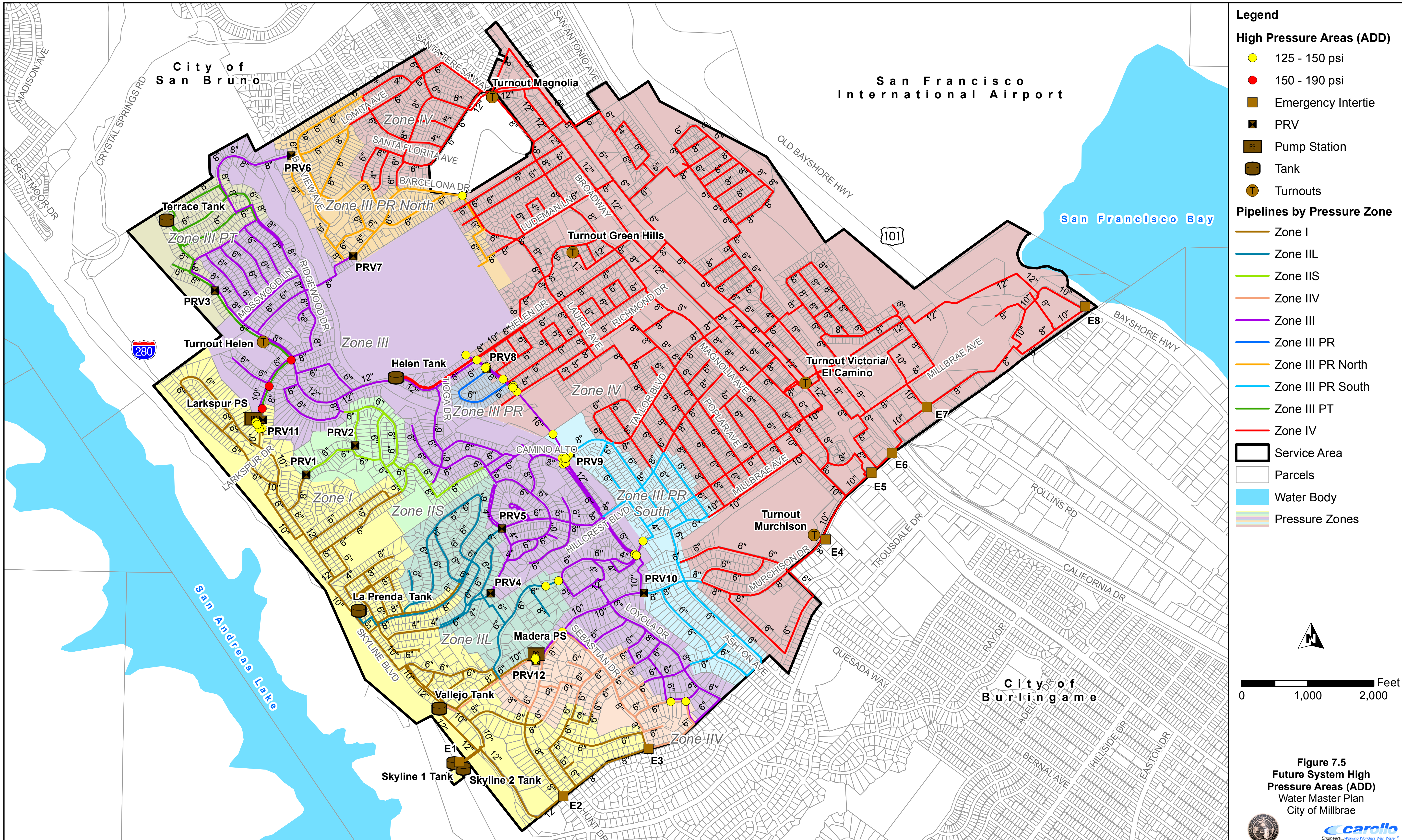


**Figure 7.5**
**Future System High Pressure Areas (ADD)**
Water Master Plan
City of Millbrae

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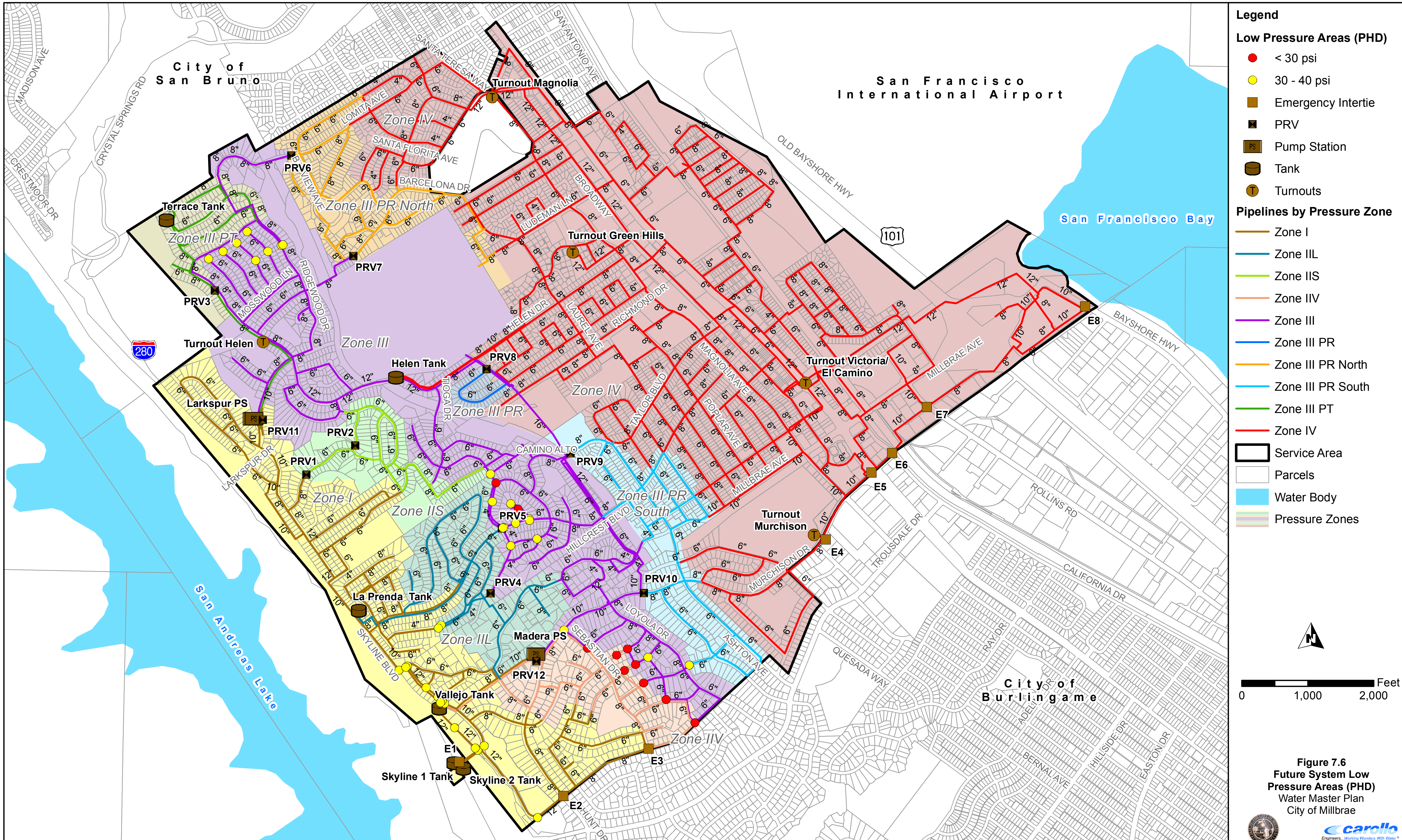


**Figure 7.6**
**Future System Low Pressure Areas (PHD)**
Water Master Plan
City of Millbrae

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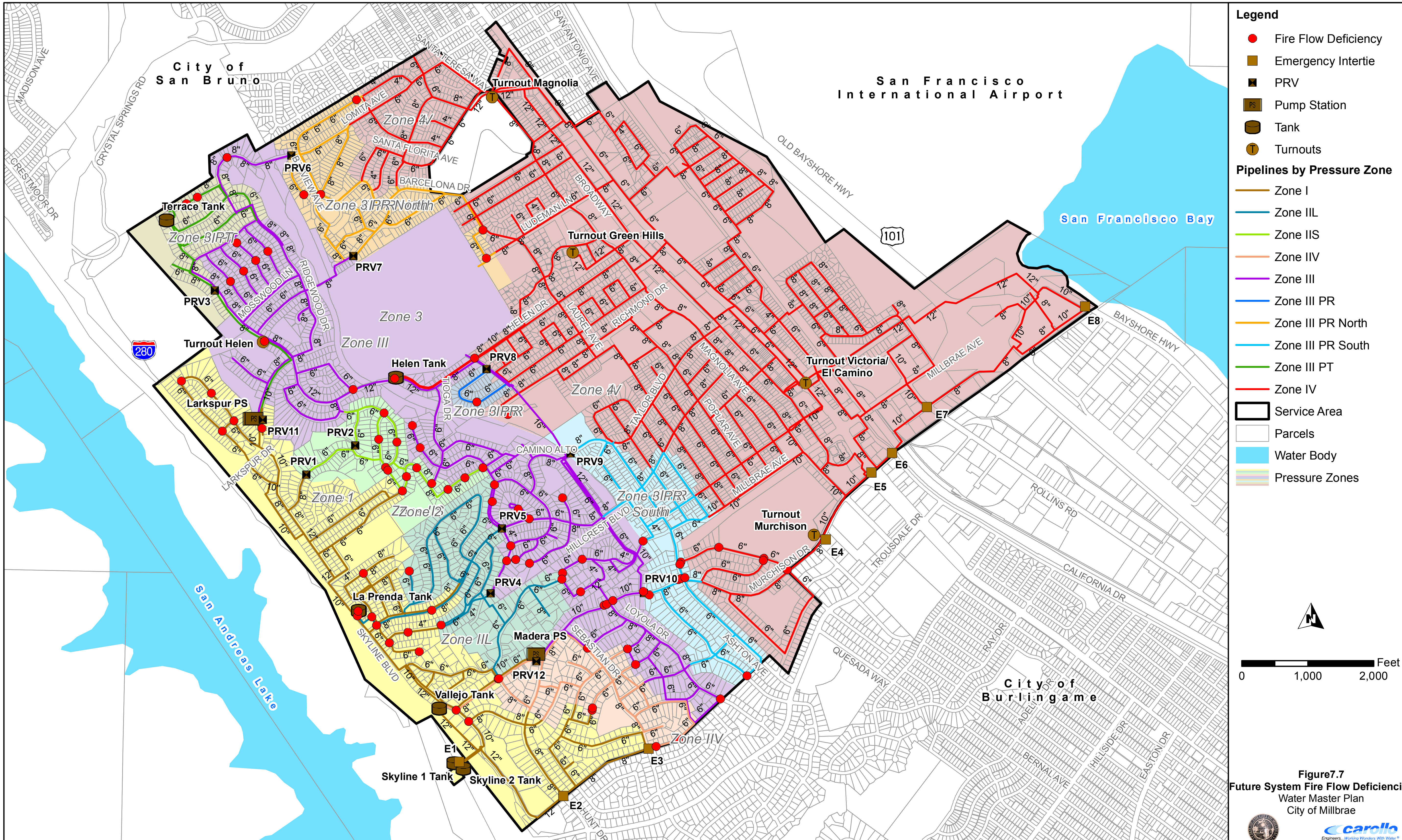


**Figure7.7**
**Future System Fire Flow Deficiencies**
Water Master Plan
City of Millbrae

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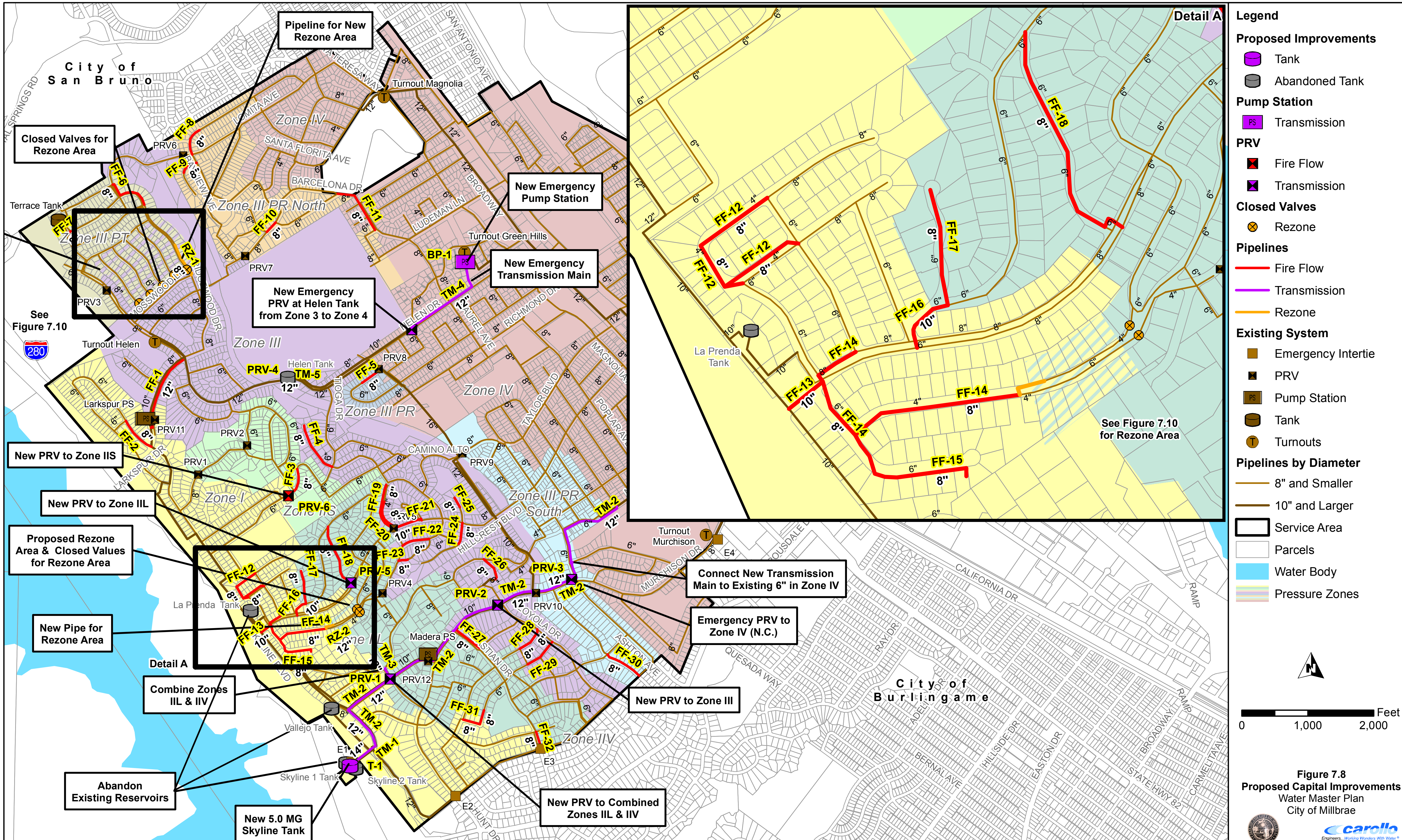


**Figure 7.8**
**Proposed Capital Improvements**
Water Master Plan
City of Millbrae

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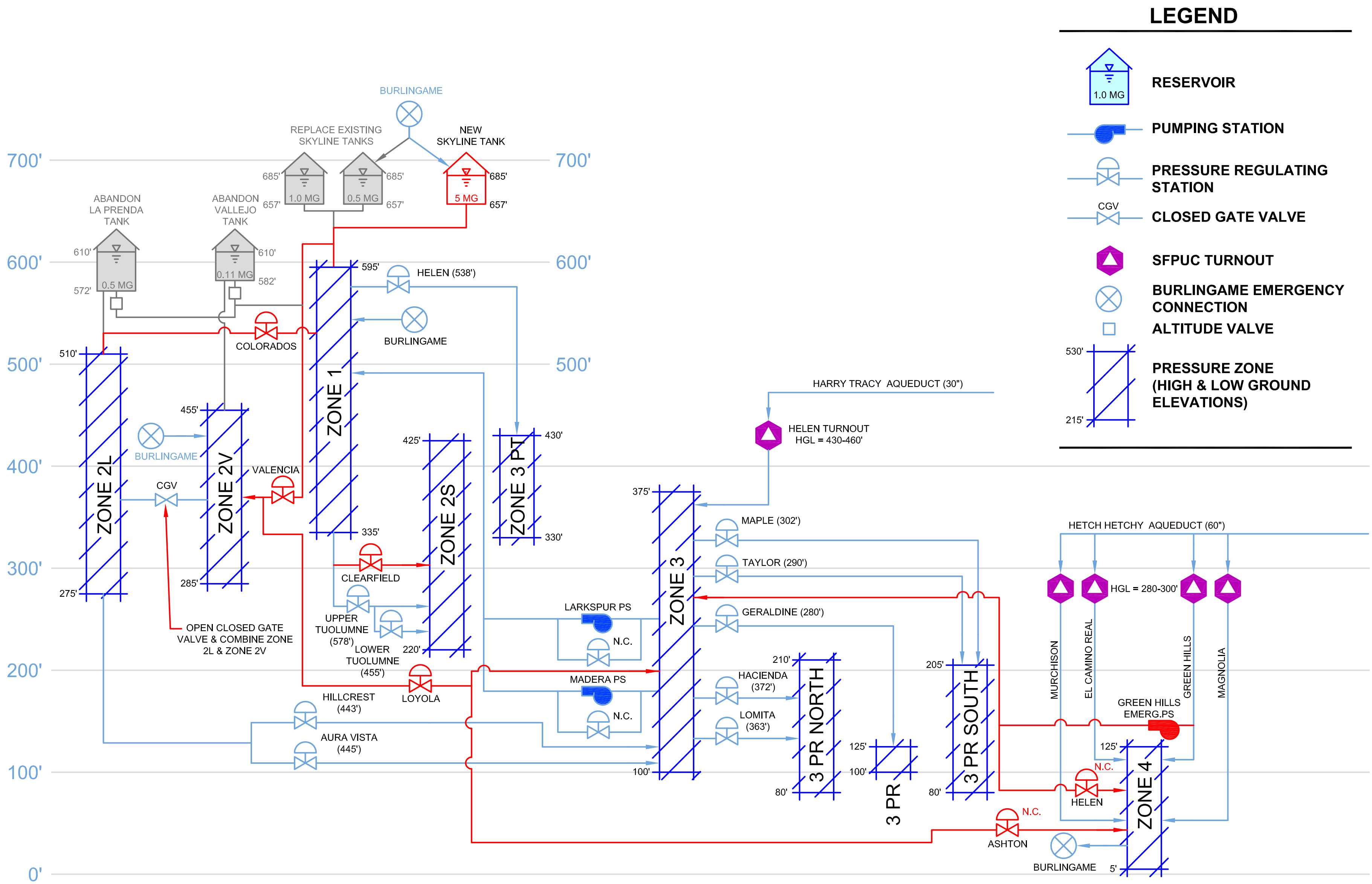


# Figure 7.9
## Future Hydraulic Profile
Water Master Plan
City of Millbrae

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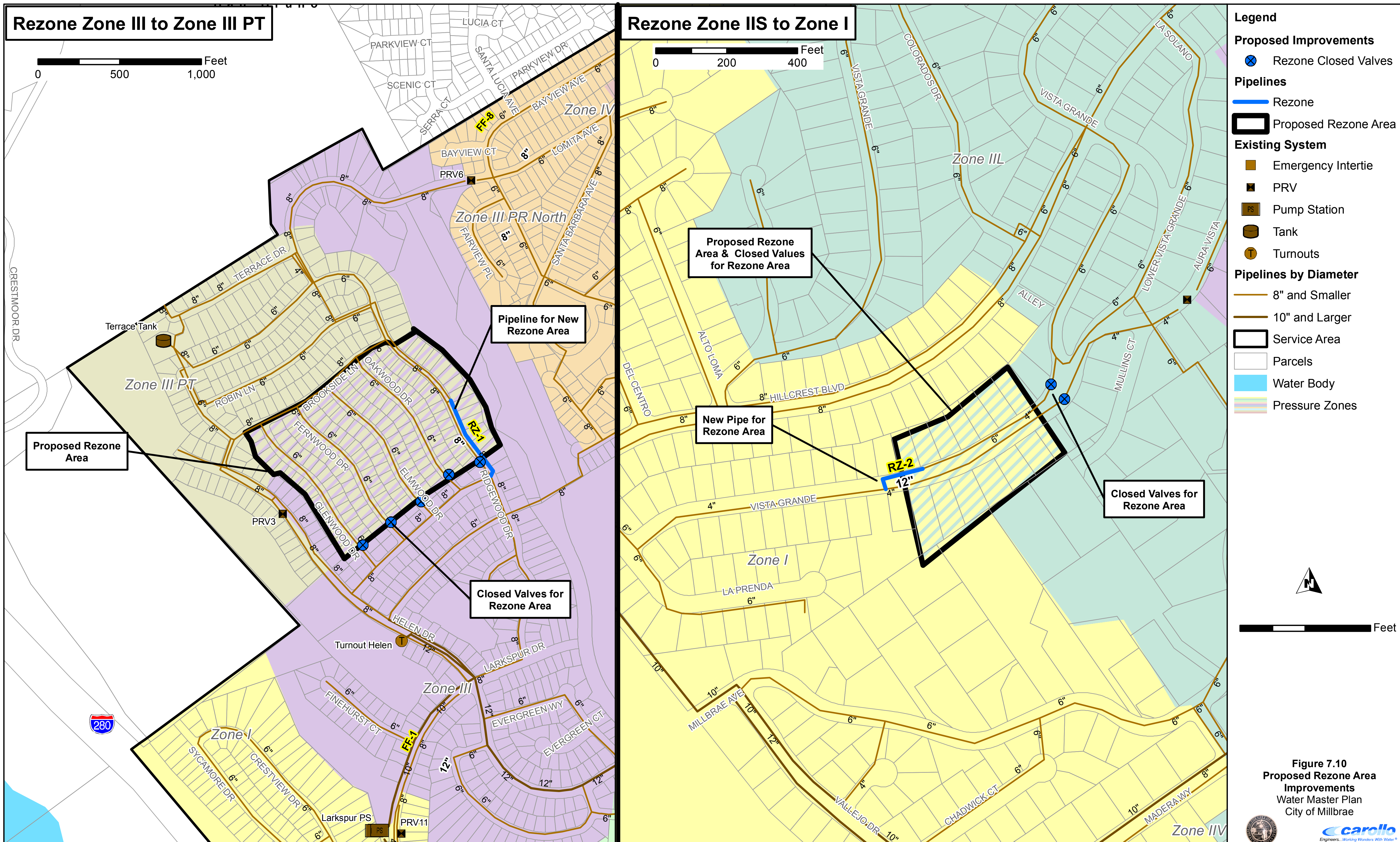


Figure 7.10
Proposed Rezone Area Improvements
Water Master Plan
City of Millbrae

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- Length: Estimated length of the proposed improvement (in feet). It should be noted that the length estimates do not account for re-routing the alignment to avoid unknown conditions.

### 7.5.1 Existing Versus Future Improvements

An existing deficiency is one where the existing facility's capacity is insufficient to meet the planning criteria (e.g. pipeline upgrades required to meet fire flow criteria) for existing users. If a project was proposed to correct an existing deficiency, then existing users were assigned 100 percent of the project's benefit, and therefore, 100 percent of the costs.

Some of the proposed improvements are required to serve future users. If a project is required to serve future growth exclusively, then it is assigned 100 percent of the future project's benefit and 100 percent of the costs.

Most projects were assigned 100 percent to existing users. The only exception to this is the new consolidated Skyline Tank, which is required to mitigate existing storage deficiencies and to served future increases in water demands. For this project, future user benefit was determined based on the percentage of additional storage capacity required to serve future growth.

### 7.5.2 Storage Improvements

As previously discussed in Section 7.3, the storage capacity analysis indicated that the City does not have adequate emergency storage under existing (2012) and future (2035) demand conditions. Based on input from City staff, it was decided that all storage in the City would be consolidated into a new replacement tank at the existing Skyline Tank site. Therefore, this Master Plan recommends that a new 5.0 MG tank be constructed at the existing Skyline Tank site (Improvement Project T-1).

In addition, new transmission pipelines (Improvement Projects TM-1, TM-2, and TM-3) and PRV stations (Improvement Projects PRV-1, PRV-2, PRV-3, and PRV-5) will need to be constructed to provide adequate pressures throughout the distribution system to accommodate the consolidated Skyline Tank.

### 7.5.3 Booster Pump Improvements

In order to supply Zones I, II, and III in the event of a supply outage at the Harry Tracy WTP, a new booster pump station is proposed at the Green Hills Turnout (Improvement Project BP-1). In accordance with the supply outage scenario criteria, the pump station would be sized to provide a firm capacity equal to the future 2035 ADD for Zones I, II, and III (1.31 mgd, or 910 gpm). For reliability purposes, it is recommended that an additional 910 gpm spare pump be installed at this location, for a total capacity of 1,820 gpm. The spare pump could also be used in the event of an outage at the Harry Tracy WTP under MDD conditions.

In addition, a new transmission main (Improvement Project TM-4) will need to be constructed to connect the new booster pump station to the Zone III water distribution system.

### 7.5.4 Transmission Improvements

In order to provide adequate water transmission for the proposed emergency improvements (see Section 7.1), transmission main improvement projects are recommended, as described below:

- **Skyline Tank Transmission Main (Projects TM-1,TM-2, and TM-3):** It is recommended that a short 14-inch diameter pipeline be installed to connect the new Skyline Tank to the existing 12-inch and 10-inch lines that cross under Highway 280. A new, 6,800-foot long, 12-inch diameter transmission main is also recommended, which would extend along Vallejo Drive, Madera Way, Murchison Drive, South Ashton Avenue, and Millbrae Avenue. The transmission main would serve Zones II and III though new PRV stations (Projects PRV-1 and PRV-2), and it would serve Zone IV in the event of an outage in the Hetch Hetchy Aqueduct through a normally closed PRV (PRV-3). The 12-inch transmission main would connect the Zone IV distribution system at the intersection of Millbrae Avenue and Palm Avenue. Finally, a short, 12-inch diameter main is recommended to connect the new transmission main (TM-2) to pressure zones II L and II V. These two pressure zones will be combined upon abandoning the La Prenda and Vallejo Tanks.
- **Green Hills Emergency Booster Pump Transmission Main (Project TM-4):** In order to connect the Green Hills Emergency Booster Pump Station from Zone IV to Zone III, it is recommended that the City install a new 900-foot, 12-inch diameter water main from the booster pump station location (adjacent to the Green Hills Turnout) to the existing abandoned 10-inch diameter main that is connected to the abandoned Helen Tank. In addition, the City should close valves and take other necessary actions as appropriate to isolate the abandoned 10-inch diameter pipe from the other Zone IV pipelines in the vicinity. Furthermore, a new PRV is recommended near the alley on Helen Drive southwest of Laurel Avenue.

### 7.5.5 Distribution System Pipeline Improvements

- The capacity analysis identified numerous small diameter pipelines, usually older 4-inch and 6-inch diameter cast iron pipe, which are not capable of providing the required fire flow at a minimum residual pressure of 20 psi, even after the emergency and rezone improvements have been implemented. The majority of the fire flow deficiencies are located in Pressure Zones I, II, and III. For these areas, it is recommended that these old small diameter pipelines be replaced to accommodate the required fire flows. Many of these fire flow improvements are located in isolated areas throughout the system. These improvements are shown on Figure 7.8, and details related to each improvement project are provided in Table 7.10.

### 7.5.6 PRV Station Improvements

In order to improve system reliability, to accommodate the movement of water, and to provide enhanced fire flow capacity, four new PRV stations are recommended, as described below:

- **Skyline Tank Transmission Main PRV Stations (Projects PRV-1, PRV-2, PRV-3, and PRV-5):** Three new PRV stations are recommended to move water from the new consolidated Skyline tank into Zone II, Zone III, and Zone IV. The locations of these PRV stations are shown on Figure 7.8. Zone II would be served by a PRV station located at the intersection of Valencia Drive and Madera Way (Project PRV-1, or the "Valencia PRV"). Zone III would be served by a new PRV station located at the intersection of Loyola Drive and Murchison Drive (Project PRV-2, or the "Loyola PRV"). These two PRV stations would typically only be operated during high demand periods when system pressures in the east side of the City tend to drop. The third PRV would be used only in the event of a supply outage at the Hetch Hetchy Aqueduct, and therefore would be normally closed. This PRV would be located at the intersection of Murchison Drive and Ashton Drive (Project PRV-3, or the "Ashton PRV"). Upon abandoning the La Prenda Tank, the model showed that system pressures would be affected in the upper reaches of Pressure Zone 2L near the tank. To mitigate this issue, and to provide additional fire flow capacity, a new PRV station is recommended (Project PRV-5, the "Colorados PRV") at the intersection of Hillcrest Boulevard and Colorados Drive.
- **Helen PRV (Project PRV-4):** In order to provide for the ability to move water from Zone III to Zone IV in the event of a supply outage at the Hetch Hetchy Aqueduct, a new PRV is recommended, which would be located on Helen Drive near the alley west of Laurel Avenue. This PRV station would be normally closed.
- **Clearfield PRV (Project PRV-6):** To address fire flow deficiencies and to provide redundancy in Pressure Zone II S, it is recommended that a second PRV be installed to serve this zone. This PRV is proposed to be located at Clearfield Drive and El Capitan Drive.

### 7.5.7 Rezone Improvements

According to discussions with City staff, the City does not wish to rezone the majority of the low and high pressure areas as identified in Section 5.1. Low pressure areas can be equipped with individual home booster stations, and high pressure areas are equipped with service connection PRVs. However, there are two low pressure areas that cannot provide the required fire flow due to the topography of the area. For this reason, it is recommended that the two areas be moved to a higher pressure zone. The location of the proposed rezone areas is shown on Figure 7.10. The recommended improvements for these areas are described:

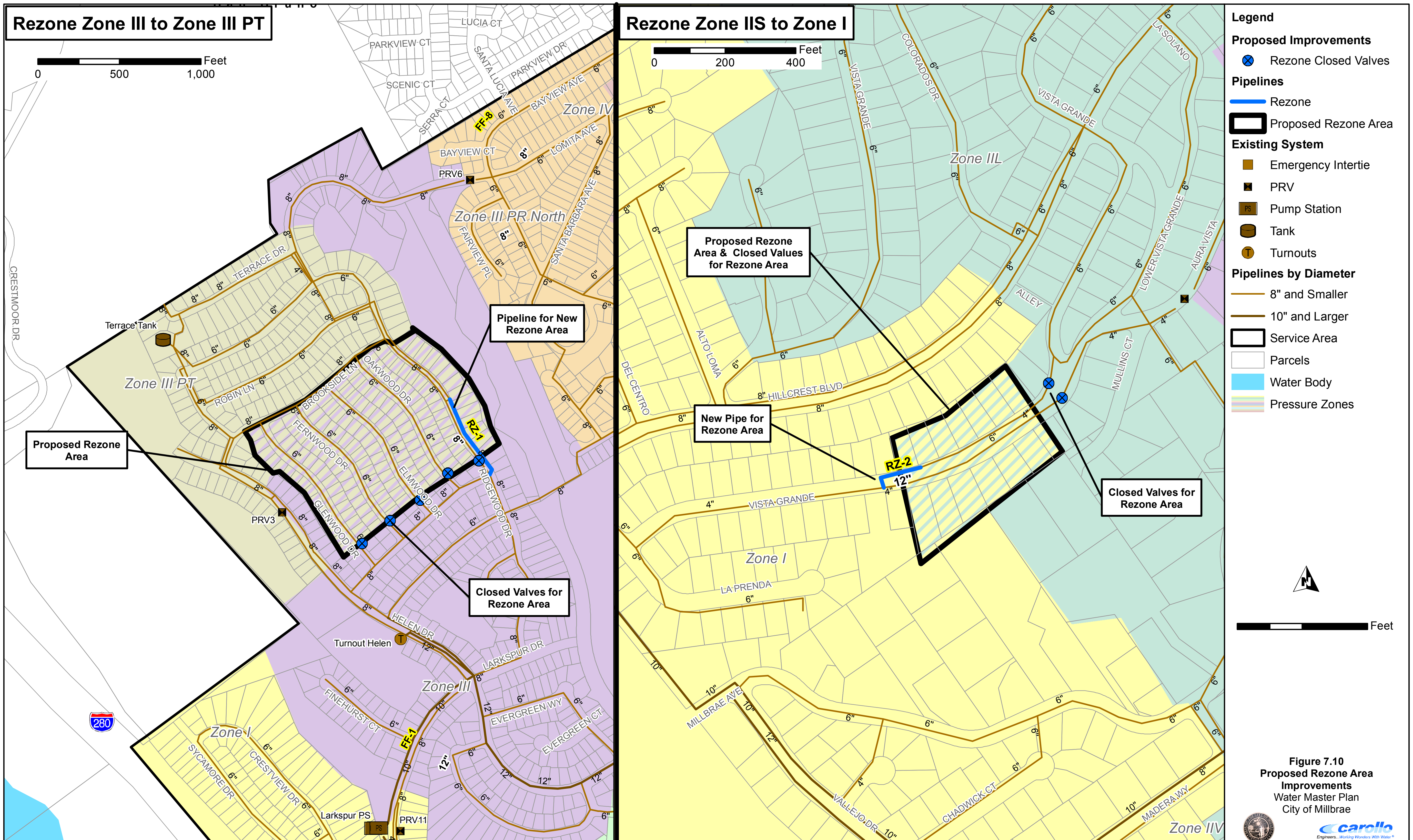

Figure 7.10
Proposed Rezone Area Improvements
Water Master Plan
City of Millbrae

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- **Rezone Area 1 (Project RZ-1):** It is recommended that the City close gate valves in the vicinity of those shown on Figure 7.10 to isolate Pressure Zones III PT and Zone III. In addition, a new 8-inch water main is recommended on Ridgewood Drive near Mosswood Lane to provide looping with the new pressure zone configuration.
- **Rezone Area 2 (Project RZ-2)**: It is recommended that a short reach of new 8-inch water main be installed Vista Grande to move the highest portion of Pressure Zone II L to Pressure Zone I. This would also require that the City close the gate valves in the general locations shown on Figure 7.10, and open the existing closed gate valves as appropriate to isolate the proposed rezone area from Pressure Zone II L.

### 7.5.8 Project Prioritization

The proposed projects provide the City with a list of improvements that will increase system reliability and correct capacity deficiencies in the distribution system. When fully implemented, the capital projects will enhance the distribution of water during maximum demand conditions through the year 2035.

Prioritizing the required capital improvements for the City's water distribution system is an important aspect of this Master Plan. The improvement projects were prioritized based on the following criteria:

4. Implementing storage and transmission improvements to provide adequate storage volume, to allow for the abandonment of seismically deficient storage tanks, and to allow for the transfer of water from Zones I, II, and III to Zone IV, which is susceptible to supply interruptions in the Hetch Hetchy Aqueduct.
5. Addressing capacity deficient pipelines that are undersized for fire flow demand conditions received the highest priority, and implementing rezoning improvements to address fire flow deficiencies in the high areas of certain pressure zones.
6. Implementing transmission improvements to allow for the movement of water from Zone IV to Zones I, II, and III. These improvements can be phased further out into the future, because the new Skyline Tank will provide emergency storage for Zones I, II, and III. In addition, the City does have emergency interconnections within Zones I, II, and III that could also be utilized in the event of a supply outage in at the Harry Tracy WTP.

The projects were phased into the following four phases:

- Phase 1: Years 2014 through 2020.
- Phase 2: Years 2021 through 2025.
- Phase 3: Years 2026 through 2030.
- Phase 4: Years 2031 through 2035.

Each improvement project was assigned to one of the four phases based on the three project prioritization criteria above. Projects that meet the first prioritization criteria were grouped in the earlier phases, whereas projects that meet the second and third prioritization criteria were grouped in the later phases. The projects shown in Figure 7.11 are color coded according to phase, which reflects their priority. Table 7.10 indicates the phasing timeframe for each capital project.

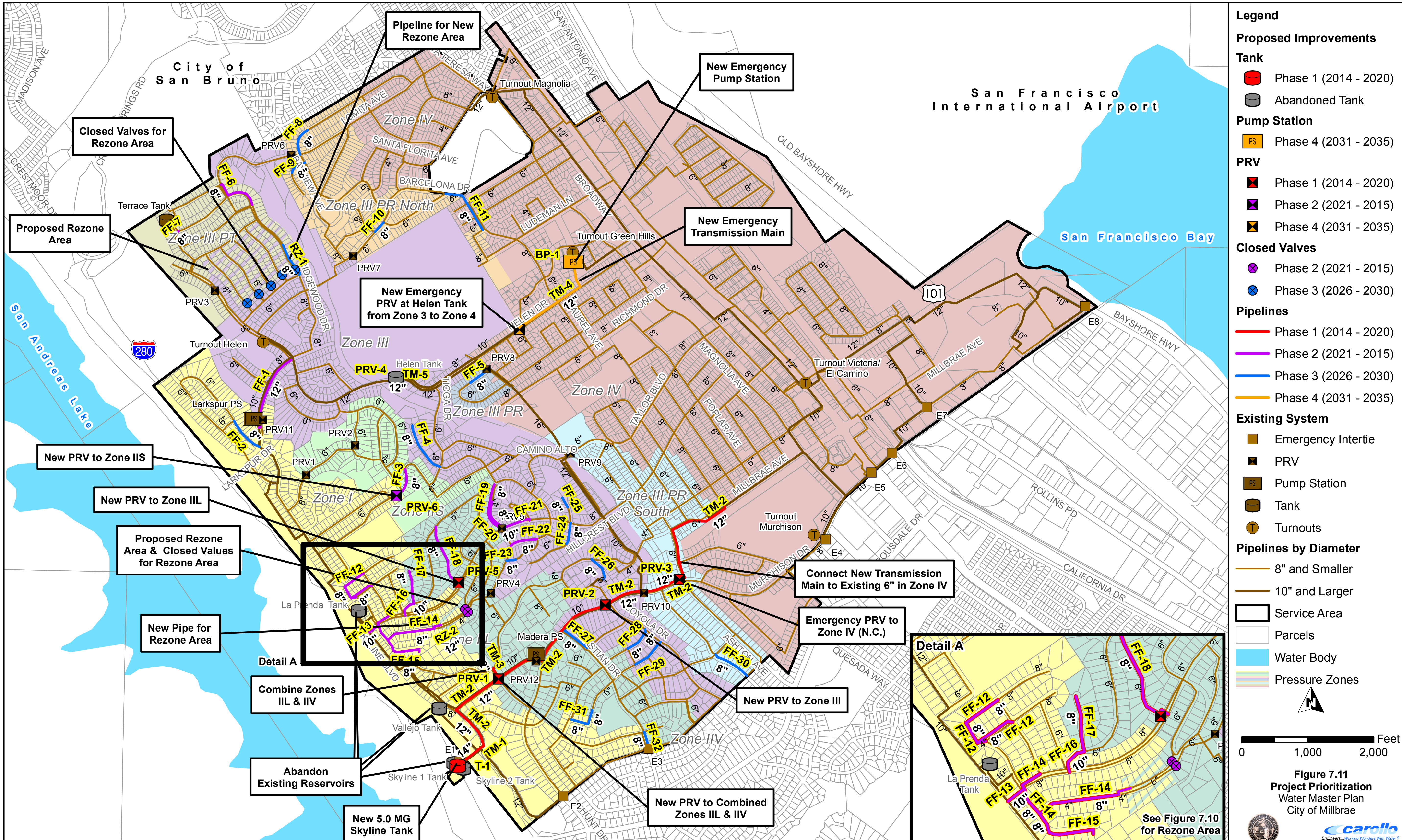


**Figure 7.11**
**Project Prioritization**
Water Master Plan
City of Millbrae

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# 8.0 CAPITAL IMPROVEMENT PLAN

This chapter presents the recommended capital improvement projects (CIP) for the City's water distribution system and summary of the capital costs. This chapter is organized to assist the City in making finance decisions. The CIP is based on the evaluation of the City's water distribution system, planning area, and land use, as detailed in the proposed improvements identified in Chapter 7.0.

## 8.1 Capital Improvement Project Costs

The capacity upgrades set the foundation for the City's water distribution system CIP. The cost estimates presented in this study are opinions developed from bid tabulations, cost curves, information obtained from previous studies, and Carollo Engineers, Inc. (Carollo) experience on other projects. The costs are based on an Engineering News Record Construction Cost Index (ENR CCI) 20-City Average of 9,750 (April 2014).

## 8.2 Cost Estimating Accuracy

The cost estimates presented in the CIP have been prepared for general master planning purposes and for guidance in project evaluation and implementation. Final costs of a project will depend on actual labor and material costs, competitive market conditions, final project scope, implementation schedule, and other variable factors such as preliminary alignment generation, investigation of alternative routings, and detailed utility and topography surveys.

The Association for the Advancement of Cost Engineering (AACE) defines an Order of Magnitude Estimate, deemed appropriate for master plan studies, as an approximate estimate made without detailed engineering data. It is normally expected that an estimate of this type would be accurate within plus 50 percent to minus 30 percent. This section presents the assumptions used in developing order of magnitude cost estimates for recommended facilities.

## 8.3 Construction Unit Cost

The construction costs are representative of water distribution system facilities under normal construction conditions and schedules. Costs have been estimated for public works construction.

### 8.3.1 <u>Pipeline Unit Cost</u>

Water distribution system pipeline improvements range in size from 8-inches to 14-inches in diameter in this Master Plan. Pipeline unit costs for relevant sized upgrades are shown in Table 8.1. The unit costs are for "typical" field conditions with construction in stable soil.

| Table 8.1 | Pipeline Construction Unit Costs<br>Water Master Plan<br>City of Millbrae |
|---|---|
| **Pipe Size (inches)** | **Pipeline Unit Cost ($/Linear Foot)** |
| 8 | 160 |
| 10 | 200 |
| 12 | 210 |
| 16 | 280 |
| 20 | 350 |

Note:
1. ENR CCI 20 City average used for estimating (April 2014) = 9,750

### 8.3.2 Storage Tank, Booster Pumps, and PRVs

Construction unit costs were developed for the storage tanks, booster pumps and groundwater supply wells. The unit costs for these facilities are summarized in Table 8.2. The unit cost for storage tanks are based on Carollo's experience on completed projects of similar size. For booster pump stations a unit cost of $3,800 per horsepower was used, based on projects of similar size. For PRV stations, a unit cost of $50,000 per station is commonly used for master planning purposes.

| Table 8.2 | Facility Construction Unit Costs<br>Water Master Plan<br>City of Millbrae |
|---|---|
| **Facility** | **Unit Cost** |
| Storage Tank Price Per Gallon = | 1.636 x (Volume, MG) $^{-0.37}$ |
| Booster Pump Stations = | $3,800 per horsepower |
| PRV Stations = | $50,000 per station |

Note:
1. ENR CCI 20 City average used for estimating (April 2014) = 9,750

## 8.4 Project Cost and Contingencies

### 8.4.1 Baseline Construction Cost

This is the total estimated construction cost, in dollars, of the proposed improvements for pipelines, storage tanks, booster pump stations, and wells. Baseline Construction Costs were developed using the following criteria:

- Pipeline: Calculated by multiplying the estimated length by the unit cost.

- Storage Tank: Calculated by multiplying the tank price per gallon by the tank volume.
- Booster Pump Station: Calculated by multiplying the horsepower by the unit cost.
- PRV Station: Based on a set cost allowance of $50,000 per station.

### 8.4.2 Estimated Construction Cost

Contingency costs must be reviewed on a case-by-case basis because they will vary considerably with each project. Consequently, it is appropriate to allow for uncertainties associated with the preliminary layout of a project. Such factors as unexpected construction conditions, the need for unforeseen mechanical items, and variations in final quantities are a few of the items that can increase project costs for which it is wise to make allowances in preliminary estimates. To assist the City in making financial decisions for these future construction projects, contingency costs will be added to the planning budget as percentages of the total construction cost, divided into two categories: Estimated Construction Cost and Capital Improvement Cost.

Since knowledge about site-specific conditions of each proposed project is limited at the master planning stage, a 25 percent contingency was applied to the Baseline Construction Cost to account for unforeseen events and unknown conditions. A 25 percent contingency to account for unknown site conditions such as poor soils, unforeseen conditions, environmental mitigations, and other unknowns is typical for master planning projects. The Estimated Construction Cost for the proposed distribution system improvement consists of the Baseline Construction Cost plus the 25 percent construction contingency.

### 8.4.3 Capital Improvement Cost

Other project construction contingency costs are divided into three subcategories, totaling 30 percent: 10 percent engineering, 10 percent construction phase professional services, and 10 percent project administration. Engineering services associated with new facilities include preliminary investigations and reports, ROW acquisition, foundation explorations, preparation of drawings and specifications during construction, surveying and staking, sampling of testing material, and start-up services. For this study, engineering costs are assumed to equal 10 percent of the Estimated Construction Cost.

Construction phase professional services covers such items as construction management, engineering services, materials testing, and inspection during construction. The cost of these items can also vary, but for the purpose of this study, it is assumed that construction phase professional services expenses will equal approximately 10 percent of the Estimated Construction Cost

Finally, there are project administration costs, which cover such items as legal fees, environmental/CEQA compliance requirements, financing expenses, administrative costs, and interest during construction. The cost of these items can also vary, but for the purpose of this Master Plan, it is assumed that project administration costs will equal 10 percent of the Estimated Construction Cost.

The Capital Improvement Cost is the total of the Estimated Construction Cost (including contingency) plus the other costs discussed in the previous paragraphs.

As shown in the following sample calculation of the Capital Improvement Cost, the total cost of all project construction contingencies (construction, engineering services, construction management, and project administration) is 62.5 percent of the Baseline Construction Cost. Note that contingencies were not applied to land acquisition costs. Calculation of the 62.5 percent is the overall mark-up on the baseline construction cost to arrive at the capital improvement cost. It is not an additional contingency.

*Example:*

| | |
|---|---|
| Baseline Construction Cost | $1,000,000 |
| Construction Contingency (25%) | 250,000 |
| Estimated Construction Cost | 1,250,000 |
| Engineering Cost (10%) | 125,000 |
| Construction Management (10%) | 125,000 |
| Project Administration (10%) | 125,000 |
| Capital Improvement Cost | $1,625,000 |

A summary of the capital project costs is presented in Table 8.3. This table identifies the projects, provides a brief description of the project, identifies facility size (e.g. pipe diameter and length), and the capital improvement cost. The table also shows the recommended phase in which the project would be implemented. The implementation timeframe was based on the priority of each project to correct existing deficiencies or to serve future users.

## 8.5 Capital Improvement Implementation

The CIPs are prioritized based on their urgency to mitigate existing deficiencies and for servicing anticipated growth. It is recommended that improvements to mitigate existing deficiencies be constructed as soon as possible.

The implementation phases are separated into 5-year increments. Each project is itemized by phase in Table 8.3 and a summary by facility type and phase is provided in Table 8.4. As shown in Table 8.4, the CIP is front loaded in Phase 1 with roughly $10 million dollars worth of CIP projects (over half of the proposed CIP). This is due to the need to construct the new storage tank at Skyline and associated transmission main in the near term.

**Table 8.3 Capital Improvement Plan**
Water Master Plan
City of Millbrae

| Figure No. | Type of Improvement | Description/ Street | Description / Limits | Ex. Size/ Diam. (in) | New Size/ Diam. (in) | Replace/ New | Length (ft) | Capital Improvement Cost(1),(2),(3) ($) | Phase 1 2014-2020 ($) | Phase 2 2021-2025 ($) | Phase 3 2026-2030 ($) | Phase 4 2031-2035 ($) | Future Users Benefit (%) | Total Capital Cost ($) | Existing Improvements ($) | Future Improvements ($) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Project Length/Size and Cost | | | | | Capital Improvement Phasing | | | | | Existing/Future U | Reimbursement Category | |
| **Storage Tanks, Booster Pumps, and PRVs** | | | | | | | | | | | | | | | | |
| T-1 | Storage Tank | Interstate Highway 280 | Consolidated Skyline | - | 5.0 MG | New | - | $ 7,328,100 | $ 7,328,100 | | | | 26.5% | $ 7,328,100 | $ 5,386,200 | $ 1,941,900 |
| BP-1 | Booster Pump | Green Hills Turnout | New Green Hills Emergency Booster Pump Station | - | 100 HP | New | - | $ 617,500 | | | | $ 617,500 | 28.7% | $ 617,500 | $ 440,300 | $ 177,200 |
| PRV-1 | Valve | Madera Way | Valencia PRV | - | - | New | - | $ 81,300 | $ 81,300 | | | | 0.0% | $ 81,300 | $ 81,300 | $ - |
| PRV-2 | Valve | Murchison Drive | Loyola PRV | - | - | New | - | $ 81,300 | $ 81,300 | | | | 0.0% | $ 81,300 | $ 81,300 | $ - |
| PRV-3 | Valve | Murchison Drive | Ashton PRV | - | - | New | - | $ 81,300 | $ 81,300 | | | | 0.0% | $ 81,300 | $ 81,300 | $ - |
| PRV-4 | Valve | Helen Drive | Helen PRV | - | - | New | - | $ 81,300 | | | | $ 81,300 | 0.0% | $ 81,300 | $ 81,300 | $ - |
| PRV-5 | Valve | Colorados Drive | Colorados PRV | - | - | New | - | $ 81,300 | $ 81,300 | | | | 0.0% | $ 81,300 | $ 81,300 | $ - |
| PRV-6 | Valve | Clearfield Drive | Clearfield Drive PRV | - | - | New | - | $ 81,300 | | $ 81,300 | | | 0.0% | $ 81,300 | $ 81,300 | $ - |
| | | | | | | | **Storage Tanks, Booster Pumps, and PRVs Subtotal** | **$ 8,433,400** | **$ 7,653,300** | **$ 81,300** | **$ -** | **$ 698,800** | **-** | **$ 8,433,400** | **$ 6,314,300** | **$ 2,119,100** |
| **Transmission Pipeline Improvements** | | | | | | | | | | | | | | | | |
| TM-1 | Transmission | At Skyline Tanks | Connect to existing Skyline Fill/Discharge Lines | - | 14 | New | 100 | $ 40,700 | $ 40,700 | | | | 0.0% | $ 40,700 | $ 40,700 | $ - |
| TM-2 | Transmission | Vallejo/Madera/Murchison/Ashton/Millbrae | From Skyline Tank to Zone IV Connection at Palm Ave. | - | 12 | New | 6,800 | $ 2,320,500 | $ 2,320,500 | | | | 0.0% | $ 2,320,500 | $ 2,320,500 | $ - |
| TM-3 | Transmission | Valencia Drive | Millbrae Avenue to Madera Way | - | 12 | New | 200 | $ 68,300 | $ 68,300 | | | | 0.0% | $ 68,300 | $ 68,300 | $ - |
| TM-4 | Transmission | Helen Drive | From Green Hills Turnout to Laurel Avenue | - | 12 | New | 1,500 | $ 511,900 | | | | $ 511,900 | 0.0% | $ 511,900 | $ 511,900 | $ - |
| | | | | | | | **Transmission Pipeline Improvement Subtotal** | **$ 2,941,400** | **$ 2,429,500** | **$ -** | **$ -** | **$ 511,900** | **-** | **$ 2,941,400** | **$ 2,941,400** | **$ -** |
| **Fire Flow Pipeline Improvements** | | | | | | | | | | | | | | | | |
| FF-1 | Fire Flow | Larkspur Drive | Larkspur PS to Helen Drive | 8 | 12 | Replace | 1,200 | $ 409,500 | | $ 409,500 | | | 0.0% | $ 409,500 | $ 409,500 | $ - |
| FF-2 | Fire Flow | Crestview Drive | Larkspur Drive to Tulip Lane | 6 | 8 | Replace | 600 | $ 156,000 | | | $ 156,000 | | 0.0% | $ 156,000 | $ 156,000 | $ - |
| FF-3 | Fire Flow | Clearfield Drive | El Capitan Dr. to e/o El Capitan Dr. | 6 | 8 | Replace | 300 | $ 78,000 | | $ 78,000 | | | 0.0% | $ 78,000 | $ 78,000 | $ - |
| FF-4 | Fire Flow | Morningside Drive | Northwest of Tioga Drive | 6 | 8 | Replace | 800 | $ 208,000 | | | $ 208,000 | | 0.0% | $ 208,000 | $ 208,000 | $ - |
| FF-5 | Fire Flow | Anita Lane | Geraldine Drive to Southwest of Geraldine Dr. | 6 | 8 | Replace | 400 | $ 104,000 | | | $ 104,000 | | 0.0% | $ 104,000 | $ 104,000 | $ - |
| FF-6 | Fire Flow | Lomita Avenue | Terrace Drive to Robin Lane | - | 8 | New | 700 | $ 182,000 | | $ 182,000 | | | 0.0% | $ 182,000 | $ 182,000 | $ - |
| FF-7 | Fire Flow | Ridgewood Drive | Connect existing 8 and 6-inch pipes | - | 8 | New | 100 | $ 26,000 | | $ 26,000 | | | 0.0% | $ 26,000 | $ 26,000 | $ - |
| FF-8 | Fire Flow | Bayview Avenue | Santa Lucia Ave. to Lomita Ave. | 6 | 8 | Replace | 500 | $ 130,000 | | | $ 130,000 | | 0.0% | $ 130,000 | $ 130,000 | $ - |
| FF-9 | Fire Flow | Fairview Place | Bayview Ave. to Southwest of Bayview Ave. | 6 | 8 | Replace | 300 | $ 78,000 | | | $ 78,000 | | 0.0% | $ 78,000 | $ 78,000 | $ - |
| FF-10 | Fire Flow | Hacienda Way | Capuchino Drive to Santa Margarita Ave. | 4 | 8 | Replace | 200 | $ 52,000 | | | $ 52,000 | | 0.0% | $ 52,000 | $ 52,000 | $ - |
| FF-11 | Fire Flow | Barcelona Drive | Capuchino Drive to Cozzolino Drive | 6 | 8 | Replace | 900 | $ 234,000 | | | $ 234,000 | | 0.0% | $ 234,000 | $ 234,000 | $ - |
| FF-12 | Fire Flow | La Prenda and Alto Loma | Neighborhood encircled by La Prenda and Alto Loma | 4 | 8 | Replace | 1,000 | $ 260,000 | | $ 260,000 | | | 0.0% | $ 260,000 | $ 260,000 | $ - |
| FF-13 | Fire Flow | Hillcrest Boulevard | La Prenda to State Highway 35 | 8 | 10 | Replace | 200 | $ 65,000 | | $ 65,000 | | | 0.0% | $ 65,000 | $ 65,000 | $ - |
| FF-14 | Fire Flow | La Prenda/Hillcrest Boulevard | Del Centro to Vista Grande | 6 | 8 | Replace | 1,200 | $ 312,000 | | $ 312,000 | | | 0.0% | $ 312,000 | $ 312,000 | $ - |
| FF-15 | Fire Flow | La Prenda | South of Vista Grande | 6 | 8 | Replace | 600 | $ 156,000 | | $ 156,000 | | | 0.0% | $ 156,000 | $ 156,000 | $ - |
| FF-16 | Fire Flow | Vista Grande and Alto Loma | Arroyo Seco to Hillcrest Boulevard | 6 | 10 | Replace | 300 | $ 97,500 | | $ 97,500 | | | 0.0% | $ 97,500 | $ 97,500 | $ - |
| FF-17 | Fire Flow | Arroyo Seco | North of Vista Grande | 6 | 8 | Replace | 500 | $ 130,000 | | $ 130,000 | | | 0.0% | $ 130,000 | $ 130,000 | $ - |
| FF-18 | Fire Flow | Colorados Drive | Vista Grande to Hillcrest Blvd. | 6 | 8 | Replace | 1,100 | $ 286,000 | | $ 286,000 | | | 0.0% | $ 286,000 | $ 286,000 | $ - |
| FF-19 | Fire Flow | West side of El Bonito Way | Hillcrest Blvd. to Morningside Dr. | 6 | 8 | Replace | 800 | $ 208,000 | | $ 208,000 | | | 0.0% | $ 208,000 | $ 208,000 | $ - |
| FF-20 | Fire Flow | East side of El Bonito Way | Hillcrest Blvd. to s/o Morningside Dr. | 4 | 8 | Replace | 500 | $ 130,000 | | $ 130,000 | | | 0.0% | $ 130,000 | $ 130,000 | $ - |
| FF-21 | Fire Flow | Hillcrest Boulevard | Corte Princesa to El Bonito Way | 4 | 10 | Replace | 400 | $ 130,000 | | $ 130,000 | | | 0.0% | $ 130,000 | $ 130,000 | $ - |
| FF-22 | Fire Flow | El Bonito Way | Auro Vista to w/o Aura Vista | 4 | 8 | Replace | 400 | $ 104,000 | | $ 104,000 | | | 0.0% | $ 104,000 | $ 104,000 | $ - |
| FF-23 | Fire Flow | Aura Vista | South of Bonito Way, before Aura Vista turns south | 4 | 8 | Replace | 100 | $ 26,000 | | | $ 26,000 | | 0.0% | $ 26,000 | $ 26,000 | $ - |
| FF-24 | Fire Flow | Via Canon | Hillcrest Blvd. to s/o Hillcrest Boulevard | 6 | 8 | Replace | 300 | $ 78,000 | | | $ 78,000 | | 0.0% | $ 78,000 | $ 78,000 | $ - |
| FF-25 | Fire Flow | Corte Dorado | North of Hillcrest Blvd. | 4 | 8 | Replace | 200 | $ 52,000 | | | $ 52,000 | | 0.0% | $ 52,000 | $ 52,000 | $ - |
| FF-26 | Fire Flow | View Terrace | South of Millbrae Ave. | 4 | 8 | Replace | 400 | $ 104,000 | | | $ 104,000 | | 0.0% | $ 104,000 | $ 104,000 | $ - |
| FF-27 | Fire Flow | Sebastian Drive | Roble Road to Murchison Dr. | 6 | 8 | Replace | 400 | $ 104,000 | | | $ 104,000 | | 0.0% | $ 104,000 | $ 104,000 | $ - |
| FF-28 | Fire Flow | Manzanita Drive | Loyola Dr. to w/o Loyola Dr. | 6 | 8 | Replace | 400 | $ 104,000 | | | $ 104,000 | | 0.0% | $ 104,000 | $ 104,000 | $ - |
| FF-29 | Fire Flow | Encina Drive | Loyola Dr. to w/o Loyola Dr. | 6 | 8 | Replace | 500 | $ 130,000 | | | $ 130,000 | | 0.0% | $ 130,000 | $ 130,000 | $ - |
| FF-30 | Fire Flow | Castenada Drive | Lake S. to e/o Lake St. | 6 | 8 | Replace | 600 | $ 156,000 | | | $ 156,000 | | 0.0% | $ 156,000 | $ 156,000 | $ - |
| FF-31 | Fire Flow | Encina Drive | Manzanita Drive to ne/o Manzanita Drive | 6 | 8 | Replace | 500 | $ 130,000 | | | $ 130,000 | | 0.0% | $ 130,000 | $ 130,000 | $ - |
| FF-32 | Fire Flow | Sebastian Drive | La Suen Dr. to Frontera Wy. | - | 8 | New | 400 | $ 104,000 | | | $ 104,000 | | 0.0% | $ 104,000 | $ 104,000 | $ - |
| | | | | | | | **Fire Flow Pipeline Improvement Subtotal** | **$ 4,524,000** | **$ -** | **$ 2,574,000** | **$ 1,950,000** | **$ -** | **-** | **$ 4,524,000** | **$ 4,524,000** | **$ -** |
| **Rezone Pipeline Improvements** | | | | | | | | | | | | | | | | |
| RZ-1 | Rezone | Ridgewood Drive | North of Moddwood Lane | - | 8 | New | 500 | $ 104,000 | | | $ 104,000 | | 0.0% | $ 104,000 | $ 104,000 | $ - |
| RZ-2 | Rezone | Vista Grande | East of La Prenda | - | 12 | New | 200 | $ 55,000 | | $ 55,000 | | | 0.0% | $ 55,000 | $ 55,000 | $ - |
| | | | | | | | **Rezone Improvement Subtotal** | **$ 159,000** | **$ -** | **$ 55,000** | **$ 104,000** | **$ -** | **-** | **$ 159,000** | **$ 159,000** | **$ -** |
| **CIP Total** | | | | | | | | | | | | | | | | |
| | | | | | | | **CIP Total** | **$ 16,057,800** | **$ 10,082,800** | **$ 2,710,300** | **$ 2,054,000** | **$ 1,210,700** | **-** | **$ 16,057,800** | **$ 13,938,700** | **$ 2,119,100** |

Notes:
1. Costs are based on an ENR CCI = 9750 (April 2014, 20 City Average)
2. Capital Improvement Cost includes a 25% contingency to account for unforseen conditions, applied to the Baseline Construction Cost.
3. Capital Improvement Cost also includes a 30%, applied to the Estimated Construction Cost, to cover other costs including Engineering, Construction Management, and Project Administration. The total markup from the Baseline Construction Cost is 62.5%

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| Table 8.4 Summary of Capital Costs by Phase<br>Water Master Plan<br>City of Millbrae | | | | | |
|---|---|---|---|---|---|
| | **Implementation Phase** | | | | |
| **Improvement Type** | **2014-20 ($, mill.)** | **2021-25 ($, mill.)** | **2026 - 30 ($, mill.)** | **2031- 35 ($, mill.)** | **Total ($, mill.)** |
| Storage Tank, Booster Pumps, and PRVs | 7.65 | 0.08 | 0.00 | 0.70 | **8.43** |
| Transmission Pipelines | 2.43 | 0.00 | 0.00 | 0.51 | **2.94** |
| Distribution Mains (FF Imp) | 0.00 | 2.57 | 1.95 | 0.00 | **4.52** |
| Rezone Improvements | 0.00 | 0.06 | 0.10 | 0.00 | **0.16** |
| **Total** | **10.08** | **2.71** | **2.05** | **1.21** | **16.06** |

Notes:
1. Costs are based on ENR CCI 20 City average of 9,750 (April 2014).

## 8.6 Existing Versus Future User Cost Share

The improvements proposed in this Master Plan either benefit existing users, or are required to service future users. All of the recommended improvements will be required even if demands do not increase in the future. All of the pipeline and PRV improvements will be sized the same based on existing and future demands. Therefore, the costs associated with these projects were assigned 100 percent to existing users. For the Skyline Tank and the emergency Green Hills Pump Station, there is a certain percentage of the constructed capacity that is specifically associated with future growth, and therefore these two projects were assigned a future users cost accordingly. An opinion of benefit to future users, based on preliminary project information, was included in Table 8.5. As shown in Table 8.5, roughly 87-percent of the recommended CIP costs are allocated to existing customers, whereas only 13-percent are attributable to future growth.

Additionally, costs are broken down for existing and future user cost share of the proposed projects by facility categories (e.g. pipelines, wells, etc.), as shown in Table 8.6. Tanks, Booster Pumps, and PRVs account for the largest portion (52-percent) of the recommended CIP at $8.43 million, followed by fire flow distribution main improvements at $4.52 million (28-percent), transmission main improvements at $2.94 million (18-percent), and rezone improvements at $0.16 million (1 percent).

| Table 8.5 | Existing Versus Future Users Cost Share<br>Water Master Plan<br>City of Millbrae | | | | |
|---|---|---|---|---|---|
| | **Implementation Phase** | | | | |
| **Improvement Type** | **2014-20 ($, mill.)** | **2021-25 ($, mill.)** | **2026 - 30 ($, mill.)** | **2031- 35 ($, mill.)** | **Total ($, mill.)** |
| Existing Users | 8.14 | 2.71 | 2.05 | 1.03 | **13.94** |
| Future Users | 1.94 | 0.00 | 0.00 | 0.18 | **2.12** |
| **Total** | **10.08** | **2.71** | **2.05** | **1.21** | **16.06** |

Notes:
1. Costs are based on ENR CCI 20 City average of 9,750 (April 2014).

| Table 8.6 | Existing Versus Future User Cost Share by Facility Type<br>Water Master Plan<br>City of Millbrae | | | | |
|---|---|---|---|---|---|
| | **Facility Type** | | | | |
| **Category** | **Tank, Boosters, and PRVs ($, mill.)** | **Trans. Mains ($, mill.)** | **Distr. Mains ($, mill.)** | **Rezone ($, mill.)** | **Total ($, mill.)** |
| Existing User | 6.31 | 2.94 | 4.52 | 0.16 | **13.94** |
| Future User | 2.12 | 0.00 | 0.00 | 0.00 | **2.12** |
| **Total** | **8.43** | **2.94** | **4.52** | **0.16** | **16.06** |

Notes:
1. Costs are based on ENR CCI 20 City average of 9,750 (April 2014).

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Appendix B

# LIST OF HISTORICAL MAIN BREAKS

| DATE | SERVICE ADDRESS | PROBLEM LOCATION | CAUSE |
|---|---|---|---|
| 9-Jul-85 | E. MILLBRAE 400 | HYDRANT | MAIN BREAK |
| 28-Nov-85 | LANDING | MAIN | MAIN BREAK |
| 13-Dec-85 | BROADWAY 1133 | MAIN | MAIN BREAK |
| 3-Dec-86 | HELEN 825 | MAIN | MAIN BREAK |
| 3-Dec-86 | HELEN 425 | MAIN | MAIN BREAK |
| 9-Jan-87 | HERMOSA/HEMLOCK | MAIN | MAIN BREAK |
| 9-Jul-87 | MURCHISON/MAGNOLIA | MAIN | MAIN BREAK |
| 31-Aug-87 | LOYOLA 265 | MAIN | MAIN BREAK |
| 21-Sep-87 | HELEN 960 | MAIN | MAIN BREAK |
| 27-Sep-87 | E. MILLBRAE 401 | MAIN | MAIN BREAK |
| 17-Oct-87 | OLD BAYSHORE | MAIN | MAIN BREAK |
| 17-Oct-87 | OLD BAYSHORE 1 | MAIN | MAIN BREAK |
| 17-Oct-87 | OLD BAYSHORE 1 | MAIN | MAIN BREAK |
| 17-Oct-87 | OLD BAYSHORE 1 | MAIN | MAIN BREAK |
| 3-Nov-87 | PARK 152 | OTHER | MAIN BREAK |
| 11-Nov-87 | ADRIAN 231 | OTHER | MAIN BREAK |
| 28-Nov-87 | SPRINGFIELD 919 | MAIN | MAIN BREAK |
| 6-Jan-88 | PARK 146,136 | MAIN/SERVICE | MAIN BREAK |
| 7-May-88 | CHADBOURNE 177 | MAIN | MAIN BREAK |
| 7-May-88 | CHADBOURNE & POPLAR | MAIN | MAIN BREAK |
| 8-Aug-88 | MILLWOOD 217 | MAIN | MAIN BREAK |
| 16-Aug-88 | VIA CANON @ HILLCREST | MAIN | MAIN BREAK |
| 20-Aug-88 | AURA VISTA 35 | MAIN | MAIN BREAK |
| 10-Oct-88 | CRESTVIEW & CLEARFIELD | MAIN | MAIN BREAK |
| 13-Oct-88 | MANZANITA 30 | MAIN | MAIN BREAK |
| 13-Oct-88 | TAYLOR 800 | MAIN | MAIN BREAK |
| 25-Oct-88 | HILLCREST/EL BONITO | OTHER | MAIN BREAK |
| 27-Oct-88 | TERRACE | MAIN | MAIN BREAK |
| 1-Nov-88 | TERRACE | MAIN | MAIN BREAK |
| 2-Nov-88 | RIDGEWOOD/REDWOOD | GATE VALVE | MAIN BREAK |
| 2-Nov-88 | RIDGEWOOD/REDWOOD | MAIN | MAIN BREAK |
| 2-Nov-88 | RIDGEWOOD/REDWOOD | MAIN | MAIN BREAK |
| 3-Nov-88 | RIDGEWOOD 1015 | MAIN | MAIN BREAK |
| 10-Nov-88 | VISTA GRANDE & ARROYO SECO | MAIN | MAIN BREAK |
| 8-Dec-88 | BONITA 624 | MAIN | MAIN BREAK |
| 1-Jan-89 | LA PRENDA/DEL CENTRO | MAIN | MAIN BREAK |
| 1-Jan-89 | LA PRENDA/DEL CENTRO | MAIN | MAIN BREAK |
| 29-Jan-89 | E. MILLBRAE 401 | OTHER | MAIN BREAK |
| 29-Jan-89 | E. MILLBRAE 401 | OTHER | MAIN BREAK |
| 30-Jan-89 | E. MILLBRAE 401 | MAIN | MAIN BREAK |
| 6-Feb-89 | LINDA VISTA 120 | MAIN | MAIN BREAK |
| 6-Feb-89 | LINDA VISTA 120 | MAIN | MAIN BREAK |
| 1-Apr-89 | SANTA MARGARITA 750 | MAIN | MAIN BREAK |
| 20-Jun-89 | MANZANITA/ENCINA | MAIN | MAIN BREAK |
| 5-Aug-89 | HILLCREST 930 | MAIN | MAIN |
| 9-Nov-89 | LOYOLA 341 | MAIN | MAIN BREAK |
| 5-Feb-90 | LARKSPUR 910 | MAIN | MAIN BREAK |
| 5-Feb-90 | LARKSPUR 910 | MAIN | MAIN BREAK |
| 22-Apr-90 | ROBIN/RIDGEWOOD | MAIN | MAIN BREAK |
| 7-Jun-90 | CENTER | MAIN | MAIN BREAK |
| 14-Jun-90 | LA PRENDA | MAIN | MAIN BREAK |
| 14-Jun-90 | LA PRENDA | MAIN | MAIN BREAK |
| 15-Jun-90 | LA PRENDA | MAIN | MAIN |
| 21-Jun-90 | LA PRENDA | MAIN | MAIN BREAK |
| 21-Jun-90 | LA PRENDA | MAIN | MAIN BREAK |

| DATE | SERVICE ADDRESS | PROBLEM LOCATION | CAUSE |
|---|---|---|---|
| 3-Aug-90 | CUARDO & LERIDA | WATER | MAIN BREAK |
| 4-Aug-90 | BEVERLY @ NADINA | WATER | MAIN BREAK |
| 13-Aug-90 | VALENCIA 206 | LEAK CHECK | MAIN BREAK |
| 3-Sep-90 | VALLEJO & VALLEJO CT | | MAIN BREAK |
| 3-Sep-90 | VALLEJO | | MAIN BREAK |
| 3-Sep-90 | VALLEJO CT | LEAK CHECK | MAIN BREAK |
| 3-Sep-90 | HILLCREST 1430 | | MAIN BREAK |
| 21-Nov-90 | LAKE 1221 | | MAIN BREAK |
| 25-Nov-90 | VISTA GRANDE 965 | MAIN | MAIN BREAK |
| 25-Nov-90 | VISTA GRANDE | LEAK CHECK | MAIN BREAK |
| 29-Nov-90 | VISTA GRANDE 965 | | MAIN BREAK |
| 26-Dec-90 | LAKE 1221 | | MAIN BREAK |
| 27-Dec-90 | TUOLUMNE 1200 | LEAK CHECK | MAIN BREAK |
| 2-Jan-91 | BROADWAY & VICTORIA | | MAIN BREAK |
| 4-Jan-91 | MAGNOLIA/RICHMOND | | MAIN BREAK |
| 19-Feb-91 | VALENCIA 206 | | MAIN BREAK |
| 6-Mar-91 | BAY & SANTA PAULA | WATER | MAIN BREAK |
| 20-Nov-91 | MILLBRAE 1248 | | MAIN BREAK |
| 16-Dec-91 | LA PRENDA 31 | MAIN & HYDRANT | MAIN BREAK |
| 10-May-92 | VISTA GRANDE 811 | DRIVEWAY | MAIN BREAK |
| 1-Jul-92 | TERRACE 1376 | MAIN | MAIN BREAK |
| 10-Nov-92 | POPLAR 197 | WATER | MAIN BREAK |
| 10-Nov-92 | TAYLOR 201 | WATER | MAIN BREAK |
| 11-Nov-92 | RIDGEWOOD 1011 | WATER LEAK CHK | MAIN BREAK |
| 3-Jun-93 | LAUREL 11 | WATERMAIN BREAK | MAIN BREAK |
| 23-Sep-93 | MINORCA 318 | WATER | MAIN BREAK |
| 25-Oct-93 | HELEN 1101 | PRIVATE | MAIN BREAK |
| 22-Nov-93 | DUMONT 50 | MAIN | MAIN BREAK |
| 30-Jan-94 | MAGNOLIA 1410 | MAIN | MAIN BREAK |
| 8-Feb-95 | CAMINO ALTO 68 | NO WATER TO TAP | MAIN BREAK |
| 3-Apr-95 | AURA VISTA 35 | MAIN | MAIN BREAK |
| 3-Apr-95 | AURA VISTA 35 | MAIN | MAIN BREAK |
| 21-Apr-95 | ASHTON 450 | MAIN | MAIN BREAK |
| 21-Apr-95 | ASHTON 450 | MAIN | MAIN BREAK |
| 7-Jul-95 | CORTE PRINCESA 22 | MAIN | MAIN BREAK |
| 7-Jul-95 | CORTE PRINCESA 22 | MAIN | MAIN BREAK |
| 7-Jul-95 | CORTE PRINCESA 22 | MAIN | MAIN BREAK |
| 29-Oct-95 | HILLCREST 1164 | MAIN | MAIN BREAK |
| 11-Dec-95 | E. MILLBRAE 400 | MAIN | MAIN BREAK |
| 12-Dec-95 | E. MILLBRAE 401 | MAIN | MAIN BREAK |
| 22-Dec-95 | ALTO LOMA 120 | | MAIN |
| 20-Feb-96 | DUMONT 50/833 CRESTVIEW | MAIN | MAIN BREAK |
| 20-Feb-96 | CRESTVIEW 833 | MAIN/SERVICE | MAIN BREAK |
| 28-Feb-96 | CHADWICK 70 | MAIN | MAIN BREAK |
| 12-Mar-96 | ROLLINS/ADRIAN | MAIN | MAIN BREAK |
| 12-Mar-96 | ADRIAN 375 | PRIVATE | MAIN BREAK |
| 12-Mar-96 | CLAREMONT 14 | MAIN | MAIN BREAK |
| 4-Apr-96 | TERRACE 1350 | MAIN | MAIN BREAK |
| 3-Aug-96 | AVIADOR 303 | MAIN | MAIN BREAK |
| 8-Aug-96 | VALENCIA 206 | MAIN | MAIN BREAK |
| 9-Aug-96 | CORTE PRINCESA 38 | MAIN | MAIN BREAK |
| 26-Aug-96 | DUMONT 40 | MAIN | MAIN BREAK |
| 17-Jan-97 | BROADWAY @ CHADBOURNE | INTERSECTION | MAIN BREAK |
| 10-Jun-97 | MAGNOLIA 621 | MAIN | MAIN BREAK |
| 18-Jun-97 | EL CAMINO 1328 | W/S? | MAIN BREAK |

| DATE | SERVICE ADDRESS | PROBLEM LOCATION | CAUSE |
|---|---|---|---|
| 23-Jun-97 | EL CAMINO 1320 | MAIN | MAIN BREAK |
| 28-Aug-97 | BANBURY 806 | MAIN | MAIN BREAK |
| 6-Sep-97 | SANTA BARBARA 651 | MAIN | MAIN BREAK |
| 16-Sep-97 | EL BONITO 10 | MAIN | MAIN BREAK |
| 7-Oct-97 | HAZEL 530 | "DIRTY WATER" | MAIN BREAK |
| 10-Dec-97 | HILLCREST 1031 | MAIN | MAIN BREAK |
| 20-Dec-97 | EL BONITO 300 | MAIN | MAIN BREAK |
| 27-Dec-97 | EVERGREEN 982 | MAIN | MAIN BREAK |
| 19-Oct-98 | AVIADOR 185 | STORAGE YD. | MAIN BREAK |
| 18-Oct-99 | ADRIAN | LEAK CHECK | MAIN BREAK |
| 6-Feb-00 | BERTOCCHI LANE | LEAK CHECK | MAIN BREAK |
| 7-Feb-00 | MAGNOLIA 990 | LEAK CHECK | MAIN BREAK |
| 8-Feb-00 | AVIADOR STORAGE FACILITY | LEAK CHECK | MAIN BREAK |
| 23-Feb-00 | EL CAMINO 501 | LEAK CHECK | MAIN BREAK |
| 23-Feb-00 | EL CAMINO 501 | LEAK CHECK | MAIN BREAK |
| 26-Feb-00 | GREEN HILLS@LAUREL | LEAK | MAIN BREAK |
| 15-Oct-00 | TAYLOR SCHOOL | CLEANUP | MAIN BREAK |
| 16-Nov-00 | LAUREL 210 | LOW PSI | MAIN BREAK |
| 6-Nov-01 | LA PRENDA 55 | STREET | MAIN BREAK |
| 18-Jun-02 | CAMINO ALTO | MAIN | MAIN BREAK |
| 27-Jun-02 | E. MILLBRAE | MAIN | MAIN BREAK |
| 26-Aug-02 | HELEN 247 | MAIN | MAIN BREAK |
| 7-Sep-02 | HELEN | MAIN 12" | MAIN BREAK |
| 2-Oct-02 | BROADWAY 316 | STREET | MAIN BREAK |
| 3-Oct-02 | JUANITA 612 | SIDEWALK | MAIN BREAK |
| 30-Oct-02 | CAMINO ALTO | MAIN | MAIN BREAK |
| 9-Jan-08 | ALTO LOMA 250 | MAIN | MAIN BREAK |
| 2-Nov-08 | MINORCA 330 | MAIN | MAIN BREAK |
| 2-Nov-08 | HELEN 950 | MAIN | MAIN BREAK |
| 17-Feb-09 | BROADWAY 1496 | MAIN | MAIN BREAK |
| 7-Nov-10 | LAUREL @ ANITA | MAIN | MAIN BREAK |
| 22-Nov-10 | DEXTER 4 | MAIN | MAIN BREAK |
| 29-Nov-10 | JUANITA 612 | MAIN | MAIN BREAK |
| 20-Jan-11 | HELEN 247 | MAIN | MAIN BREAK |

Appendix C

# FACILITY DETAILS

This appendix includes the following:

- PRV Maintenance Records
- Manufacturer Pump Curves
- Sequence of Events for Pump Controls

# P.R.V. MAINTENANCE RECORD

SITE LOCATION: **1320 tuolumne (upper)**

INSTALATION DATA :

| | VALVE # 1 | VALVE # 2 | VALVE # 3 |
|---|---|---|---|
| MANUFACTURER | **Ames** | **CLA-VAL** | |
| SIZE | **2"** | **6"** | |
| MODEL NO. | **910** | **100- 01** | |
| INLET PRESSURE | **110 psi** | **110 psi** | |
| OUTLET PRESSURE | **60 psi** | **60 psi** | |
| PILOT SETTINGS | **60 PSI** | **55 PSI** | |

SERVICE DATA :

| DATE: | SERVICE PREFORMED: | PARTS: |
|---|---|---|
| 11/12/2009 | | |
| | **2" AMES** | **Model #** 910 |
| | | **Serial #** 139316 |
| | | |
| | No Info. On Pilot System | |
| | | |
| | | |
| | | |
| | **6" Cla - Val and Pilot Cleaning** | |
| | | |
| | | |
| | Replaced: Diaphragm | # 87893 E |
| | | # V 1692 C |
| | | # V 5138 C |
| | | |
| | Disc Retainer (epoxy coated) | # 6935801 J |
| | | |
| | Note: Bolt Replacement (12 bolts per cover) | |
| | Bolt size 3/4 -10 X 2" coarse threads. Cleaned,Flushed and Reassembled | |
| | **Pilot replaced on 12/10/09** | |
| | Pilot System - 30 -300 3/8 CRD | # 71943-04H |
| | Pilot Adjutments -1 turn = 27psi | |
| | | |

**Procedure:** If the 2" PRV can't keep up with the demand-Install pressure gauges at 1315 and 1320 Tuolumne and monitor. Go to Morningside @ Clearfield and open the valve next to the red zone valve check pressure at 1315 and 1320 pressure should rise about 10psi from 60 to 70. close valves at PRV and check pressure if pressure is steady at 70psi continue on with your maintenance

# P.R.V. MAINTENANCE RECORD

SITE LOCATION: **1166 Tuolumne @ Tuolumne ct. (lower)**

INSTALATION DATA :

| | VALVE # 1 | VALVE # 2 | VALVE # 3 |
|---|---|---|---|
| MANUFACTURER | **CLA-VAL** | | |
| SIZE | **6"** | | |
| MODEL NO. | **100- 01** | | |
| INLET PRESSURE | **110 psi** | | |
| OUTLET PRESSURE | **60psi** | | |
| PILOT SETTINGS | **60 PSI** | | |

SERVICE DATA :

| DATE: | SERVICE PREFORMED: | PARTS: |
|---|---|---|
| | | |
| 11/5/2009 | | |
| | **6" Cla - Val and Pilot Cleaning** | |
| | | |
| | Replaced: Diaphragm | # 87893 E |
| | Washer Spacers | # V 1692 C |
| | Disc | # V 5138 C |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | Note: Bolt Replacement (12 bolts per cover) | # 71943-04H |
| | | |
| | Pilot Adjutments -1 turn = 27psi | |
| | | |

**Procedure:** Install pressure gauges on hydrant upstream and at 1166 tuolumne downstream.
**Open Zone** valve at Sleepy hollow and Ahwahnee, check pressure at 1166 tuolumne for should be no changes!!! Continue with your maintenance

# P.R.V. MAINTENANCE RECORD

SITE LOCATION: **850 Taylor @ Minorca**

INSTALATION DATA :

| | VALVE # 1 | VALVE # 2 | VALVE # 3 |
|---|---|---|---|
| MANUFACTURER | **CLA-VAL** | **CLA-VAL** | |
| SIZE | **2"** | **6"** | |
| MODEL NO. | **n/a** | **100- 01** | |
| INLET PRESSURE | **150 psi** | **150 psi** | |
| OUTLET PRESSURE | **75 psi** | **75 psi** | |
| PILOT SETTINGS | **75 psi** | **70 psi** | |

SERVICE DATA :

| DATE: | SERVICE PREFORMED: | PARTS: |
|---|---|---|
| 11/12/2009 | | |
| | **2" Cla - Val and Pilot Cleaning** | |
| | | |
| | Replaced: Diaphragm | # 80522 G |
| | Washer Spacers | # V 5232 D |
| | Disc | # V 5564 K |
| | | |
| | | |
| | | |
| | | |
| | | |
| | Pilot Adjutments -1 turn = 27psi | |
| 11/12/2009 | | |
| | **6" Cla - Val and Pilot Cleaning** | |
| | | |
| | | |
| | Replaced: Diaphragm | # 87893 E |
| | Washer Spacers | # V 1692 C |
| | Disc | # V 5138 C |
| | | |
| | Note: Bolt Replacement (12 bolts per cover) | |
| | Bolt size 3/4 -10 X 2" coarse threads. Cleaned,Flushed and Reassembled | |
| | | |
| | Pilot System - 30 -300 3/8 CRD | # 71943-04H |
| | Pilot Adjutments -1 turn = 27psi | |
| | | |
| | | |
| | | |

# P.R.V. MAINTENANCE RECORD

SITE LOCATION: **Maple @ Murchison**

INSTALATION DATA :

| | VALVE # 1 | VALVE # 2 | VALVE # 3 |
|---|---|---|---|
| MANUFACTURER | **CLA-VAL** | **CLA-VAL** | |
| SIZE | **2"** | **6"** | |
| MODEL NO. | **n/a** | **100- 01** | |
| INLET PRESSURE | **130 psi** | **130 psi** | |
| OUTLET PRESSURE | **52 psi** | **52 psi** | |
| PILOT SETTINGS | **52 PSI** | **45 PSI** | |

SERVICE DATA :

| DATE: | SERVICE PREFORMED: | PARTS: |
|---|---|---|
| 11/2/2009 | | |
| | **2" Cla - Val and Pilot Cleaning** | |
| | | |
| | Replaced: Diaphragm | # 80522 G |
| | Washer Spacers | # V 5232 D |
| | Disc | # V 5564 K |

| DATE | SERVICE | PARTS |
|---|---|---|
| 11/2/2009 | | |
| | **6" Cla - Val and Pilot Cleaning** | |
| | | |
| | | |
| | Replaced: Diaphragm | # 87893 E |
| | Washer Spacers | # V 1692 C |
| | Disc | # V 5138 C |
| | Disc Retainer (epoxy coated) | # 6935801 J |
| | Note: Bolt Replacement (12 bolts per cover) | |
| | Bolt size 3/4 -10 X 2" coarse threads. Cleaned,Flushed and Reassembled | |
| | | |
| | Pilot System - 30 -300 3/8 CRD | # 71943-04H |
| | Pilot Adjutments -1 turn = 27psi | |

# P.R.V. MAINTENANCE RECORD

SITE LOCATION: **Aura Vista**

INSTALATION DATA :

| | VALVE # 1 | VALVE # 2 | VALVE # 3 |
|---|---|---|---|
| MANUFACTURER | **CLA-VAL** | | |
| SIZE | **4"** | | |
| MODEL NO. | **N/A** | | |
| INLET PRESSURE | **108 psi** | | |
| OUTLET PRESSURE | **75psi** | | |
| PILOT SETTINGS | **75 psi** | | |

SERVICE DATA :

| DATE: | SERVICE PREFORMED: | PARTS: |
|---|---|---|
| 11/2/2009 | | |
| | **4" Cla - Val and Pilot Cleaning** | |
| | Replaced: Diaphragm | # 86807 F |
| | Washer Spacers | # V 0634 F |
| | Disc | # V 546 F |
| | Note: Bolt Replacement (12 bolts per cover) | # 71943-04H |
| | Pilot Adjutments -1 turn = 27psi | |

**Procedure:** For maintenance or **PRV Failure** close upstream valve, check pressure. psi should hold at 75, system will ride on hillcrest PRV . Close downstream

# P.R.V. MAINTENANCE RECORD

SITE LOCATION: **Hillcrest @ El Bonito**

INSTALATION DATA :

| | VALVE # 1 | VALVE # 2 | VALVE # 3 |
|---|---|---|---|
| MANUFACTURER | **CLA-VAL** | | |
| SIZE | **6"** | | |
| MODEL NO. | **N/A** | | |
| INLET PRESSURE | **110 psi** | | |
| OUTLET PRESSURE | **60 psi** | | |
| PILOT SETTINGS | **55 psi** | | |

SERVICE DATA :

| DATE: | SERVICE PREFORMED: | PARTS: |
|---|---|---|
| | | |
| 12/10/2009 | | |
| | **6" Cla - Val and Pilot Cleaning** | |
| | | |
| | Replaced: Diaphragm | # 87893 E |
| | Washer Spacers | # V 1692 C |
| | Disc | # V 5138 C |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | Note: Bolt Replacement (12 bolts per cover) | # 71943-04H |
| | | |
| | Pilot Adjutments -1 turn = 27psi | |
| | | |
| **Procedure:** | For maintenance or **PRV Failure** close upstream valve, check pressure. psi should hold at 60, system will ride on Aura Vista PRV . Close downstream | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

# P.R.V. MAINTENANCE RECORD

SITE LOCATION: **Madera Across From Pump Station**

INSTALATION DATA :

| | VALVE # 1 | VALVE # 2 | VALVE # 3 |
|---|---|---|---|
| MANUFACTURER | **CLA-VAL** | **CLA-VAL** | |
| SIZE | **2"** | **6"** | |
| MODEL NO. | **n/a** | **100- 01** | |
| INLET PRESSURE | **140 psi** | **140 psi** | |
| OUTLET PRESSURE | **110 psi** | **110 psi** | |
| PILOT SETTINGS | **105 psi** | **100 psi** | |

SERVICE DATA :STANDBY

| DATE: | SERVICE PREFORMED: | PARTS: |
|---|---|---|
| 11/4/2009 | | |
| | **2" Cla - Val and Pilot Cleaning** | |
| | | |
| | Replaced: Diaphragm | # 80522 G |
| | Washer Spacers | # V 5232 D |
| | Disc | # V 5564 K |
| | | |
| | | |
| | | |
| | | |
| | | |
| 11/4/2009 | | |
| | **6" Cla - Val and Pilot Cleaning** | |
| | | |
| | | |
| | Replaced: Diaphragm | # 87893 E |
| | Washer Spacers | # V 1692 C |
| | Disc | # V 5138 C |
| | Disc Retainer (epoxy coated) | # 6935801 J |
| | | |
| | Note: Bolt Replacement (12 bolts per cover) | |
| | Bolt size 3/4 -10 X 2" coarse threads. Cleaned,Flushed and Reassembled | |
| | **2" pipe needs replacing all piping needs paint and vault needs pump ???** | |
| | | |
| | Pilot System - 30 -300 3/8 CRD | # 71943-04H |
| | Pilot Adjutments -1 turn = 27psi | |
| | | |
| | | |

# P.R.V. MAINTENANCE RECORD

SITE LOCATION: **Larkspur in Pump Station**

INSTALATION DATA :

| | VALVE # 1 | VALVE # 2 | VALVE # 3 |
|---|---|---|---|
| MANUFACTURER | **CLA-VAL** | | |
| SIZE | **8"** | | |
| MODEL NO. | **N/A** | | |
| INLET PRESSURE | **140 psi** | | |
| OUTLET PRESSURE | **44 psi** | | |
| PILOT SETTINGS | **40 psi** | | |

SERVICE DATA : STANDBY

| DATE: | SERVICE PREFORMED: | PARTS: |
|---|---|---|
| 12/14/2009 | | |
| | **8" Cla - Val and Pilot Cleaning** | |
| | Replaced: Diaphragm | # 11359 H |
| | Washer Spacers | # V 5133 D |
| | Disc | # V 5566 E |
| | Note: Bolt Replacement (12 bolts per cover) | # 71943-04H |
| | Pilot Adjutments -1 turn = 27psi | |
| **Procedure :** | **For maintenance or Shut Down @ HTTP. Increse pilot pressure 1/2 of a turn** | |
| | **This will match pressure in system** | |

# P.R.V. MAINTENANCE RECORD

SITE LOCATION: **Vallejo Tank Site (altitude valve)**

INSTALATION DATA :

| | VALVE # 1 | VALVE # 2 | VALVE # 3 |
|---|---|---|---|
| MANUFACTURER | **CLA-VAL** | | |
| SIZE | **6"** | | |
| MODEL NO. | **N/A** | | |
| INLET PRESSURE | **45 psi** | | |
| OUTLET PRESSURE | **n/a psi** | | |

SERVICE DATA :

| DATE: | SERVICE PREFORMED: | PARTS: |
|---|---|---|
| 1/7/2010 | | |
| | **6" Cla - Val and Pilot Cleaning** | |
| | Replaced: Diaphragm | # 87893 E |
| | Washer Spacers | # V 1692 C |
| | Disc | # V 5138 C |
| | Disc Retainer (epoxy coated) | # 6935801 J |
| | 3/8 Check Valve / 81-01 | # C 5631 B |
| | Flow Check Control /CVC | # V 3375 C |
| **Procedure:** | Tank Isolation-Close outlet valve on tank, Madera regulator should | |
| | Adjustments to the Altitude Control (1Spring) **1 Turn = 3/4 of a ft** | |
| | Adjustments to the flow check control **1 Turn = 4 inches** | |

# P.R.V. MAINTENANCE RECORD

SITE LOCATION: **La Prenda Tank Site (altitude valve)**

INSTALATION DATA :

| | VALVE # 1 | VALVE # 2 | VALVE # 3 |
|---|---|---|---|
| MANUFACTURER | **CLA-VAL** | **Bailey** | |
| SIZE | **10"** | **8"** | |
| MODEL NO. | **N/A** | | |
| INLET PRESSURE | **55 psi** | **55 psi** | |
| OUTLET PRESSURE | **n/a psi** | **14 psi** | |

SERVICE DATA :

| DATE: | SERVICE PREFORMED: | PARTS: |
|---|---|---|
| | | |
| 1/22/2010 | | |
| | **10" Cla - Val and Pilot Cleaning** | |
| | Replaced: Diaphragm | # V 5576 D |
| | Washer Spacers | # V 5160 G |
| | Disc | # V 5569 J |
| | Disc Retainer (epoxy coated) | # 6935801 J |
| | 3/8 Check Valve / 81-01 | # C 5631 B |
| | Flow Check Control /CVC | # V 3375 C |
| 3/30/2011 | Replaced : Stem and Seat | |
| | Cover bearing | |
| | | |
| 2/14/2011 | Rebuilt: Altitude controler Model # | CDS-5 |
| | | |
| | Adjustments to the Altitude Control (2 Spring) **1 Turn = 1 1/2 ft** | |
| | Adjustments to the flow check control **1 Turn = 4 inches** | |
| | | |
| **Procedure:** | Tank Isolation-Close outlet valve on tank open zone valve located at | |
| | Madera and Valencia the system (zone II) will ride on vallejo tank | |
| | only if regulator (bypass) can't be used | |
| | | |
| | **8" Bailey Valve** | |
| | | |
| | Note: This valve is an 8" PRV (**bypass valve**) only used when Tank or Altitude valve | |
| | is out of service. **Pressure on PRV is set at 15psi and should not exceed that pressure** | |
| | | |

# P.R.V. MAINTENANCE RECORD

SITE LOCATION: **Lomita @ Bayview**

INSTALATION DATA :

| | VALVE # 1 | VALVE # 2 | VALVE # 3 |
|---|---|---|---|
| MANUFACTURER | **Watts** | **Watts** | **Watts** |
| SIZE | **2"** | **4"** | **6"** |
| MODEL NO. | | | |
| INLET PRESSURE | **132psi** | **132psi** | **132psi** |
| OUTLET PRESSURE | **85psi** | **85psi** | **85psi** |
| PILOT SETTINGS | **85psi** | **82psi** | **79psi** |

SERVICE DATA :

| DATE: | SERVICE PREFORMED: | PARTS: |
|---|---|---|
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# P.R.V. MAINTENANCE RECORD

SITE LOCATION: **Hacienda**

INSTALATION DATA :

| | VALVE # 1 | VALVE # 2 | VALVE # 3 |
|---|---|---|---|
| MANUFACTURER | Watts | Watts | Watts |
| SIZE | 2" | 4" | 6" |
| MODEL NO. | | | |
| INLET PRESSURE | 125psi | 125psi | 125psi |
| OUTLET PRESSURE | 80psi | 80psi | 80psi |
| PILOT SETTINGS | 80psi | 76psi | 72psi |

SERVICE DATA :

| DATE: | SERVICE PREFORMED: | PARTS: |
|---|---|---|
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# P.R.V. MAINTENANCE RECORD

SITE LOCATION: Helen

INSTALATION DATA :

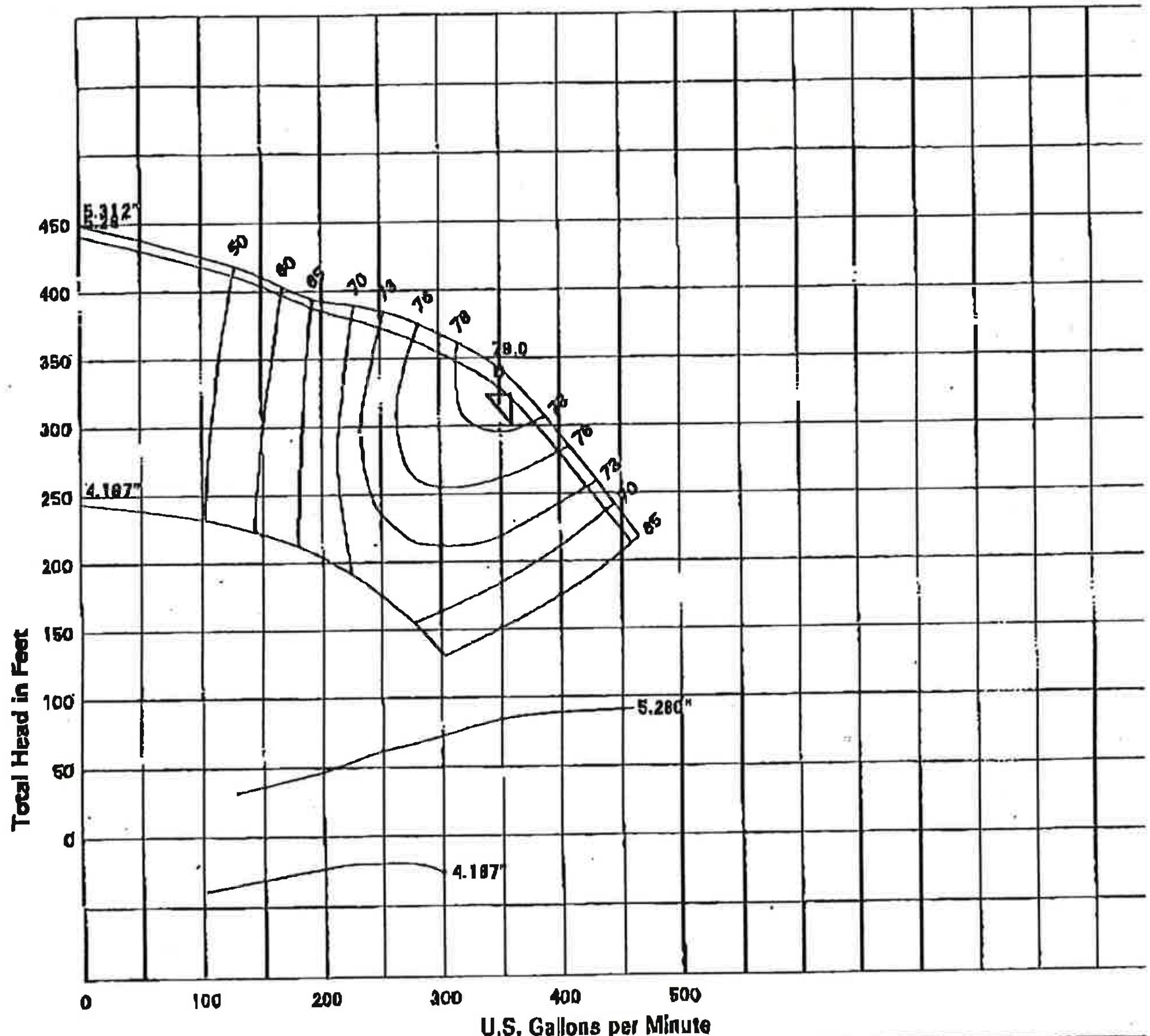
| | VALVE # 1 | VALVE # 2 | VALVE # 3 |
|---|---|---|---|
| MANUFACTURER | Bailey | Bailey | Bailey |
| SIZE | 2" | 4" | 6" |
| MODEL NO. | | | |
| INLET PRESSURE | 159psi | 159psi | 159psi |
| OUTLET PRESSURE | 94psi | 94psi | 94psi |
| PILOT PRESSURE | 94psi | 90psi | 87psi |

SERVICE DATA :

| DATE: | SERVICE PREFORMED: | PARTS: |
|---|---|---|
| | | |

FLOWSERVE

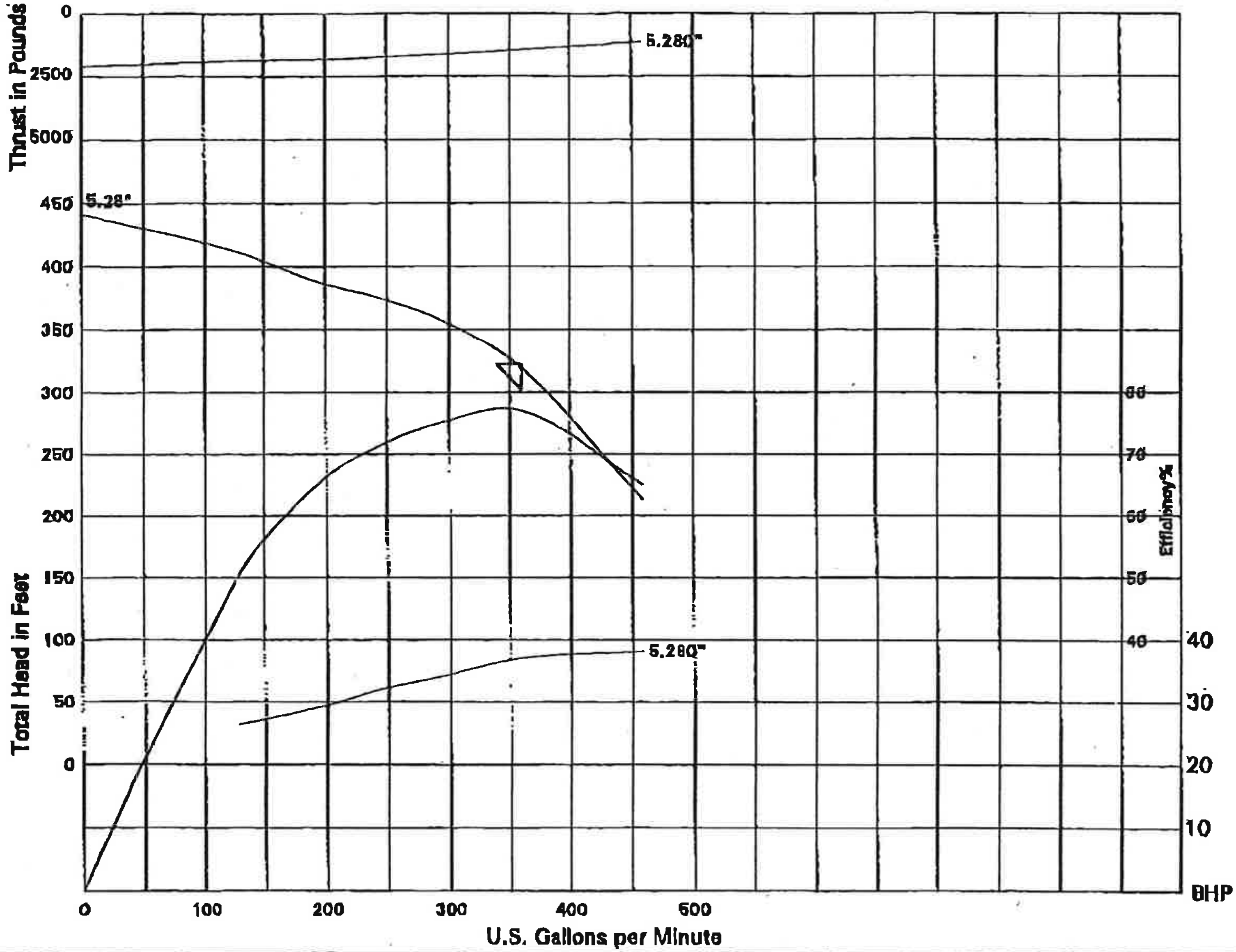
Byron Jackson Pumps | United Centrifugal Pumps | Wilson Snyder Pumps | Stark Engineered Pumps | Durco ANSI Std Pumps




| | | | |
|---|---|---|---|
| Purchaser: | Proposition: | PRIMER v2.10 D0000156 |
| End User: | Curve No.: | |
| Project: | SalesPerson: Hugh Soubee | Pump Size & Type |
| Item/Spec: | Date: | |

**FLOWSERVE**

| Byron Jackson Pumps | United Centrifugal Pumps | Wilson - Snyder Pumps | ...ork Engineered Pumps | Durco ANSI Std Pumps |
|---|---|---|---|---|




**STANDARD INFO**

Revision date: 7/29/94
Minimum Submergence: 18"
Vanes: 9
Ns = Pump Specific Speed: 2725
Eye Area: 6.5 in²
U : 23.0 ft/sec
Rating number: 3404
Original RPM: 1760

**DESIGN CALC (APPROXIMATE)**

Stages - design: 12
Trim Diameter - design: 5.28"
Efficiency: - design: 77.0%
Head reserve available: 3.4%
Head rise to shutoff: 36.6%
Power - design: 37.7 BHP
Thrust - design: 1438.5 BHP
NPSH required: 0.0 Feet

**DESIGN PARAMETERS**

RPM: 1765
Flow: 360 GPM
Head: 323 ft
NPSHA: 0.0 ft +
SpGr: 1.00
Visc: 1

| | | | |
|---|---|---|---|
| Purchaser: | Proposition: | PRIMER v2.10 10000158 | |
| End User: | Curve No.: | | |
| Project: | SalesPerson: Hugh Sosbee | Pump Size & Type | 8" G "H" |
| Item/Spec: | Date: | | |

# SEQUENCE OF EVENTS FOR MILLBRAE POTABLE WATER PUMP CONTROLS

Table of Contents



## Chapter 1. The overall scheme

These controls run pumps at the Larkspur and Madera pump stations. The purpose of the controls is to fill Skyline tank each night between 21:30 (9:30 PM) and 7:30 AM, and to run pumps as little as possible the rest of the time. This has been implemented due to an agreement with PG&E to minimize power use during the day. For the purposes of the controls, the day is 7:30 - 21:30 and night is 21:30 - 7:30.

During the day, pumps may be started and stopped from Xview Slide #6 for Larkspur P.S., #7 for Madera, and Slide 12, the Master Pump slide.

During the night, the system automatically starts and stops pumps in order to fill the Skyline tanks. Every half-hour, the system reads the Skyline tanks' level and calculates the flow required to fill the tanks by 7:30. This flow requirement is sent to both pump stations. For normal operation (no relevant RTUs down) this flow requirement is the same for Larkspur and Madera pump stations. Again, the flow requirement number is the GPM required to fill Skyline by 7:30 AM--the number is calculated as if Larkspur and Madera were not two separate pump stations at all, but simply six pumps available to fill the tank. Controls in the Larkspur and Madera RTUs turn pumps on and off to achieve the desired flow.

Since the system operates automatically at night, direct operator pump starts and stops are prohibited then. If need be, the operator can influence which pumps run by setting the start thresholds and the lead-lag order of the pumps, see Chapter 3.

## 2. Daytime pump starts and stops

To start a pump, click on the picture of the pump on the appropriate slide. A quick-menu should appear. If the pump is off, there will be a START button in the quick-menu. Click the "START" button to start the pump.

If the pump is on when its target is clicked, there will be a STOP button in the quick-menu. Click STOP to stop the pump.

On the pump station slides #6 and #7, next to each pump is a gray box.

In this box, the topmost entry is labeled "S/S" and is a green "OFF" or a red "ON." The "OFF" or "ON" can be clicked to get the quick-menu and start/stop the pump. (In MISERese, the clickable item is called a "target.")

The next entry is labeled "Alarm." This target should say NORMAL in green. If the pump is commanded to start, and has not done so after 90 seconds, RUN FAIL will appear in red in this target. This alarm will also occur if the pump is running and then stops without an RTU command to stop. Please see Chapter 4 for more information about RUN FAIL behavior.

The third entry is labeled "Requested." Here is how it works: At the RTU, the Digital Output (DO) that commands the RTU is connected to a Digital Input (DI) on the RTU, in parallel with the relay coil the DO is really there to operate. The DI is therefore an accurate reflection of whether the RTU is telling the pump to run. The DI operates the "Requested" target, which will say "ON" or "OFF." This target is set up NOT to respond to clicking, so no one thinks it is the way to start the pump.

If the Skyline tank level falls too low during the day, pumps will automatically be started. On Slides #6 and #7, next to each pump is a green box labeled "Day Setup: Skyline Level for Pump n Start." Click the blue number target in each box to set the Skyline level that will automatically start the pump. Click the "Change Point Value" button, then enter the desired level in the resulting field.

If the Skyline level is at or below a pump's auto-start level, no operator should stop the pump. If you want to stop a pump in these circumstances, first change the auto-start level to a value below the current Skyline level.

3. Nighttime pump starts and stops

During the Night (21:30 - 7:30), pumps are operated automatically. On slides #6 and 7, note the green box with targets labeled "Skyline Tank Level" and "Night Flow Request." The "Night Flow Request" target contains the requested total GPM to be pumped by Larkspur and Madera pump stations. This number is set automatically every half-hour during the night. At 7:15 each morning, the night flow request is set to 0.

In the box labeled "Night Setup" are the GPM request thresholds for the pump station's Lead, Lag1 and Lag2 pumps to start. To change any of these values, click the number, then click the "SET-PT Value" button in the quick-menu. This will bring up an entry box containing the current value. Replace this value with the desired value.

In the lower left corner of each pump station slide, is a table with number targets labeled "Nighttime Lead/Lag Order." The pump set to 1 is the lead pump and will run the most.

To change the lead/lag order, click each number and click the "SET-PT Value" button, then enter the desired value, 1, 2 or 3. The system verifies that no two pumps are set to the same lead/lag order value.

While you are changing the values, a message will appear above the table:

Lead-lag order invalid, pumps will start simultaneously!

The message will go away within 15 seconds, once the values are set correctly. If the values remain invalid for more than two minutes, an alarm will appear saying "LEAD/LG NBRS INVALID."

The RTU controls include an arrangement to prevent two or three pumps in a pump station from starting simultaneously. If no pumps are running, only one pump is allowed to start, no matter what flow request is present. After one pump has been running for thirty seconds, a second pump is allowed to start. After two pumps have been running for thirty seconds, the third pump is allowed to start.

PREVENTING PUMPS FROM STARTING: If a pump is in poor condition and should only be run in case water is desperately needed, make that pump the Nighttime Lead/Lag Order 3 pump for its pump station. You can also set the GPM Threshold for the Order 3 (2'nd Lag) pump to a high value. If you want to absolutely prevent automatic starting of the pump, you can also disable the pump's Start/Stop point. Find the "S/S OFF" for the bad pump in its pump station slide. Click the word OFF. This should get you a Quick-menu for the point xxx-PMPn-SS for the bad pump. Click the Disable Point button in the quick-menu. To reverse this action, click the "OFF" again and click Enable Point in the quick-menu. CAUTION: If the Lead pump in a pump station has its xxx-PMPn-SS point disabled, then NONE of the pumps in the station will start automatically at night. If the Order 2 pump is disabled, neither it nor the Order 3 pump will start automatically at night.

## Chapter 4. Safety Features and Interlocks

### A. Skyline Tank Level:

If the Skyline tank level should reach 26.6 ft at any time of day or night, any running pumps will automatically be stopped, and the lockout assumes "control ownership" so that no operator or other control can start any pump. Control ownership is released when the level has dropped below 26.5 ft.

If the Skyline tank level should reach 26.5 ft at any time of day or night, both Night Flow Request points will be forced to 0 if they are not 0 already. If this happens, the lockout assumes control ownership so that no operator or automatic operation may increase the setpoints. Control ownership is released after the Skyline level has fallen to 25.5 ft.

On Slide 2, note the box that presents "Level from RTU," "Level Status" and "Level for Calcs." In normal operation, the "Level from RTU" is passed to the "Level for Calcs" every 15 seconds. All controls using the Skyline level are actually using the "Level for Calcs."

The "Level from RTU" is checked every 15 seconds to make sure it has not gone down by an unrealistic amount. If the tank level shows more than

5 feet lower than it was 15 seconds ago, this means there is a problem with the level transmitter or its connection. The "Level Status" point comes on and goes into alarm. While the "Level Status" point is on, the tank level reported by the RTU is not passed to the "Level for Calcs." This prevents all the LAR and MAD pumps from being started because of a bad tank level indication. When the "Level Status" point is on, it will say "SUSPECT" in Xview--the system does not trust the reported tank level.

If a "Level Status" alarm occurs, once the correct "Level from RTU" has been restored, the "Level Status" point needs to be reset by an operator for the "Level for Calcs" point to resume updating. The "Level Status" point SKY-LVL-STS appears in targets on Skyline Slide 2 and on Resets Slide 9. On either slide, click the word SUSPECT, then click the RESET button in the quick-menu. You can click the Acknowledge Alarm button also, but acknowledging the alarm does not reset the point.

B. Seismic Valve Positions:

If either of the Skyline seismic valves is less than 20% open, all LAR and MAD pumps are sent STOP commands if they are requested ON. If this happens, control ownership is taken so that no operator or automatic control can start the pumps. Control is released after both valves are more than 20% open.

If either of the Skyline seismic valves is less than 20% open, the night flow request setpoints are forced to 0 if they are not 0 already, and control ownership is assumed so that no operator or control can increase the flow request setpoints. Control is released after both valves are more than 20% open.

The Skyline seismic valve positions are screened like the Skyline level. On Slide 2, note the boxes "V1 Pos from RTU" and "V2 Pos from RTU." If one of these valve positions is ever 70% lower than it was 15 seconds ago, then the corresponding "Position Status" point will come on and go into alarm.

The Position Status points have to be reset by an operator after the correct valve position readings are restored, to resume updating of the "Position for Calcs" points.

The "Position Status" points appear in Resets slide 9 as well as in Slide 2. To reset a Position Status, click the word SUSPECT. Then click RESET in the resulting quick-menu. Acknowledging a Position Status alarm does not reset the Position Status, the RESET operation must be performed too.

The two "Position Status" points have acronyms SKY-V%-POS-STS.

C. Seismic Resets:

Skyline, LaPrenda and Vallejo tanks have seismic detector hardware that automatically shuts the seismic valves if an earthquake is detected. If this happens, reset(s) must be issued to re-open the valves. This can be done at the tanks, but it can also be done from Resets Slide 9.

Click the word RESET for the appropriate Seismic Valve, and then click RESET in the quick-menu.

The Seismic Reset points have acronyms *-SEIS-RESET.

D. Pump Run Fails LAR and MAD:

If the RTU is commanding a LAR or MAD pump to run, but the pump has not been running for 90 seconds or more, a "Pump Fail" binary point will come on and go into alarm. The "Pump Fail" points must be reset by an operator to restore normal operation of the pumps. These points also appear in Resets Slide 9 in addition to the pump station slides.

At night, the Pump Fail behavior is different than during the day. At night, in addition to turning on the Pump Fail binary, the RTU will issue a STOP command to the pump. During the day, the alarm point comes on, but the RTU does not automatically issue a STOP.

E. Suction and Discharge Pressure Lockouts LAR and MAD:

If the suction pressure goes below 10 psi at night, the latest pump to start will be immediately stopped by the RTU. If the suction pressure is still below 10 psi after 30 seconds, the second-latest to start will be stopped, and similarly for the earliest to start. These stop commands are issued by the RTU regardless of how many pumps are actually running. Therefore, if one pump were running and the RTU stopped it due to suction pressure, but the suction pressure remained too low, the RTU would issue two more stop commands at 30 second intervals, for example.

If any such stop commands are issued by the RTU, an alarm will go off at the central. On the pump station slide, flashing text will appear below the "Suction Press" box: "Pump stop(s) issued on suct pr." This text can be made to disappear by acknowledging the alarm, then clicking the text and pressing RESET in the quick-menu. If an operator does not reset the alarm in this way, it will reset (but not acknowledge) itself the next time 5:00PM comes around.

There is a similar arrangement for suction pressure over 156 psi.

F. Pump requests if Skyline RTU down:

If the Skyline RTU goes down during the night, the LAR pumpage request is set to 300 if it was greater than 300, and to 0 if it was less than 300. The MAD pumpage request is set to 860 if it was greater than 860, and 0 if it was less than 860.

**Appendix D**

# VALIDATION DETAILS

This appendix includes the following:

- Model Validation Data Gathering Plan
- December 2012 Pump Test Reports
- Daily Turnout Meters Readings, January 3-5, 2013
- Pumps Running Status, January 3-5, 2013

City of Millbrae

**MODEL VALIDATION DATA GATHERING PLAN**

FINAL
December 21, 2012

199 SOUTH LOS ROBLES AVENUE • SUITE 530 • PASADENA, CALIFORNIA 91101 • (626) 535-0180 • FAX (626) 535-0185

**City of Millbrae**

**MODEL VALIDATION DATA GATHERING PLAN**

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## LIST OF TABLES



## LIST OF FIGURES

# MODEL VALIDATION DATA GATHERING PLAN

This validation plan covers data gathering needs and schedule to validate the accuracy of City of Millbrae's existing hydraulic water model.

## 1.0 DATA GATHERING SCHEDULE

The first two of the six temporary pressure loggers (PLs) were provided to the City at Meeting No. 2 on December 5, 2012 and were subsequently installed on the same day (PLs C1 and C2). During that meeting, the draft calibration plan was reviewed and the locations of all PLs were finalized. The remaining four PLs (C3 through C6) were shipped on December 19, 2012 and shall be installed by December 21st. Data gathering for hydraulic model validation will take place from Tuesday January 1 to Saturday January 5. The preliminary data gathering schedule is presented in Table 1.

**Table 1 Validation Data Gathering Schedule**
Model Validation Data Gathering Plan
City of Millbrae

| | | | | | | |
|---|---|---|---|---|---|---|
| Monday December 3 | Tuesday December 4 | Wednesday December 5 **Install PLs C1 and C2** | Thursday December 6 | Friday December 7 | Saturday December 8 | Sunday December 9 |
| Monday December 10 | Tuesday December 11 | Wednesday December 12 | Thursday December 13 | Friday December 14 | Saturday December 15 | Sunday December 16 |
| Monday December 17 | Tuesday December 18 | Wednesday December 19 | Thursday December 20 **Install PLs C3 to C6** | Friday December 21 | Saturday December 22 | Sunday December 23 |
| Monday December 24 | Tuesday December 25 | Wednesday December 26 | Thursday December 27 | Friday December 28 | Saturday December 29 | Sunday December 30 |
| Monday December 31 | Tuesday January 1 **SCADA data gathering starts at 00:05 AM** | Wednesday January 2 **- Reset PLs C1 and C2 by Carollo** **- Read flow meters at all turnouts at noon (City)** | Thursday January 3 **Read flow meters at all turnouts at noon (City)** | Friday January 4 **- Read flow meters at all turnouts at noon (City)** **- Remove all PLs and ship to Carollo** | Saturday January 5 **SCADA data gathering ends at 00:05 AM** | Sunday January 6 |

The PLs C1 and C2 were originally programmed by Carollo to collect data from December 5, 2012 to January 1, 2013. An engineer from Carollo, accompanied by a City staff, will be deployed to the site in the morning of Wednesday January 2 to reset the loggers so that they can record during the validation period.

The PLs C3 through C6 are programmed by Carollo such that they each start data collection at 00:05 AM on December 20, 2012. These PLs have the capacity to record data for 112 days. All PLs may be removed on January 4 after the final turnout meter reading on that day. The actual model validation period will be a 24-hour period from either noon on January 2 through noon on January 3 or from noon on January 3 through noon on January 4. This period is selected because this will allow manual reading of SFPUC turnout flow deliveries during day time (rather than midnight) and outside the morning peak period (5-8 am) when demand typically fluctuate greatly. The manual readings need to be as close to 24 hours as possible to allow calculating the City’s water demand for the validation period. The SCADA data collection is recommended to overlap this 48-hour validation period by sufficient time to maximize the overlap of PL and SCADA readings.

Assuming that the City can provide Carollo with an electronic copy of the recorded SCADA data by Monday January 7, the model validation can start in the second week of January 2013.

## 2.0 OVERVIEW OF VALIDATION PROCESS

The model validation is a process in which the extended period simulation (EPS) parameters of the hydraulic model are compared with actual field conditions. This is accomplished by comparing model pressures, flows, and tank levels to field conditions over a 24-hour period of similar demand and system boundary conditions. Tank levels along with pressure and flows from the turnouts, booster stations, and if available, the pressure reducing stations will be recorded to compare with model results. The system demands and the facility control settings including pump stations and pressure reducing stations will be adjusted in the model to represent field conditions during the data gathering period.

## 3.0 DATA REQUIRED FOR EXTENDED PERIOD VALIDATION

The data required for model validation consists of records of system pressures, tank levels, and flows from the City’s imported water connections, booster stations, and the pressure reducing stations. These system pressures will be gathered by six temporary pressure loggers, which will be attached to hydrants throughout the distribution system. The proposed locations of these loggers are shown on Figure 1 and subsequent detailed maps.

Additional data, including system controls and operational details, will be required to establish boundary conditions and controls for the model. The data requested for model validation is listed by site in Table 2. As shown, a target system interval of 5 minutes will be used for data gathering. If any facilities listed lack the capabilities to measure any of the desired parameters or record data in 5 minute intervals (e.g. flow totalizers), assumptions will be necessary to interpolate data for the validation.

Carollo met with City staff on December 5 and went over the data gathering process and finalized the data gathering parameters shown in Table 2. The pressure settings of all pressure reducing stations were obtained during or subsequent to Meeting No. 2 on December 5.

**Table 2 EPS Calibration Data Gathering Parameters**
Model Calibration Plan
City of Millbrae

| Facility Name | Measurement | Unit | Interval | Source |
|---|---|---|---|---|
| **Reservoirs** | | | | |
| Skyline Tank 1 | level | ft | 5 min | SCADA |
| Skyline Tank 2 | level | ft | 5 min | SCADA |
| La Prenda | level | ft | 5 min | SCADA |
| Vallejo | level | ft | 5 min | SCADA |
| **Booster Stations** | | | | |
| Madera PS | Flow | gpm | 5 min | SCADA |
| | suction pressure | psi | 5 min | SCADA |
| | discharge pressure | psi | 5 min | SCADA |
| Larkspur PS | Flow | gpm | 5 min | SCADA |
| | suction pressure | psi | 5 min | SCADA |
| | discharge pressure | psi | 5 min | SCADA |
| **Pressure Loggers** | | | | |
| C1 | pressure | psi | 5 min | PL |
| C2 | pressure | psi | 5 min | PL |
| C3 | pressure | psi | 5 min | PL |
| C4 | pressure | psi | 5 min | PL |
| C5 | pressure | psi | 5 min | PL |
| C6 | pressure | psi | 5 min | PL |
| **Turnouts (System Inflows)** | | | | |
| Helen | flow | gpm | 5 min | Manual |
| Murchison | flow | gpm | 5 min | Manual |
| Victoria | flow | gpm | 5 min | Manual |
| Green Hills | flow | gpm | 5 min | Manual |
| Magnolia | flow | gpm | 5 min | Manual |
| City of Burlingame (if used) | flow | gpm | 5 min | Manual |

# 4.0 FORMAT OF DATA

## 4.1 SCADA Data

All SCADA data needs to be provided in MS Excel or a MS database format. The SCADA data shall be collected from Tuesday January 1 on 00:05 AM to Saturday January 5 00:05 AM. Table 3 presents a sample format for the SCADA data.

**Table 3 Sample SCADA Data Format**
**Model Calibration Plan**
**City of South Pasadena**

| TANK3_LEVEL | | TANK2_LEVEL | | PS9_PRESSUR_SUCT | | PS9_PRESSUR_DISC | |
|---|---|---|---|---|---|---|---|
| **time** | **ft** | **time** | **ft** | **time** | **psi** | **time** | **psi** |
| 2/1/09 1:00 | 27.61 | 2/1/09 1:00 | 25.73 | 2/1/09 1:00 | 44.53 | 2/1/09 1:00 | 120.59 |
| 2/1/09 1:15 | 27.52 | 2/1/09 1:15 | 25.54 | 2/1/09 1:15 | 44.65 | 2/1/09 1:15 | 117.05 |
| 2/1/09 1:30 | 27.35 | 2/1/09 1:30 | 25.39 | 2/1/09 1:30 | 44.20 | 2/1/09 1:30 | 119.63 |
| 2/1/09 1:45 | 25.12 | 2/1/09 1:45 | 25.29 | 2/1/09 1:45 | 45.34 | 2/1/09 1:45 | 119.42 |
| 2/1/09 2:00 | 25.59 | 2/1/09 2:00 | 25.13 | 2/1/09 2:00 | 45.13 | 2/1/09 2:00 | 115.52 |
| 2/1/09 2:15 | 25.60 | 2/1/09 2:15 | 27.56 | 2/1/09 2:15 | 45.26 | 2/1/09 2:15 | 117.21 |
| 2/1/09 2:30 | 25.55 | 2/1/09 2:30 | 27.60 | 2/1/09 2:30 | 44.59 | 2/1/09 2:30 | 117.29 |
| 2/1/09 2:45 | 27.96 | 2/1/09 2:45 | 27.90 | 2/1/09 2:45 | 45.01 | 2/1/09 2:45 | 117.05 |
| 2/1/09 3:00 | 25.76 | 2/1/09 3:00 | 27.67 | 2/1/09 3:00 | 45.75 | 2/1/09 3:00 | 116.55 |
| 2/1/09 3:15 | 25.41 | 2/1/09 3:15 | 26.51 | 2/1/09 3:15 | 44.22 | 2/1/09 3:15 | 116.91 |
| 2/1/09 3:30 | 25.56 | 2/1/09 3:30 | 27.31 | 2/1/09 3:30 | 44.42 | 2/1/09 3:30 | 115.15 |
| 2/1/09 3:45 | 25.06 | 2/1/09 3:45 | 26.96 | 2/1/09 3:45 | 45.04 | 2/1/09 3:45 | 119.02 |
| 2/1/09 4:00 | 25.11 | 2/1/09 4:00 | 27.00 | 2/1/09 4:00 | 44.17 | 2/1/09 4:00 | 120.00 |

Notes:
This sample was taken from a different SCADA system and thus may not represent the exact format of the City’s SCADA output.

Depending on the interval of data available and record keeping capabilities of the SCADA system, modifications may need to be made to the SCADA system prior to the validation week (and impacting the schedule). It would be preferable to our team to obtain SCADA data on 5-minute intervals. However, hourly intervals would be sufficient if 5-minute intervals are not possible. If the SCADA data is queried from each facility independently, the time of each data point should be included in the output report.

## 4.2 Circular Charts

If required, our team will digitize any circular charts in hourly intervals for the data point that are not available on SCADA and listed in Table 2. The City should provide color copies of any circular charts for facility parameters requested. If the facility is offline for the duration of the entire data-gathering period, there is no need to provide circular charts for that facility. If the City uses circle charts, the accuracy of these data points will be limited in comparison to SCADA data.

## 4.3 Manual Facilities

For any manually operated facilities listed in Table 2 operated during the data-gathering period, an operational log should be substituted for the requested facility parameters. It is assumed that flow totalizers are used to take readings at the turnouts. If there is no SCADA at the turnouts, flow totalizers at each of the 5 turnouts should be read manually on Janaury 2, 3 and 4 at noon time. On each of these three days, the readings for all turnouts should be as close to each other as possible.

For any manually operated pump used during the validation week, the hours that the pump is on or off, along with the flow rate during each operation period will be needed. Photocopies of the log sheets for these pumps would be sufficient. If the City finds it more convenient, a handwritten or electronic log of all sites would also be sufficient.

### 4.4 Temporary Pressure Loggers

Carollo has provided 6 temporary pressure loggers (marked C1 through C6) to be attached to hydrants within the City's distribution system. Our team has indicated general locations for the 6 pressure loggers on Figure 1, with additional zoomed in detail shown in Figures 2 through 7. City staff will install near these locations as local meters and appurtenances allow.

## 5.0 REQUIRED EQUIPMENT / STAFF

### 5.1 Required Staff (City)

This task will require City employees to place all of the pressure loggers in the field by Friday December 21 and remove them all any time after the last meter reading on Friday January 4. City staff shall be responsible for installation/removal of data loggers on hydrants, driving City vehicles or any other function involving City property. The City shall ensure the safe shipment of all loggers back to Carollo.

The City operators will need to read and document flow totalizers at each of the 5 turnouts on the following three days at noon time: January 2, 3 and 4.

### 5.2 Required Equipment (City)

- Appropriate wrenches and equipment to place loggers at each location.

### 5.3 Required Equipment (Carollo)

- 6 pressure loggers – Dickson PR150 (C3, C4, C5 and C6) and PR300 (C1 and C2)
- Maps of field locations for pressure loggers

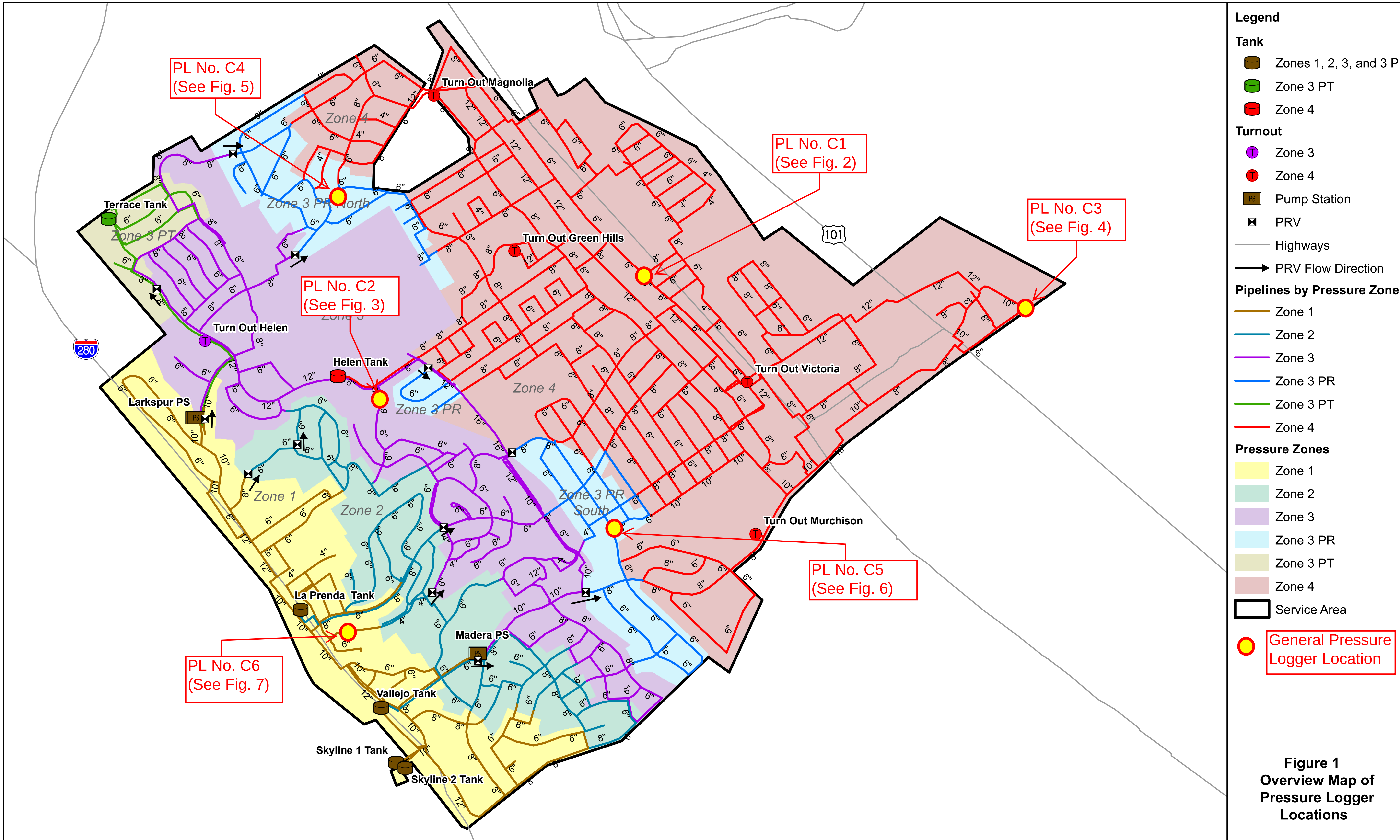



**Figure 1**
**Overview Map of Pressure Logger Locations**

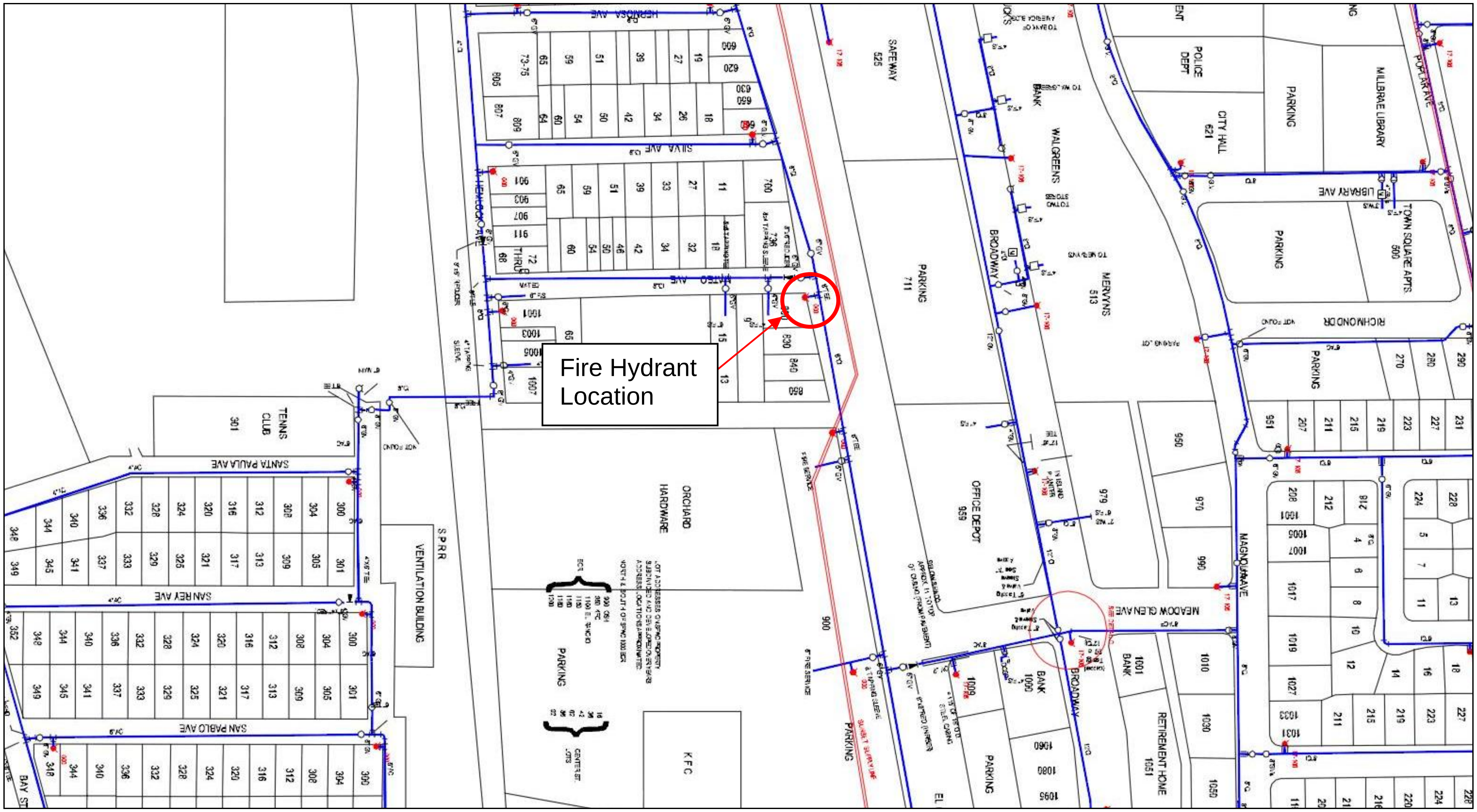



**Figure 2 Fire Hydrant Location for Pressure Logger C1**

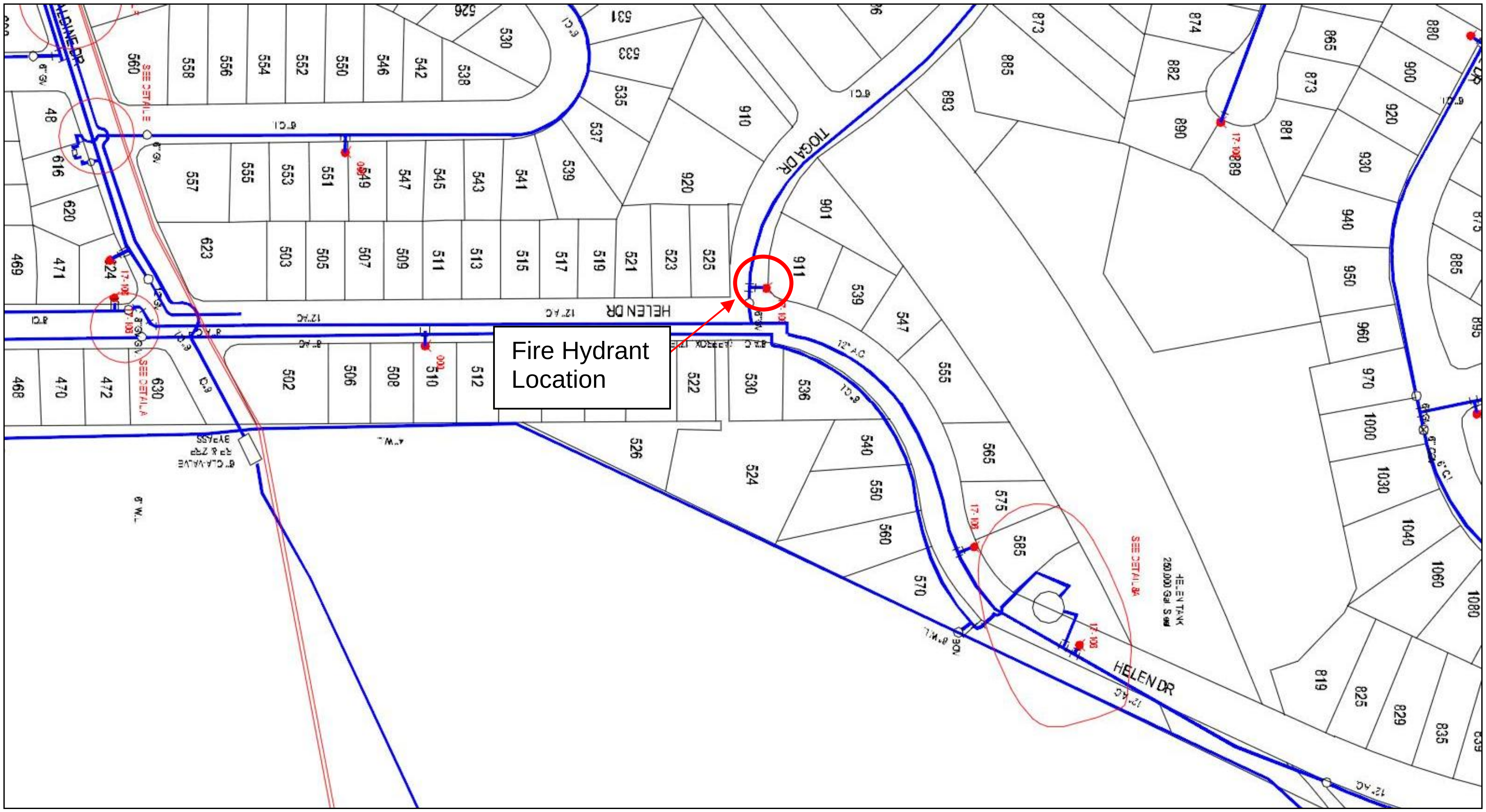



**Figure 3 Fire Hydrant Location for Pressure Logger C2**

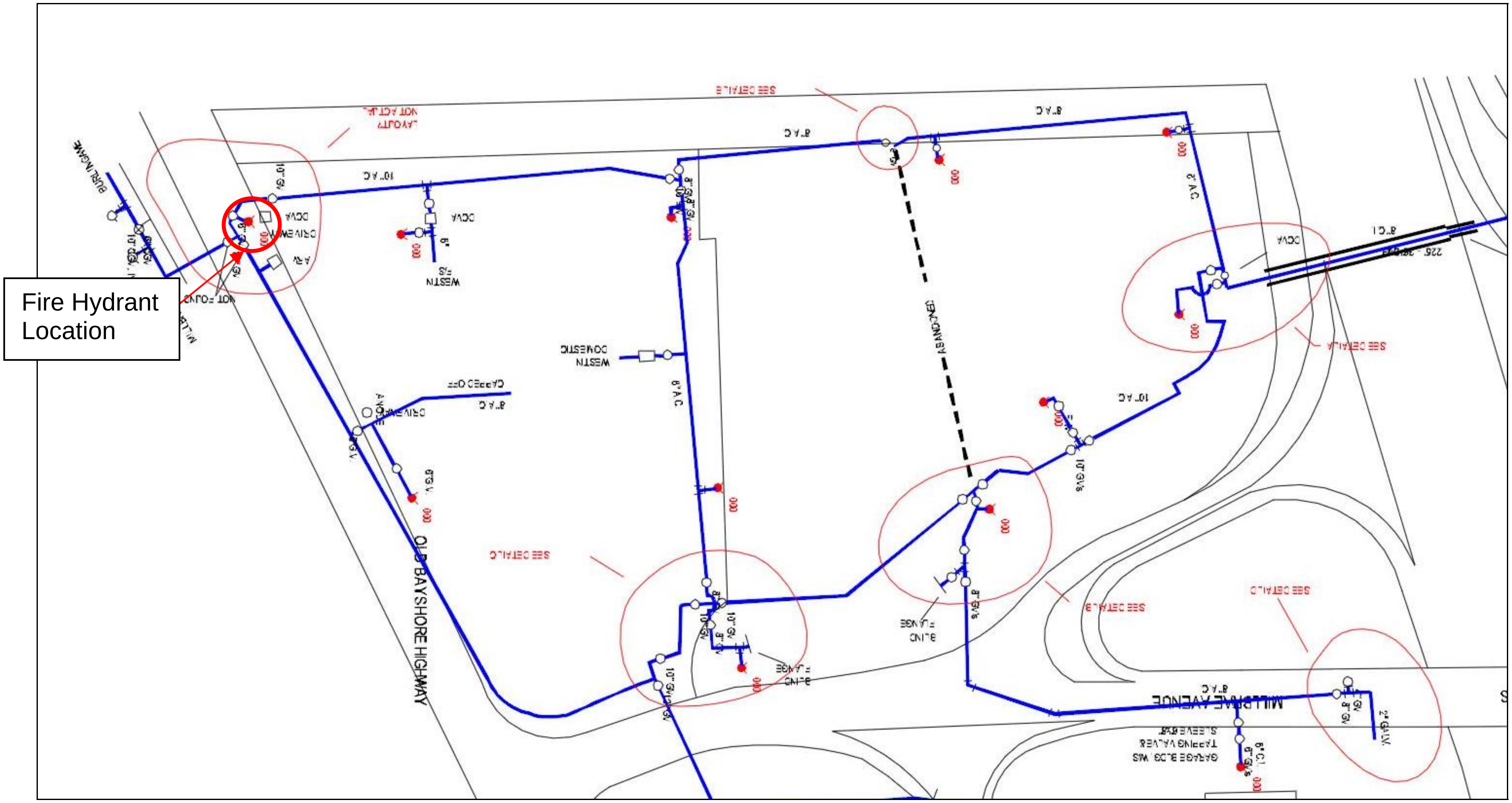



**Figure 4 Fire Hydrant Location for Pressure Logger C3**

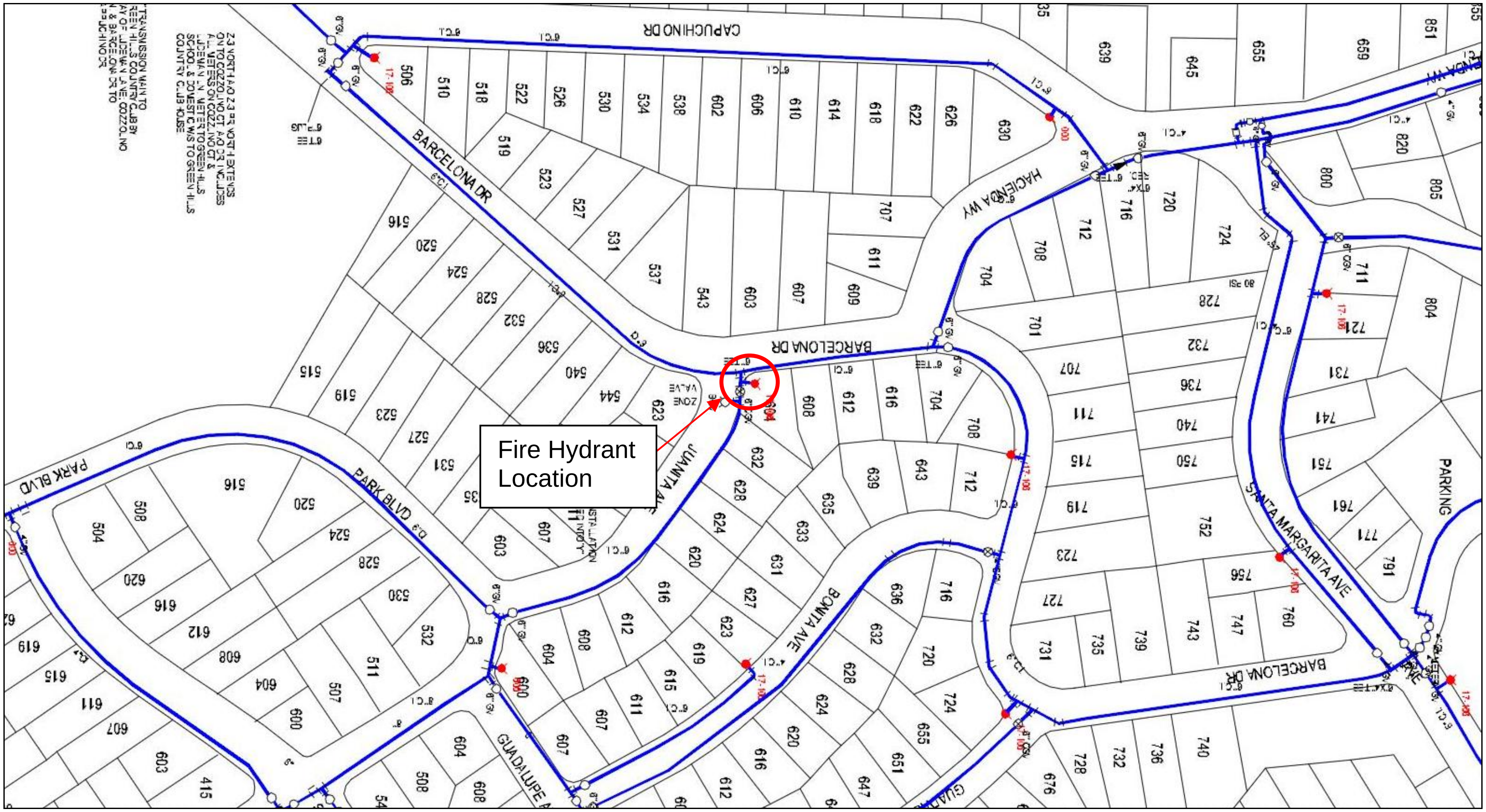



**Figure 5 Fire Hydrant Location for Pressure Logger C4**

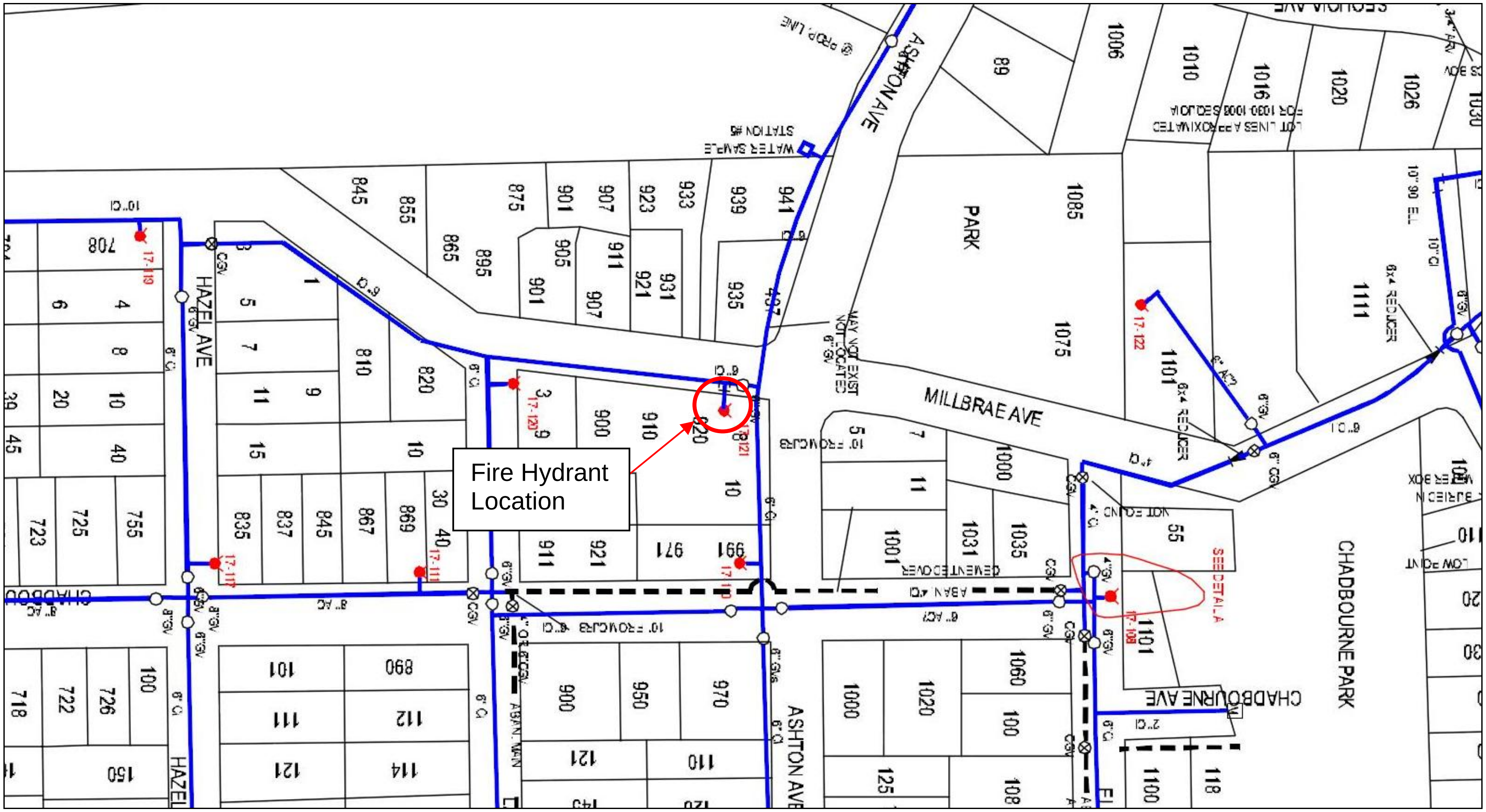



**Figure 6 Fire Hydrant Location for Pressure Logger C5**

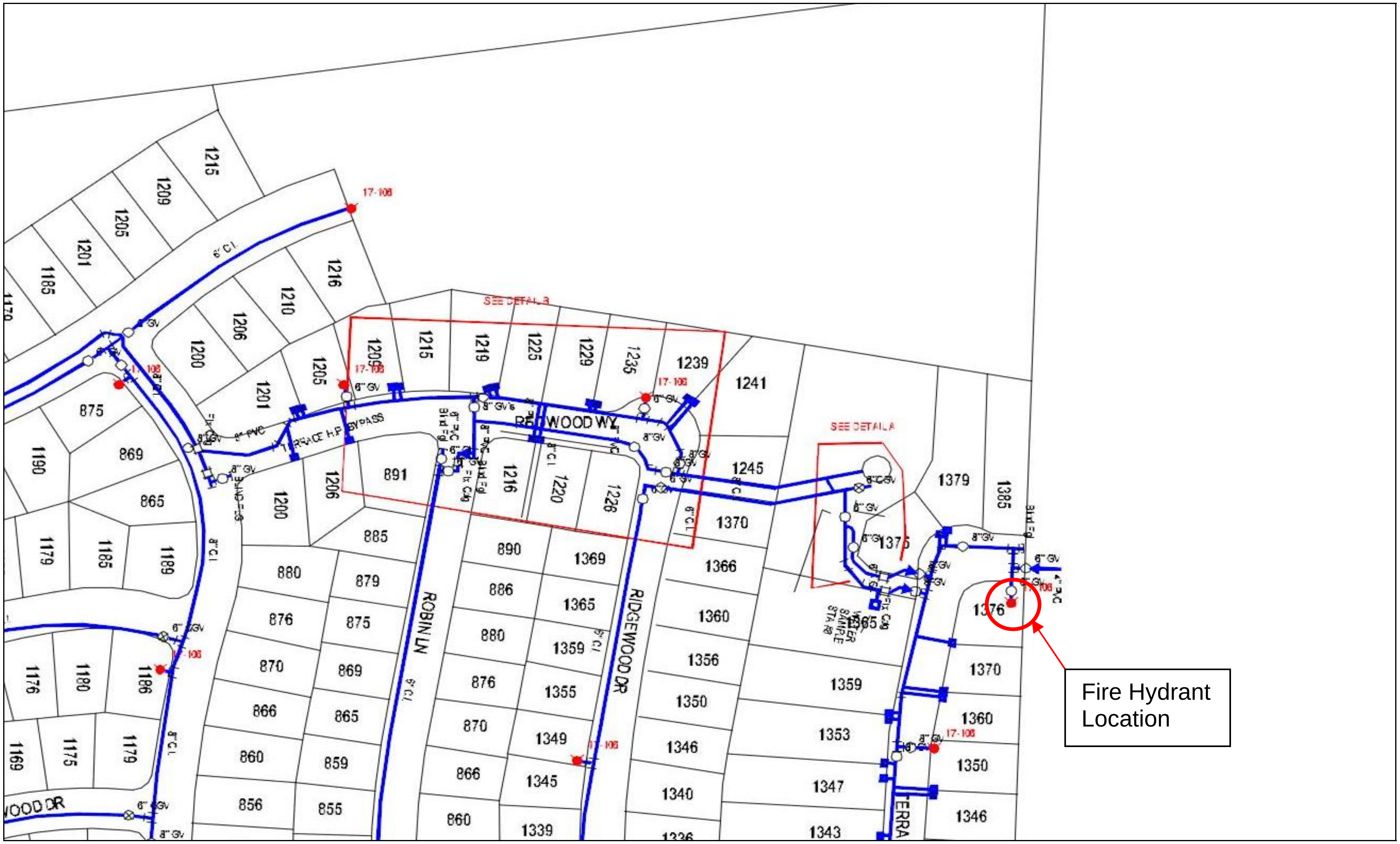



**Figure 7 Fire Hydrant Location for Pressure Logger C6**

**CONFIDENTIAL/PROPRIETARY INFORMATION**
**PUMPING COST ANALYSIS**

JIM HARRINGTON
CITY OF MILLBRAE
400 EAST MILLBRAE AVE.
MILLBRAE, CA 94030

**Test Date - 12/21/2012**
Analysis Date - 12/21/2012

Pump: LARKSPUR P3 HP: 40.0

PUMP TEST REFERENCE NUMBER: 106274

The following Pumping Cost Analysis is presented as an aid to your cost accounting. This analysis is an estimate prepared from data acquired from the pump test performed 12/21/2012 and information provided by you.

*Please pay careful attention to the assumptions. The estimated savings are only valid for the assumptions made and conditions measured during the pump test.*

| | EXISTING CONDITIONS | ASSUMED IMPROVED EFFICIENCY | ESTIMATED SAVINGS FROM IMPROVED EFFICIENCY |
|---|---|---|---|
| **1. Overall pumping efficiency:** | 58% | 65% | |
| **2. Motor loaded at:** | 94% | 97% | |
| **3. Flow rate (gpm):** | 399 | 450 | |
| **Inlet Pressure (psi):** | -46 | -46 | |
| **Discharge Pressure (psi):** | 144 | 148 | |
| **4. Total Dynamic Head (feet):** | 226 | 236 | |
| **5. Million Gallons Pump** | 0.57 | 0.65 | |
| **6. Hours of Operation/yr:** | 453 | 402 | |
| **7. Kilowatt-Hours per Mill Gal:** | 1,236 | 1,138 | **98** |
| **8. Estimated Total kWh per Year:** | 13,404 | 12,343 | **1,061** |
| **9. Average Cost per kWh:** | $0.160 | | |
| **10. Average Cost per hour:** | $4.73 | $4.92 | **($0.18)** |
| **11. Average Cost Per Mill Gal:** | $197.74 | $182.08 | **$15.66** |
| **12. Estimated Acre Ft. per Year :** | 33 | 33 | |
| **13. Operating Hours per Year:** | 453 | 402 | **51** |
| **14. Overall Pumping Efficiency:** | 58% | 65% | |
| ***15. Estimated Total Annual Cost:*** | *$2,145* | *$1,975* | ***$170*** |

It is sincerely hoped that this information will prove helpful to you, and that your concerns over maintaining optimum pumping efficiency will continue. If you have any questions, please contact Bob Fraker at (707) 829-3127.

Regards,

Bob Fraker

# Pumping Efficiency Testing Services

## (707) 829-3127

## Pump Test Report

*v.5.2 1/11/2011*

| | | | |
|---|---|---|---|
| **Pump/Location:** | Larkspur P3/980 Larkspur Drive | **HP:** 40 | **Utility:** PG&E |
| **GPS Coord.:** | **Long** -122.4179 **Lat** 37.59818 | **Pump Make:** | Floway |
| **Motor Make:** | U.S. | **Type:** | Vertical Turbine Boos |
| **Customer Addr:** | City of Millbrae<br>400 East Millbrae Ave.<br>Millbrae, CA 94030 | **Meter Number:** | 0111R3 |
| | | **Serial Number:** | F07-01108158-GT-02 |
| | | **Voltage:** 230 | **Amps:** 90 |
| **Contact:** | Jim Harrington | **Our Test #:** | 3 |

**Phone:** (650) 259-2374 **Fax:** (650) 692-6356 **Cell:**

**Test Date:** 12/21/2012 **Tester:** Bob Fraker

| | |
|---|---|
| **Run Number ('E' = used for cost analysis):** | E-1 |
| **1. Inlet Pressure (PSI):** | -46 |
| **2. Standing Water Level (Ft):** | NA |
| **3. Draw Down (Ft):** | NA |
| **4. Recovered Water Level (Ft):** | NA |
| **5. Discharge Pressure at Gauge (PSI):** | 144 |
| **6. Total Lift (Ft):** | 226 |
| **7. Flow Velocity (Ft/Sec):** | 4.5 |
| ***8. Measured Flow Rate (GPM):*** | 399 |
| **9. Customer Flow Rate (GPM):** | 0 |
| **10. Specific Capacity (GPM/Ft draw):** | NA |
| **11. Acre Feet per 24 Hr:** | 1.8 |
| **Million Gallons per 24 Hr:** | 0.575 |
| **12. Cubic Feet per Second (CFS):** | 0.9 |
| **13. Horsepower Input to Motor:** | 40 |
| **14. Percent of Rated Motor Load (%):** | 94 |
| **15. Kilowatt Input to Motor:** | 30 |
| **16. Kilowatt Hours per Mill Gal:** | 1,236 |
| **17. Cost to Pump a Million Gal:** | $197.74 |
| **18. Energy Cost ($/Hour)** | $4.73 |
| **19. Base Cost per Kwh:** | $0.160 |
| **20. NamePlate RPM:** | 1,780 |
| **21. RPM at GearHead:** | 0 |
| ***22. Overall Pumping Efficiency (%):*** | **58** |

*If line 1 is negative then pump inlet is under pressure.*

*If a Flow Velocity (line 7) is less than 1 ft/second, the accuracy of the test is suspect.*

*Note any major difference between the "Measured" flow rate and the "Customer's" (lines 8,9).*

All results are based on conditions during the time of the test. If these conditions vary from the normal operation of your pump, the results shown may not describe the pump's normal performance.

Overall efficiency of this plant is considered to be fair assuming this run represents plant's normal operating condition.

Pump Nameplate Data: 360 GPM @ 325 TDH.

Estimated savings of 32 kWh/AF and $169.84 annual energy costs from a retrofit

Current OPE of 58% and estimated potential OPE of 65%

**CONFIDENTIAL/PROPRIETARY INFORMATION**
**PUMPING COST ANALYSIS**

JIM HARRINGTON
CITY OF MILLBRAE
400 EAST MILLBRAE AVE.
MILLBRAE, CA 94030

**Test Date - 12/21/2012**
Analysis Date - 12/21/2012

Pump: MADERA P2 HP: 40.0

PUMP TEST REFERENCE NUMBER: 106276

The following Pumping Cost Analysis is presented as an aid to your cost accounting. This analysis is an estimate prepared from data acquired from the pump test performed 12/21/2012 and information provided by you.

*Please pay careful attention to the assumptions. The estimated savings are only valid for the assumptions made and conditions measured during the pump test.*

| | EXISTING CONDITIONS | ASSUMED IMPROVED EFFICIENCY | ESTIMATED SAVINGS FROM IMPROVED EFFICIENCY |
|---|---|---|---|
| **1. Overall pumping efficiency:** | 59% | 65% | |
| **2. Motor loaded at:** | 94% | 102% | |
| **3. Flow rate (gpm):** | 411 | 430 | |
| **Inlet Pressure (psi):** | -46 | -46 | |
| **Discharge Pressure (psi):** | 144 | 158 | |
| **4. Total Dynamic Head (feet):** | 226 | 258 | |
| **5. Million Gallons Pump** | 0.59 | 0.62 | |
| **6. Hours of Operation/yr:** | 646 | 617 | |
| **7. Kilowatt-Hours per Mill Gal:** | 1,208 | 1,245 | **-37** |
| **8. Estimated Total kWh per Year:** | 19,251 | 19,842 | **-591** |
| **9. Average Cost per kWh:** | $0.160 | | |
| **10. Average Cost per hour:** | $4.77 | $5.14 | **($0.37)** |
| **11. Average Cost Per Mill Gal:** | $193.33 | $199.27 | **($5.93)** |
| **12. Estimated Acre Ft. per Year :** | 49 | 49 | |
| **13. Operating Hours per Year:** | 646 | 617 | **29** |
| **14. Overall Pumping Efficiency:** | 59% | 65% | |
| ***15. Estimated Total Annual Cost:*** | *$3,080* | *$3,175* | ***($95)*** |

It is sincerely hoped that this information will prove helpful to you, and that your concerns over maintaining optimum pumping efficiency will continue. If you have any questions, please contact Bob Fraker at (707) 829-3127.

Regards,

Bob Fraker

# Pumping Efficiency Testing Services
## (707) 829-3127
## Pump Test Report

*v.5.2 1/11/2011*

| | | | |
|---|---|---|---|
| **Pump/Location:** | Madera P2/1362 Madera Way | **HP:** 40 | **Utility:** PG&E |
| **GPS Coord.:** | **Long** -122.4031 **Lat** 37.5869 | **Pump Make:** | Floway |
| **Motor Make:** | U.S. | **Type:** | Vertical Turbine Boos |
| **Customer Addr:** | City of Millbrae | **Meter Number:** | 1004461387 |
| | 400 East Millbrae Ave. | **Serial Number:** | F07-01108158ST-04 |
| | Millbrae, CA 94030 | **Voltage:** 230 | **Amps:** 90 |
| **Contact:** | Jim Harrington | **Our Test #:** | 5 |
| **Phone:** (650) 259-2374 | **Fax:** (650) 692-6356 **Cell:** | | |

**Test Date:** <u>12/21/2012</u> **Tester:** Bob Fraker

| | |
|---|---|
| **Run Number ('E' = used for cost analysis):** | E-1 |
| **1. Inlet Pressure (PSI):** | -46 |
| **2. Standing Water Level (Ft):** | NA |
| **3. Draw Down (Ft):** | NA |
| **4. Recovered Water Level (Ft):** | NA |
| **5. Discharge Pressure at Gauge (PSI):** | 144 |
| **6. Total Lift (Ft):** | 226 |
| **7. Flow Velocity (Ft/Sec):** | 4.7 |
| ***8. Measured Flow Rate (GPM):*** | **411** |
| **9. Customer Flow Rate (GPM):** | 0 |
| **10. Specific Capacity (GPM/Ft draw):** | NA |
| **11. Acre Feet per 24 Hr:** | 1.8 |
| **Million Gallons per 24 Hr:** | 0.592 |
| **12. Cubic Feet per Second (CFS):** | 0.9 |
| **13. Horsepower Input to Motor:** | 40 |
| **14. Percent of Rated Motor Load (%):** | 94 |
| **15. Kilowatt Input to Motor:** | 30 |
| **16. Kilowatt Hours per Mill Gal:** | 1,208 |
| **17. Cost to Pump a Million Gal:** | $193.33 |
| **18. Energy Cost ($/Hour)** | $4.77 |
| **19. Base Cost per Kwh:** | $0.160 |
| **20. NamePlate RPM:** | 1,780 |
| **21. RPM at GearHead:** | 0 |
| ***22. Overall Pumping Efficiency (%):*** | **59** |

*If line 1 is negative then pump inlet is under pressure.*

*If a Flow Velocity (line 7) is less than 1 ft/second, the accuracy of the test is suspect.*

*Note any major difference between the "Measured" flow rate and the "Customer's" (lines 8,9).*

All results are based on conditions during the time of the test. If these conditions vary from the normal operation of your pump, the results shown may not describe the pump's normal performance.

Overall efficiency of this plant is considered to be fair assuming this run represents plant's normal operating condition.

Nameplate Data: 360 GPM @ 325' TDH.

Estimated savings of -12 kWh/AF and ($94.54) annual energy costs from a retrofit

Current OPE of 59% and estimated potential OPE of 65%

**CONFIDENTIAL/PROPRIETARY INFORMATION**
**PUMPING COST ANALYSIS**

JIM HARRINGTON
CITY OF MILLBRAE
400 EAST MILLBRAE AVE.
MILLBRAE, CA 94030

**Test Date - 12/21/2012**
Analysis Date - 12/21/2012

Pump: MADERA P3 HP: 40.0

PUMP TEST REFERENCE NUMBER: 106277

The following Pumping Cost Analysis is presented as an aid to your cost accounting. This analysis is an estimate prepared from data acquired from the pump test performed 12/21/2012 and information provided by you.

*Please pay careful attention to the assumptions. The estimated savings are only valid for the assumptions made and conditions measured during the pump test.*

| | EXISTING CONDITIONS | ASSUMED IMPROVED EFFICIENCY | ESTIMATED SAVINGS FROM IMPROVED EFFICIENCY |
|---|---|---|---|
| **1. Overall pumping efficiency:** | 54% | 65% | |
| **2. Motor loaded at:** | 96% | 97% | |
| **3. Flow rate (gpm):** | 383 | 450 | |
| **Inlet Pressure (psi):** | -46 | -46 | |
| **Discharge Pressure (psi):** | 144 | 148 | |
| **4. Total Dynamic Head (feet):** | 226 | 236 | |
| **5. Million Gallons Pump** | 0.55 | 0.65 | |
| **6. Hours of Operation/yr:** | 558 | 475 | |
| **7. Kilowatt-Hours per Mill Gal:** | 1,316 | 1,138 | **178** |
| **8. Estimated Total kWh per Year:** | 16,880 | 14,594 | **2,285** |
| **9. Average Cost per kWh:** | $0.160 | | |
| **10. Average Cost per hour:** | $4.84 | $4.92 | **($0.08)** |
| **11. Average Cost Per Mill Gal:** | $210.60 | $182.08 | **$28.51** |
| **12. Estimated Acre Ft. per Year :** | 39 | 39 | |
| **13. Operating Hours per Year:** | 558 | 475 | **83** |
| **14. Overall Pumping Efficiency:** | 54% | 65% | |
| ***15. Estimated Total Annual Cost:*** | *$2,701* | *$2,335* | ***$366*** |

It is sincerely hoped that this information will prove helpful to you, and that your concerns over maintaining optimum pumping efficiency will continue. If you have any questions, please contact Bob Fraker at (707) 829-3127.

Regards,

Bob Fraker

# Pumping Efficiency Testing Services
# (707) 829-3127
# Pump Test Report

*v.5.2 1/11/2011*

| | | | |
|---|---|---|---|
| **Pump/Location:** | Madera P3/1362 Madera Way | **HP:** 40 | **Utility:** PG&E |
| **GPS Coord.:** | **Long** -122.4031 **Lat** 37.5869 | **Pump Make:** | Floway |
| **Motor Make:** | U.S. | **Type:** | Vertical Turbine Boos |
| **Customer Addr:** | City of Millbrae<br>400 East Millbrae Ave.<br>Millbrae, CA 94030 | **Meter Number:** | 1004461387 |
| | | **Serial Number:** | F07-0110815GT-01 |
| | | **Voltage:** 230 | **Amps:** 90 |
| **Contact:** | Jim Harrington | **Our Test #:** | 6 |

**Phone:** (650) 259-2374 **Fax:** (650) 692-6356 **Cell:**

**Test Date:** 12/21/2012 **Tester:** Bob Fraker

| | |
|---|---|
| **Run Number ('E' = used for cost analysis):** | E-1 |
| **1. Inlet Pressure (PSI):** | -46 |
| **2. Standing Water Level (Ft):** | NA |
| **3. Draw Down (Ft):** | NA |
| **4. Recovered Water Level (Ft):** | NA |
| **5. Discharge Pressure at Gauge (PSI):** | 144 |
| **6. Total Lift (Ft):** | 226 |
| **7. Flow Velocity (Ft/Sec):** | 4.3 |
| ***8. Measured Flow Rate (GPM):*** | **383** |
| **9. Customer Flow Rate (GPM):** | 0 |
| **10. Specific Capacity (GPM/Ft draw):** | NA |
| **11. Acre Feet per 24 Hr:** | 1.7 |
| **Million Gallons per 24 Hr:** | 0.552 |
| **12. Cubic Feet per Second (CFS):** | 0.9 |
| **13. Horsepower Input to Motor:** | 41 |
| **14. Percent of Rated Motor Load (%):** | 96 |
| **15. Kilowatt Input to Motor:** | 30 |
| **16. Kilowatt Hours per Mill Gal:** | 1,316 |
| **17. Cost to Pump a Million Gal:** | $210.60 |
| **18. Energy Cost ($/Hour)** | $4.84 |
| **19. Base Cost per Kwh:** | $0.160 |
| **20. NamePlate RPM:** | 1,780 |
| **21. RPM at GearHead:** | 0 |
| ***22. Overall Pumping Efficiency (%):*** | **54** |

*If line 1 is negative then pump inlet is under pressure.*

*If a Flow Velocity (line 7) is less than 1 ft/second, the accuracy of the test is suspect.*

*Note any major difference between the "Measured" flow rate and the "Customer's" (lines 8,9).*

All results are based on conditions during the time of the test. If these conditions vary from the normal operation of your pump, the results shown may not describe the pump's normal performance.

Overall efficiency of this plant is considered to be fair assuming this run represents plant's normal operating condition.

Nameplate Data: 360 GPM @ 325' TDH.

Estimated savings of 58 kWh/AF and $365.67 annual energy costs from a retrofit

Current OPE of 54% and estimated potential OPE of 65%

**CONFIDENTIAL/PROPRIETARY INFORMATION**
**PUMPING COST ANALYSIS**

JIM HARRINGTON
CITY OF MILLBRAE
400 EAST MILLBRAE AVE.
MILLBRAE, CA 94030

**Test Date - 12/21/2012**
Analysis Date - 12/21/2012

Pump: LARKSPUR P1 HP: 40.0

PUMP TEST REFERENCE NUMBER: 106272

The following Pumping Cost Analysis is presented as an aid to your cost accounting. This analysis is an estimate prepared from data acquired from the pump test performed 12/21/2012 and information provided by you.

*Please pay careful attention to the assumptions. The estimated savings are only valid for the assumptions made and conditions measured during the pump test.*

| | EXISTING CONDITIONS | ASSUMED IMPROVED EFFICIENCY | ESTIMATED SAVINGS FROM IMPROVED EFFICIENCY |
|---|---|---|---|
| **1. Overall pumping efficiency:** | 57% | 65% | |
| **2. Motor loaded at:** | 96% | 97% | |
| **3. Flow rate (gpm):** | 402 | 450 | |
| **Inlet Pressure (psi):** | -41 | -41 | |
| **Discharge Pressure (psi):** | 140 | 142 | |
| **4. Total Dynamic Head (feet):** | 229 | 234 | |
| **5. Million Gallons Pump** | 0.58 | 0.65 | |
| **6. Hours of Operation/yr:** | 737 | 658 | |
| **7. Kilowatt-Hours per Mill Gal:** | 1,258 | 1,129 | **128** |
| **8. Estimated Total kWh per Year:** | 22,361 | 20,080 | **2,281** |
| **9. Average Cost per kWh:** | $0.160 | | |
| **10. Average Cost per hour:** | $4.85 | $4.88 | **($0.03)** |
| **11. Average Cost Per Mill Gal:** | $201.24 | $180.72 | **$20.53** |
| **12. Estimated Acre Ft. per Year :** | 55 | 55 | |
| **13. Operating Hours per Year:** | 737 | 658 | **79** |
| **14. Overall Pumping Efficiency:** | 57% | 65% | |
| ***15. Estimated Total Annual Cost:*** | *$3,578* | *$3,213* | *$365* |

It is sincerely hoped that this information will prove helpful to you, and that your concerns over maintaining optimum pumping efficiency will continue. If you have any questions, please contact Bob Fraker at (707) 829-3127.

Regards,

Bob Fraker

# Pumping Efficiency Testing Services

## (707) 829-3127

## Pump Test Report

*v.5.2 1/11/2011*

**Pump/Location:** Larkspur P1/980 Larkspur Drive
**GPS Coord.:** Long -122.4179 **Lat** 37.59818
**Motor Make:** U.S.
**Customer Addr:** City of Millbrae
400 East Millbrae Ave.
Millbrae, CA 94030
**Contact:** Jim Harrington
**Phone:** (650) 259-2374 **Fax:** (650) 692-6356 **Cell:**

**HP:** 40 **Utility:** PG&E
**Pump Make:** Floway
**Type:** Vertical Turbine Boos
**Meter Number:** 0111R3
**Serial Number:** F07-01108158-GT-02
**Voltage:** 230 **Amps:** 90
**Our Test #:** 1

**Test Date:** **12/21/2012** **Tester:** Bob Fraker

| | |
|---|---|
| **Run Number ('E' = used for cost analysis):** | E-1 |
| **1. Inlet Pressure (PSI):** | -41 |
| **2. Standing Water Level (Ft):** | NA |
| **3. Draw Down (Ft):** | NA |
| **4. Recovered Water Level (Ft):** | NA |
| **5. Discharge Pressure at Gauge (PSI):** | 140 |
| **6. Total Lift (Ft):** | 229 |
| **7. Flow Velocity (Ft/Sec):** | 4.6 |
| ***8. Measured Flow Rate (GPM):*** | **402** |
| **9. Customer Flow Rate (GPM):** | 0 |
| **10. Specific Capacity (GPM/Ft draw):** | NA |
| **11. Acre Feet per 24 Hr:** | 1.8 |
| **Million Gallons per 24 Hr:** | 0.579 |
| **12. Cubic Feet per Second (CFS):** | 0.9 |
| **13. Horsepower Input to Motor:** | 41 |
| **14. Percent of Rated Motor Load (%):** | 96 |
| **15. Kilowatt Input to Motor:** | 30 |
| **16. Kilowatt Hours per Mill Gal:** | 1,258 |
| **17. Cost to Pump a Million Gal:** | $201.24 |
| **18. Energy Cost ($/Hour)** | $4.85 |
| **19. Base Cost per Kwh:** | $0.160 |
| **20. NamePlate RPM:** | 1,780 |
| **21. RPM at GearHead:** | 0 |
| ***22. Overall Pumping Efficiency (%):*** | **57** |

*If line 1 is negative then pump inlet is under pressure.*

*If a Flow Velocity (line 7) is less than 1 ft/second, the accuracy of the test is suspect.*

*Note any major difference between the "Measured" flow rate and the "Customer's" (lines 8,9).*

All results are based on conditions during the time of the test. If these conditions vary from the normal operation of your pump, the results shown may not describe the pump's normal performance.

Overall efficiency of this plant is considered to be fair assuming this run represents plant's normal operating condition.

Pump Nameplate Data: 360 GPM. @ 325' TDH.

Estimated savings of 42 kWh/AF and $364.91 annual energy costs from a retrofit

Current OPE of 57% and estimated potential OPE of 65%

**CONFIDENTIAL/PROPRIETARY INFORMATION**
**PUMPING COST ANALYSIS**

JIM HARRINGTON
CITY OF MILLBRAE
400 EAST MILLBRAE AVE.
MILLBRAE, CA 94030

**Test Date - 12/21/2012**
Analysis Date - 12/21/2012

Pump: LARKSPUR P2 HP: 40.0

PUMP TEST REFERENCE NUMBER: 106273

The following Pumping Cost Analysis is presented as an aid to your cost accounting. This analysis is an estimate prepared from data acquired from the pump test performed 12/21/2012 and information provided by you.

*Please pay careful attention to the assumptions. The estimated savings are only valid for the assumptions made and conditions measured during the pump test.*

| | EXISTING CONDITIONS | ASSUMED IMPROVED EFFICIENCY | ESTIMATED SAVINGS FROM IMPROVED EFFICIENCY |
|---|---|---|---|
| **1. Overall pumping efficiency:** | 58% | 65% | |
| **2. Motor loaded at:** | 98% | 100% | |
| **3. Flow rate (gpm):** | 412 | 450 | |
| **Inlet Pressure (psi):** | -40 | -40 | |
| **Discharge Pressure (psi):** | 140 | 145 | |
| **4. Total Dynamic Head (feet):** | 231 | 243 | |
| **5. Million Gallons Pump** | 0.59 | 0.65 | |
| **6. Hours of Operation/yr:** | 1,615 | 1,479 | |
| **7. Kilowatt-Hours per Mill Gal:** | 1,250 | 1,172 | **78** |
| **8. Estimated Total kWh per Year:** | 49,904 | 46,774 | **3,130** |
| **9. Average Cost per kWh:** | $0.160 | | |
| **10. Average Cost per hour:** | $4.94 | $5.06 | **($0.12)** |
| **11. Average Cost Per Mill Gal:** | $199.98 | $187.44 | **$12.54** |
| **12. Estimated Acre Ft. per Year :** | 123 | 123 | |
| **13. Operating Hours per Year:** | 1,615 | 1,479 | **136** |
| **14. Overall Pumping Efficiency:** | 58% | 65% | |
| ***15. Estimated Total Annual Cost:*** | *$7,985* | *$7,484* | ***$501*** |

It is sincerely hoped that this information will prove helpful to you, and that your concerns over maintaining optimum pumping efficiency will continue. If you have any questions, please contact Bob Fraker at (707) 829-3127.

Regards,

Bob Fraker

# Pumping Efficiency Testing Services

## (707) 829-3127

## Pump Test Report

*v.5.2 1/11/2011*

| | | | | | |
|---|---|---|---|---|---|
| **Pump/Location:** | Larkspur P2/980 Larkspur Drive | | **HP:** 40 | **Utility:** | PG&E |
| **GPS Coord.:** | **Long** -122.4179 | **Lat** 37.59818 | **Pump Make:** | Floway | |
| **Motor Make:** | U.S. | | **Type:** | Vertical Turbine Boos | |
| **Customer Addr:** | City of Millbrae | | **Meter Number:** | 0111R3 | |
| | 400 East Millbrae Ave. | | **Serial Number:** | F07-01108158-GT-03 | |
| | Millbrae, CA 94030 | | **Voltage:** 230 | **Amps:** | 90 |
| **Contact:** | Jim Harrington | | **Our Test #:** | 2 | |
| **Phone:** (650) 259-2374 | **Fax:** (650) 692-6356 | **Cell:** | | | |

**Test Date:** <u>**12/21/2012**</u> **Tester:** Bob Fraker

| | |
|---|---|
| **Run Number ('E' = used for cost analysis):** | E-1 |
| **1. Inlet Pressure (PSI):** | -40 |
| **2. Standing Water Level (Ft):** | NA |
| **3. Draw Down (Ft):** | NA |
| **4. Recovered Water Level (Ft):** | NA |
| **5. Discharge Pressure at Gauge (PSI):** | 140 |
| **6. Total Lift (Ft):** | 231 |
| **7. Flow Velocity (Ft/Sec):** | 4.7 |
| ***8. Measured Flow Rate (GPM):*** | **412** |
| **9. Customer Flow Rate (GPM):** | 0 |
| **10. Specific Capacity (GPM/Ft draw):** | NA |
| **11. Acre Feet per 24 Hr:** | 1.8 |
| **Million Gallons per 24 Hr:** | 0.593 |
| **12. Cubic Feet per Second (CFS):** | 0.9 |
| **13. Horsepower Input to Motor:** | 41 |
| **14. Percent of Rated Motor Load (%):** | 98 |
| **15. Kilowatt Input to Motor:** | 31 |
| **16. Kilowatt Hours per Mill Gal:** | 1,250 |
| **17. Cost to Pump a Million Gal:** | $199.98 |
| **18. Energy Cost ($/Hour)** | $4.94 |
| **19. Base Cost per Kwh:** | $0.160 |
| **20. NamePlate RPM:** | 1,780 |
| **21. RPM at GearHead:** | 0 |
| ***22. Overall Pumping Efficiency (%):*** | **58** |

*If line 1 is negative then pump inlet is under pressure.*

*If a Flow Velocity (line 7) is less than 1 ft/second, the accuracy of the test is suspect.*

*Note any major difference between the "Measured" flow rate and the "Customer's" (lines 8,9).*

All results are based on conditions during the time of the test. If these conditions vary from the normal operation of your pump, the results shown may not describe the pump's normal performance.

Overall efficiency of this plant is considered to be fair assuming this run represents plant's normal operating condition.

Pump Nameplate Data: 360 GPM @ 325 TDH.

Estimated savings of 26 kWh/AF and $500.78 annual energy costs from a retrofit

Current OPE of 58% and estimated potential OPE of 65%

**CONFIDENTIAL/PROPRIETARY INFORMATION**
**PUMPING COST ANALYSIS**

JIM HARRINGTON
CITY OF MILLBRAE
400 EAST MILLBRAE AVE.
MILLBRAE, CA 94030

**Test Date - 12/21/2012**
Analysis Date - 12/21/2012

Pump: MADERA P1 HP: 40.0

PUMP TEST REFERENCE NUMBER: 106275

The following Pumping Cost Analysis is presented as an aid to your cost accounting. This analysis is an estimate prepared from data acquired from the pump test performed 12/21/2012 and information provided by you.

*Please pay careful attention to the assumptions. The estimated savings are only valid for the assumptions made and conditions measured during the pump test.*

| | EXISTING CONDITIONS | ASSUMED IMPROVED EFFICIENCY | ESTIMATED SAVINGS FROM IMPROVED EFFICIENCY |
|---|---|---|---|
| **1. Overall pumping efficiency:** | 58% | 65% | |
| **2. Motor loaded at:** | 94% | 97% | |
| **3. Flow rate (gpm):** | 399 | 450 | |
| **Inlet Pressure (psi):** | -46 | -46 | |
| **Discharge Pressure (psi):** | 144 | 148 | |
| **4. Total Dynamic Head (feet):** | 226 | 236 | |
| **5. Million Gallons Pump** | 0.57 | 0.65 | |
| **6. Hours of Operation/yr:** | 500 | 443 | |
| **7. Kilowatt-Hours per Mill Gal:** | 1,236 | 1,138 | **98** |
| **8. Estimated Total kWh per Year:** | 14,795 | 13,623 | **1,172** |
| **9. Average Cost per kWh:** | $0.160 | | |
| **10. Average Cost per hour:** | $4.73 | $4.92 | **($0.18)** |
| **11. Average Cost Per Mill Gal:** | $197.74 | $182.08 | **$15.66** |
| **12. Estimated Acre Ft. per Year :** | 37 | 37 | |
| **13. Operating Hours per Year:** | 500 | 443 | **57** |
| **14. Overall Pumping Efficiency:** | 58% | 65% | |
| ***15. Estimated Total Annual Cost:*** | *$2,367* | *$2,180* | ***$187*** |

It is sincerely hoped that this information will prove helpful to you, and that your concerns over maintaining optimum pumping efficiency will continue. If you have any questions, please contact Bob Fraker at (707) 829-3127.

Regards,

Bob Fraker

# Pumping Efficiency Testing Services

## (707) 829-3127

## Pump Test Report

*v.5.2 1/11/2011*

| | | | | | |
|---|---|---|---|---|---|
| **Pump/Location:** | Madera P1/1362 Madera Way | | | **HP:** 40 | **Utility:** PG&E |
| **GPS Coord.:** | **Long** -122.4031 | **Lat** 37.5869 | | **Pump Make:** | Floway |
| **Motor Make:** | U.S. | | | **Type:** | Vertical Turbine Boos |
| **Customer Addr:** | City of Millbrae | | | **Meter Number:** | 1004461387 |
| | 400 East Millbrae Ave. | | | **Serial Number:** | F07-01108152GT-02 |
| | Millbrae, CA 94030 | | | **Voltage:** 230 | **Amps:** 90 |
| **Contact:** | Jim Harrington | | | **Our Test #:** | 4 |

**Phone:** (650) 259-2374 **Fax:** (650) 692-6356 **Cell:**

**Test Date:** 12/21/2012 **Tester:** Bob Fraker

| | |
|---|---|
| **Run Number ('E' = used for cost analysis):** | E-1 |
| **1. Inlet Pressure (PSI):** | -46 |
| **2. Standing Water Level (Ft):** | NA |
| **3. Draw Down (Ft):** | NA |
| **4. Recovered Water Level (Ft):** | NA |
| **5. Discharge Pressure at Gauge (PSI):** | 144 |
| **6. Total Lift (Ft):** | 226 |
| **7. Flow Velocity (Ft/Sec):** | 4.5 |
| ***8. Measured Flow Rate (GPM):*** | **399** |
| **9. Customer Flow Rate (GPM):** | 0 |
| **10. Specific Capacity (GPM/Ft draw):** | NA |
| **11. Acre Feet per 24 Hr:** | 1.8 |
| **Million Gallons per 24 Hr:** | 0.575 |
| **12. Cubic Feet per Second (CFS):** | 0.9 |
| **13. Horsepower Input to Motor:** | 40 |
| **14. Percent of Rated Motor Load (%):** | 94 |
| **15. Kilowatt Input to Motor:** | 30 |
| **16. Kilowatt Hours per Mill Gal:** | 1,236 |
| **17. Cost to Pump a Million Gal:** | $197.74 |
| **18. Energy Cost ($/Hour)** | $4.73 |
| **19. Base Cost per Kwh:** | $0.160 |
| **20. NamePlate RPM:** | 1,780 |
| **21. RPM at GearHead:** | 0 |
| ***22. Overall Pumping Efficiency (%):*** | **58** |

*If line 1 is negative then pump inlet is under pressure.*

*If a Flow Velocity (line 7) is less than 1 ft/second, the accuracy of the test is suspect.*

*Note any major difference between the "Measured" flow rate and the "Customer's" (lines 8,9).*

All results are based on conditions during the time of the test. If these conditions vary from the normal operation of your pump, the results shown may not describe the pump's normal performance.

Overall efficiency of this plant is considered to be fair assuming this run represents plant's normal operating condition.

Nameplate Data: 360 GPM @ 325' TDH.

Estimated savings of 32 kWh/AF and $187.46 annual energy costs from a retrofit

Current OPE of 58% and estimated potential OPE of 65%

# City of Millbrae
# Turnout Meter Reads

| | January 3, 2013 | January 4, 2013 | January 5, 2013 |
|---|---|---|---|
| Location: | Park Place | Park Place | Park Place |
| Time: | 10:30 | 10:25 | 10:25 |
| Read (s): | 79134.6 | 79316.6 | 79514.5 |
| Location: | Greenhills | Greenhills | Greenhills |
| Time: | 10:40 | 10:35 | 10:35 |
| Read (s): | 60190 | 60397 | 60616 |
| | 24488 | 24711 | 24943 |
| Location: | Meadows | Meadows | Meadows |
| Time: | 10:50 | 10:40 | 10:45 |
| Read (s): | 294219 | 294398 | 294635 |
| | 355586 | 355747 | 355964 |
| | 165121 | 165493 | 165936 |
| Location: | Murchison | Murchison | Murchison |
| Time: | 11:00 | 11:00 | 11:00 |
| Read (s): | 10645.1 | 10677.3 | 10733.3 |
| | 6168 | 6297 | 6425 |
| Location: | Victoria | Victoria | Victoria |
| Time: | OFF LINE | OFF LINE | OFF LINE |
| Read (s): | | | |

| Date | Time | Pump | Status | Note |
|---|---|---|---|---|
| | | | | |
| Thursday, January 03, 2013 | Start Value | LAR-PMP1-SS | OFF | Normal |
| Thursday, January 03, 2013 | Start Value | LAR-PMP2-SS | ON | Normal |
| Thursday, January 03, 2013 | Start Value | LAR-PMP3-SS | OFF | Normal |
| Thursday, January 03, 2013 | Start Value | MAD-PMP1-SS | OFF | Normal |
| Thursday, January 03, 2013 | Start Value | MAD-PMP2-SS | ON | Normal |
| Thursday, January 03, 2013 | Start Value | MAD-PMP3-SS | OFF | Normal |
| Thursday, January 03, 2013 | 1:00:13 AM | LAR-PMP2-SS | OFF | Normal |
| Thursday, January 03, 2013 | 5:12:12 AM | MAD-PMP2-SS | OFF | Normal |
| Thursday, January 03, 2013 | 9:31:36 PM | MAD-PMP2-SS | ON | Normal |
| Thursday, January 03, 2013 | 9:33:44 PM | LAR-PMP2-SS | ON | Normal |
| Thursday, January 03, 2013 | 9:34:38 PM | MAD-PMP3-SS | ON | Normal |
| Thursday, January 03, 2013 | 10:30:14 PM | MAD-PMP3-SS | OFF | Normal |
| Friday, January 04, 2013 | 3:00:10 AM | LAR-PMP2-SS | OFF | Normal |
| Friday, January 04, 2013 | 4:30:38 AM | LAR-PMP2-SS | ON | Normal |
| Friday, January 04, 2013 | 5:00:15 AM | LAR-PMP2-SS | OFF | Normal |
| Friday, January 04, 2013 | 7:21:10 AM | MAD-PMP2-SS | OFF | Normal |
| Friday, January 04, 2013 | 9:31:36 PM | MAD-PMP2-SS | ON | Normal |
| Friday, January 04, 2013 | 9:34:26 PM | LAR-PMP2-SS | ON | Normal |
| Saturday, January 05, 2013 | 12:00:58 AM | LAR-PMP2-SS | OFF | Normal |
| Saturday, January 05, 2013 | 4:33:57 AM | MAD-PMP2-SS | OFF | Normal |
| Saturday, January 05, 2013 | 9:31:36 PM | MAD-PMP2-SS | ON | Normal |
| Saturday, January 05, 2013 | 9:34:26 PM | LAR-PMP2-SS | ON | Normal |

Appendix E

# STORAGE TANKS SEISMIC EVALUATION TM

Engineers...Working Wonders With Water™

2700 YGNACIO VALLEY RD SUITE 300
WALNUT CREEK, CA 94598
FAX: (925) 930-0208
PHONE: (925) 932-1710

# TECHNICAL MEMORANDUM

| | | | |
|---|---|---|---|
| **Project Name:** | Water Master Plan | **Date:** | May 22, 2013 |
| **Client:** | City of Millbrae | **Project Number:** | 9107A.00 |
| **Prepared By:** | Yousef Nouri | | |
| **Reviewed By:** | Mike Dadik | | |
| **Subject:** | Task 6 – Water Storage Tanks Seismic Evaluation and Retrofit | | |
| **Distribution:** | Tim Loper | | |

This memorandum is to summarize Carollo's structural observations and results of the Seismic Evaluation of the City of Millbrae (City) Water Storage Tanks. This task was performed as part of the Water Master Plan (WMP) project for the City.

## 1.0 SCOPE OF WORK

### 1.1 Document Review

The following documents were made available to Carollo for assessment of the tanks, their design, as well as their existing conditions.

- 1974 La Prenda Design Drawings by KCA Engineers
- 1994 Rehabilitation of Water Storage Tanks by KLH-CREM Inc.
- 1995 Piping Modifications Drawings by KLH-CREM Inc.
- 1983 Water Master Plan by Boone Cook and Associates
- 2010 Urban Water Management Plan by Kennedy/Jenks Consultants
- 2008 Dive Reports by Inland Potable Inc.
- 2011 Dive Reports by Inland Potable Inc.
- 2010 Water Reservoir Condition Assessment Report by V&A

### 1.2 Site Visit

Carollo conducted a site visit to each reservoir to document the field conditions, noting any seismic upgrades, and to identify any conditions that are not represented in the record drawings or previous reports. The exterior of the tanks and the site and field measurements were documented during Carollo's visit.

### 1.3 Seismic Evaluation

A seismic evaluation of the reservoirs was performed based upon the provisions set forth in the 2011 edition of AWWA D 100, Welded Carbon Steel Tanks for Water Storage, which is the most relevant design standard for welded steel tanks that are used to store water. The strength of materials and member sizes was based upon the information obtained from the record drawings, and the thickness gauge testing of the tank shell performed during Carollo's site visit.

### 1.4 Documentation

The results of Carollo's evaluation are presented in this Internal Memorandum (IM) for incorporation in the 50-percent Draft Report. Mitigation approaches are presented for the seismic vulnerabilities that were identified during the analysis. In addition, to assist the City with mitigation planning efforts, planning level cost estimates for implementation of seismic retrofit recommendations are included.

## 2.0 VISUAL OBSERVATIONS

Carollo conducted inspections of the City's tanks on January 24, 2013. Carollo did not have the opportunity to inspect the interior of the tanks during the site visit. Therefore, recently performed dive reports were summarized and used to evaluate the condition of the interior of the tanks. This portion of the IM discusses the observations and findings from the inspections for each of the City's tanks. It was noted that flexible pipe connections were added to the inlet and outlet pipes for La Prenda, Skyline 1, Skyline 2 and Vallejo tanks as part of the Piping Modifications Project in 1995.

### 2.1 La Prenda Tank

The La Prenda tank, located at 406 California Highway 35, is a welded steel tank constructed in 1977. The tank has a 48 foot diameter and aheight of 38 feet. The welded steel tank capacity is 500,000 gallons.

The La Prenda Tank is classified as "Essential" by the City in the Dames and Moore (D&M) report in 1988. This classification refers to the importance of the tank to the City's water supply following a seismic event.

- <u>Tank Shell Exterior:</u> Minor staining was observed on the exterior. The exterior coating of the tank seems to have aged. The existing coating has been recently patched in stained locations by the City.

- <u>Tank Shell Interior</u>: During a recent dive inspection, the inlet, outlet and ladder, man way, interior walls and floor were found in good condition with staining and less than one percent corrosion noted. Some staining was observed on the overflow along with minor corrosion mostly on the inside of the overflow box.

Heavy corrosion was observed on the drain. The interior roof was found in fair condition with concentrated cell and surface corrosion noted. The support column was found in fair to poor condition with 50% blistering and 30% corrosion noted.

- Piping connections: The inlet and outlet pipes are connected to the tank through ball-type flexible expansion joint couplings (EBAA Iron Flex-Tend). However the overflow outlet pipe is connected to the ground without any flexibility (see Figure 2.1.1).

Figure 2.1.2 La Prenda Tank Piping Connections

## 2.2 Skyline Tanks 1 and 2

Skyline Tanks 1 and 2 are welded steel tanks located on Junipero Sera Freeway inside the Golden Gate National Recreational Area in the City of Burlingame.

Skyline Tank 1 (North) is an 80 foot diameter, 32 foot tall, 1,000,000 gallon tank. This tank was constructed in 1958 and is considered an “Essential” water supply facility for the City following an earthquake.

Skyline Tank 2 (South) is a 55-foot diameter, 28-foot tall, 500,000 gallon tank. The tank was constructed in 1962 is also considered an “Essential” facility. .

- Tank Shell Exterior South tank access hatch and exterior coating has been locally patched and repaired. Minor staining and corrosion was observed at the manway hatch for the North tank as well as on the top of the walls.

- Tank Shell Interior: The interior walls, the inlet pipe, the manway and the overflow box were found in fair condition with some staining and corrosion. The ladder and drain were found in poor condition with some staining, cracking, and corrosion noted. The interior roofs were found in poor condition with heavy concentrated corrosion mainly at the supports. Minor corrosion and deterioration of the coating was observed on the support columns.

The interior walls, support column and the floor were found in fair to poor condition with cracking, blistering and corrosion noted. The interior roof was found in fair to poor condition with concentrated cells corrosion present at the supports.

- Piping connections: The inlet and outlet pipes are connected to the tank through Flex-Tends However the overflow outlet pipe is connected to the ground only with a single restrained flexible coupling above ground. This connection is not designed for the minimum requirements of the current building code. (see Figure 2.2.3).

Figure 2.2.4 Skyline Tank 2 Piping connections

## 2.3 Vallejo Tank

The Vallejo tank is located on 100 Vallejo Drive. The welded steel tank is a 26-foot diameter, 31-foot tall, 112,000 gallon tank. The tank was classified as non-essential or “Ordinary” by the City in 1988.

- Tank Shell Exterior: Tank shell exterior was found in good condition. It appears that the coating has been locally maintained and patched where needed.

- Tank Shell Interior: The inlet, outlet, ladder, and the overflow were found in poor condition with pitting, delamination, blistering and corrosion. The manway and drain were found in poor condition with blistering and corrosion noted. The interior roof was found in good condition with some corrosion. The interior walls, support column and the floor were found in poor condition with de-lamination, blistering and corrosion.

- Piping connections: The inlet and outlet pipes have flexible connections. The overflow pipe only has a single restrained flexible coupling above ground. This attachment is not designed for the minimum deflection required per the current building code. Therefore, it is expected to sustain some damage in a large seismic event.

## 2.4 Helen Tank

Helen tank is located on 595 Helen Drive. The welded steel tank is a 38-foot diameter, 31-foot tall 250,000 gallon tank. The tank was classified as “essential” to the City’s water supply following a seismic event, however is currently out-of-service.

- Tank Shell Exterior: The tank has been recoated very recently and appears in good to very good condition.

- Tank Shell Interior: The inlet, outlet, ladder and drain were found in poor condition with 95% corrosion noted. The overflow was found in fair condition with 30% corrosion noted. The interior walls were found in fair condition with staining, pitting, delamination and corrosion. The interior roof and man way were found in good to fair condition with locations of concentrated cell corrosion. The support column was found in poor condition with pitting, 80% blistering and 33% corrosion.

- Piping connections: Only the inlet pipe has a stainless steel bellows connection. All other piping has rigid connections to the tank and is likely to sustain damage during a seismic event (see Figure 2.4.5)

Figure 2.4.6 Helen Tank Piping Connections

## 3.0 THICKNESS GAUGE TEST RESULTS

Thickness of the tank shell is used to analyze anticipated seismic performance of the tank walls. Record drawings were not available so representative samples of the shell plates were measured and the findings used for the structural evaluation. The measurements were randomly located in each shell course and not detailed enough to be considered a corrosion survey.

Carollo measured the thickness of the steel plates, using a handheld thickness gauge, in different locations on the tank exterior. The measured values are listed in Table 2.4.1. In general, the thickness of the plate did not vary significantly between test locations.

**Table 2.4.2 Tank Shell Thickness Gauge Test Results**
Water Master Plan – Seismic Assessment
City of Millbrae

| Tank | 1st Course | 2nd Course | 3rd Course | 4th Course | 5th Course |
|---|---|---|---|---|---|
| La Prenda | 0.41” | 0.34” | 0.32” | 0.31” | TOP[1] |
| Skyline 1 (North) | 0.51” | 0.35” | 0.28” | 0.27” – TOP | |
| Skyline 2 (South) | 0.39” | 0.33” | 0.27” | 0.28” – TOP | |
| Vallejo | 0.26” | 0.26” | - [3] | TOP | |
| Helen | 0.29” [2] | 0.29” | - [3] | - [3] | TOP |

[1] TOP identifies the course as the top course of the tank
[2] Bottom Course seems to be buried by 2 to 3 inches
[3] No measurements were taken above shell courses with a nominal 0.25-inch thickness.

## 4.0 SEISMIC ASSESSMENT FINDINGS

Using the information gathered during the document review process and Carollo's site visit, structural analysis of the existing tanks was performed to determine how the seismic load demands compare to the structural capacity of the tank. This evaluation was based upon the provisions set forth in the 2011 edition AWWA D 100, Welded Carbon Steel Tanks for Water Storage.

In order to analyze the tanks for seismic performance, lateral seismic loads were determined based on the requirements of the 2010 California Building Code (CBC) and 2005 American Society of Civil Engineers, Minimum Design Loads Standard (ASCE 7-05).

The strength of materials and member sizes were based upon the limited information obtained from the record drawings. Tank shell thickness results measured during Carollo's site visit were used in the analysis to identify regions of high stress or overstress.

In seismic analysis of steel tanks three key considerations are taken into account:

1. Freeboard requirements: sloshing of the tank contents during an earthquake create sloshing waves that will induce additional loads on the tank wall and roof shells. The current design guidelines of AWWA D 100, and California Building Code require additional allowance made in the height of the tank to accommodate the sloshing wave.

2. Anchorage requirements: high seismic demand on the tank and its contents may create overturning moments or may cause the tank to slide. To evaluate the risk of sliding or overturning a factor of safety can be calculated.

3. Tank Shell Stress Analysis: the increased stresses created in the tank due to the seismic loads are calculated, as outlined in AWWA D 100, in order to avoid excessive damage to the tank shells and roof during an earthquake.

The following section presents the results of Carollo's seismic assessment of the tanks.

## 4.1 Freeboard Requirements

- La Prenda Tank: The required freeboard height based on the seismic analysis is 11.5 feet. The available height to accommodate sloshing is 2 feet and is therefore deficient.
- Skyline Tank 1: The required freeboard height based on the seismic analysis is 12.1 feet. The hydraulic grade line is at the top of the tank and therefore the tank does not have any room to accommodate sloshing.
- Skyline Tank 2: The required freeboard height based on the seismic analysis is 13.8 feet. The available height to accommodate sloshing is 4 feet and is therefore deficient.
- Vallejo Tank: The required freeboard height based on the seismic analysis is 8.5 feet. The available height to accommodate sloshing is 4 feet and is therefore deficient.
- Helen Tank: The required freeboard height based on the seismic analysis is 9.0 feet. The available height to accommodate sloshing is 5 feet and is therefore deficient.

## 4.2 Anchorage Requirements

- La Prenda Tank: The tank is not anchored against overturning. The factors of safety against overturning and sliding are 0.3 and 0.9 respectively. Therefore, the tank requires anchoring in order to avoid substantial damage during an earthquake.
- Skyline Tank 1: The tank has a factor of safety of 0.9 against overturning, and 1.4 against sliding. Therefore, the tank requires anchoring in order to avoid overturning.
- Skyline Tank 2: The tank has a factor of safety of 0.5 against overturning, and 1.1 against sliding. Therefore, the tank requires anchoring in order to avoid overturning.
- Vallejo Tank: The tank has a factor of safety of 0.2 against overturning, and 0.8 against sliding. Therefore, the tank is considered unstable and requires anchoring in order to avoid significant damage during an earthquake.
- Helen Tank: The tank has a factor of safety of 0.2 against overturning, and 0.8 against sliding. Therefore, the tank is considered unstable and requires anchoring in order to avoid significant damage during an earthquake.

## 4.3 Tank Shell Stress Analysis

The shell stresses were analyzed assuming the “self anchored” condition, as outlined by AWWA D 100, since none of the tanks are anchored to their foundations. In all tanks except for the Vallejo tank, the shell appears to be designed for the hydrostatic forces and does not consider seismic loads. Analysis shows the tank shells to be deficient in resisting hydrodynamic hoop tension. Therefore, during a seismic event the tank shell can be expected to sustain damage and possibly a catastrophic loss of contents.

Considering that the tanks require anchoring, tank shells were also analyzed assuming “anchored” condition (per AWWA D 100). Stress analysis of the tanks shows that all tanks, including the Vallejo tank, are deficient for compression buckling. This deficiency may cause bulging at the base called “elephant foot buckling”, or shell floor failure.

Recommendations for replacement and strengthening of the lower portion of the tanks were developed based on the stress analysis performed.

# 5.0 RECOMMENDATIONS

This section presents the recommended alternatives based on the field inspections, and the structural analysis performed.

It should be noted that corrosion of the tank shell contributes to weakening and potential failure of the shell during a seismic event. If not addressed, the rate of the corrosion of the steel members will gradually accelerate. In order to remediate the corrosion of the steel tanks effectively, sand blasting the steel members, and reapplying coating is recommended.

## 5.1 Freeboard Requirements

During a seismic event the contents of the tank will experience a significant amount of sloshing. The sloshing will impact the tank roof. If the geometry of the tank does not allow for the sloshing to occur, a large force will be applied to the roof members. Tanks that were designed prior to 1990’s do not allocate additional wall heights to accommodate for sloshing; neither were the roofs designed for the impact of the sloshing wave. Based on Carollo’s analysis, all of the City’s tanks are deficient with respect to the California Building Code’s sloshing requirements. In order to address the freeboard deficiency in the tanks, two approaches can be used:

### 5.1.1 Alternative 1: Raising the Roof to the Required Height

In this approach the roof is raised as required to accommodate for sloshing. The main disadvantage of this method is the extent of the labor required to perform the retrofit.

### 5.1.2 Alternative 2: Lowering the Operating Hydraulic Line

In this approach, by lowering the water surface elevation in the tank, the required freeboard will be provided in the tanks. This method reduces the capacity of the tank and the water delivery system and may not be feasible.

Based on a comparison between the different alternatives, Carollo recommends Alternative 1 for retrofit of all the City's tanks if the tanks are not replaced. This retrofit alternative was used to develop estimated project costs presented in Section 6 of this IM.

## 5.2 Anchorage Requirements

The analysis performed on the tanks shows that all five tanks require anchoring against overturning, sliding, or both. In order to address this deficiency, two alternatives are presented here. Construction costs are estimated for each alternative and are presented in Section 6 of this IM.

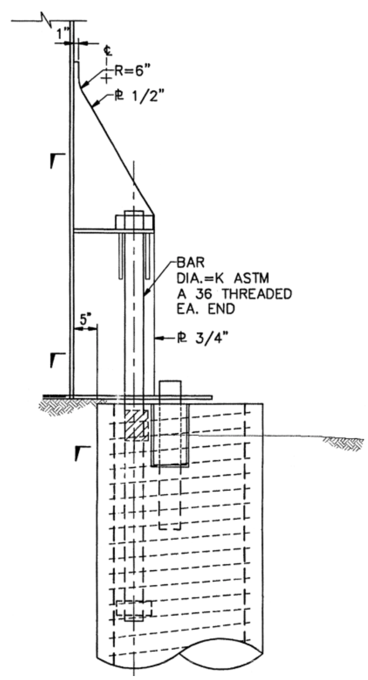
### 5.2.1 <u>Alternative 1: Drilled Piers</u>

This alternative was originally designed as part of the City's Rehabilitation of Water Storage Tanks project in 1995. In this approach shallow drilled piers are drilled around the perimeter of the tanks. Brackets welded to the tank shell are then bolted to the drilled pier (Figure 5.2.1).

The advantage of this method is that the location of the piers can be adjusted to avoid conflicts with piping and other obstructing elements. This method is especially advantageous in the case of La Prenda tank which is constructed against the hillside on the north side, limiting access for other methods of construction.

Implementation of this alternative will require the tank to be taken offline for the duration of the construction. Reapplication of the coating inside the tank is also necessary as welding the brackets to the shell will damage existing coating.

Figure 5.2.2 Anchorage Alternative 1 – Drilled Piers



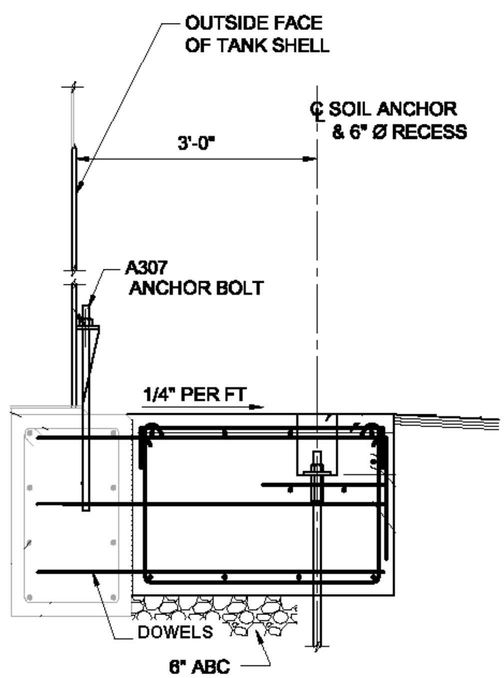
### 5.2.2 Alternative 2: Extended Foundation with Rock Anchors

In this approach, a new ring foundation is constructed as an extension to the existing tank foundation. This foundation depending on the design uplift forces is then anchored to the ground using soil or rock anchors. Similar to Alternative 1, the tank shell is bolted to the newly constructed foundation around the perimeter (Figure 5.2.3).

The main advantage of this method is that the tank shell is anchored to its existing foundation thereby the tank and the foundation act as a single structure. However, this method requires a larger area around the tank for excavation and access to the tank foundation. Similar to Alternative 1, this alternative also requires tank shutdown during construction and reapplication of the interior coating.

Planning level cost estimates were developed for the anchorage alternatives for each tank, in order to determine the most suitable alternative.

Figure 5.2.4 Anchorage Alternative 2 – Soil Anchors




## 5.3 Tank shell overstress

Replacing all or part of the shell course that is overstressed will address excessive seismic stress in the tank shell. This work will be completed in segments around the perimeter of the tank in order to maintain stability during seismic or wind events. A steel portal frame will be designed and welded around each segment before removing the shell to reinforce the opening. New coating will be required for the interior and exterior of the new shell course.

For each tank, the part of the shell that is deficient for hydrodynamic loads requires replacement or some other form of retrofit. The zone of deficiency for each tank is listed below:

- La Prenda Tank: bottom 10 feet
- Skyline Tank 1: bottom three courses, a total of 18 feet
- Skyline Tank 2: bottom 10 feet
- Vallejo Tank: bottom 4 feet.
- Helen Tank: bottom 4 feet.

Retrofit of the tank shells as described above is a costly and time-consuming process. As a result for the Skyline Tank 1, because of the extent of the deficiency, Carollo recommends the tank to be replaced.

Other approaches can be considered for the retrofit of the seismically deficient shells. Such methods would attempt to strengthen the shell locally by adding stiffeners or straps. However, the analysis and design guidelines of the AWWA D 100 standard would not be applicable to local strengthening of the shell, therefore requiring costly, and elaborate structural analysis of the tanks.

## 5.4 Summary of Recommendations

Table 5.4.1 summarizes the recommended alternatives for each tank. Different retrofit recommendations for each tank are grouped together in three alternatives. Cost estimates for each retrofit alternative are presented in Section 6.

**Table 5.4.2 Summary of Recommended Retrofit Alternatives**
Water Master Plan – Seismic Assessment
City of Millbrae

| Tank | Alternative 1 Drilled Shafts Anchors | Alternative 2 Soil Anchors | Alternative 3 Replacement of All Tanks |
|---|---|---|---|
| La Prenda | Replace Bottom 10ft of Tank Shell, Raise Roof, Install Anchors, Apply Coating | Replace Bottom 10ft of Tank Shell, Raise Roof, Install Anchors, Apply Coating | Replace Tank |
| Skyline 1 (North) | Replace Tank | Replace Tank | Replace Tank |
| Skyline 2 (South) | Replace Bottom 10ft of Tank Shell, Raise Roof, Install Anchors, Apply Coating | Replace Bottom 10ft of Tank Shell, Raise Roof, Install Anchors, Apply Coating | Replace Tank |
| Vallejo | Replace Bottom 4ft of Tank Shell, Raise Roof, Install Anchors, Apply Coating | Replace Bottom 4ft of Tank Shell, Raise Roof, Install Anchors, Apply Coating | Replace Tank |
| Helen | Replace Bottom 4ft of Tank Shell, Raise Roof, Install Anchors, Apply Coating | Replace Bottom 4ft of Tank Shell, Raise Roof, Install Anchors, Apply Coating | Replace Tank |

## 6.0 COST ESTIMATES

The estimated construction costs presented in this IM are based on preliminary structural retrofit recommendations as developed herein and include retrofit of the tanks for sloshing loads.

The estimated construction costs for each structure were developed based on a variety of sources. Once the initial costs were prepared, a 30 percent contingency was applied to reflect uncertainties at the pre-design stage and assumptions used in the estimating methods.

A summary of retrofit projects and the estimated costs associated with them are presented in Table 5.4.1. If the tank water surface elevations were lowered, the total project cost would be approximately $1,500,000 less for alternatives 1 and 2.

**Table 5.4.2 Comparison of Construction Cost Estimates for Retrofit Alternatives**
Water Master Plan – Seismic Assessment
City of Millbrae

| Tank | Alternative 1 Drilled Shafts Anchors | Alternative 2 Soil Anchors | Alternative 3 Replacement of All Tanks |
|---|---|---|---|
| La Prenda | 1,029,500 | 876,500 | 1,888,500 |
| Skyline 1 (North) | 2,869,000 | 2,869,000 | 2,869,000 |
| Skyline 2 (South) | 1,127,000 | 1,012,500 | 2,307,500 |
| Vallejo | 445,500 | 426,500 | 815,500 |
| Helen | 643,500 | 566,500 | 1,310,000 |
| **Total** | **6,113,500** | **5,741,000** | **9,190,500** |

**Prepared By: Yousef Nouri**

Yousef Nouri

Appendix F

# EMERGENCY IMPROVEMENTS TECHNICAL MEMORANDUM

Engineers...Working Wonders With Water®

# TECHNICAL MEMORANDUM

| | | | |
|---|---|---|---|
| **Project Name:** | City of Millbrae Water Master Plan | **Date:** | October 23, 2013 |
| **Client:** | City of Millbrae | **Project Number:** | 9107A00 |
| **Prepared By:** | Bijan Sadeghi | | |
| **Reviewed By:** | Inge Wiersema, Tim Loper | | |
| **Subject:** | Development and Evaluation of Emergency Improvement Alternatives | | |
| **Distribution:** | Cyrus Kianpour, Dennis Deimer, Khee Lim | | |

## 1.0 INTRODUCTION

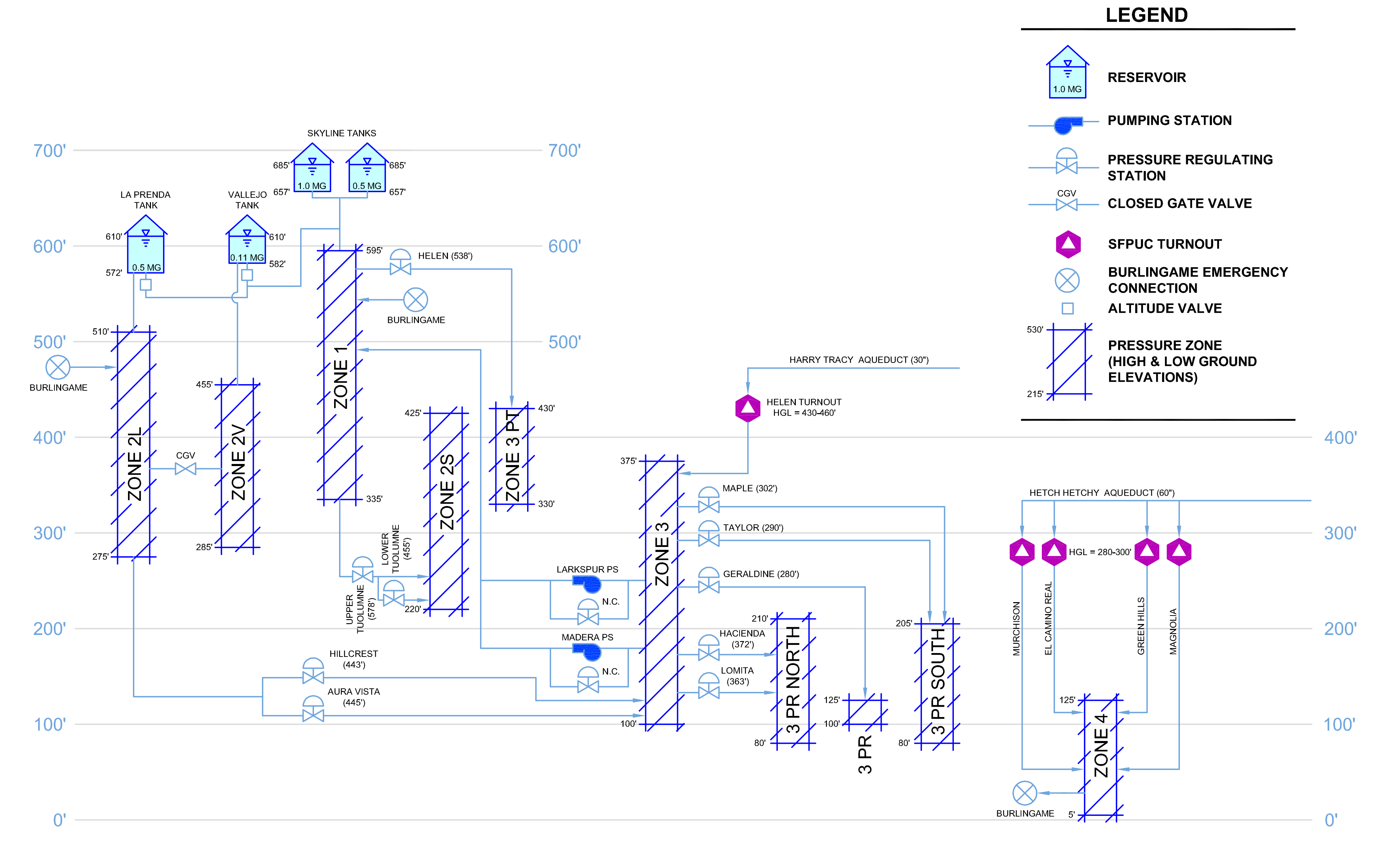
The City of Millbrae's (City's) contracted with Carollo Engineers (Carollo) to conduct an analysis of their water distribution system to determine potential improvements that would increase the reliability of the system during emergencies. As part of the analysis, Carollo developed multiple alternatives to increase the system reliability that evaluated storage requirements, hydraulic constraints, and system operations. This Technical Memorandum (TM) details the analysis of the system during emergency conditions and summarizes the recommendation that best meets the City's goals and objectives.

## 2.0 SYSTEM DESCRIPTION AND PROJECT OBJECTIVES

The City's water distribution system is separated into four major pressure zones. As shown in the distribution system's hydraulic profile in **Figure 1**, the upper pressure zones (Zones 1, 2, and 3) are hydraulically disconnected from Zone 4. The upper pressure Zones 1, 2, 3 and their sub zones are served from a single supply source, the Harry Tracy Water Treatment Plant (WTP) which is located just outside City boundaries within the County of San Mateo. Water from this WTP is available to the City at the Helen turnout through a 30-inch diameter transmission main. The turnout is located within approximately 200 ft of the plant and has three 6-inch diameter meters with combined capacity of 4,500 gpm. Zone 4 is also supplied from a single source, the 60-inch diameter Hetch Hetchy aqueduct, through four turnouts with a combined capacity of 8,800 gpm. The aqueduct water is supplied from Crystal Spring Reservoir, approximately five miles south of the City.

Because zones 1, 2, and 3 are hydraulically isolated from Zone 4, the system operates as two separate networks. Lack of redundant supplies within the upper and lower zones has made the City vulnerable to potential outages of the Harry Tracy WTP and/or the Hetch Hetchy aqueduct. The problem is more evident for Zone 4, where unlike the upper pressure zones, no storage or receiving intertie with neighboring cities is available for use during emergencies.

The objective of this analysis is to evaluate alternatives that allow the upper and lower zones to provide supply during an emergency situation where one of the two sources may be out of service.




# FIGURE 1
# HYDRAULIC PROFILE SCHEMATIC
## CITY OF MILLBRAE

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carollo

# 3.0 FUTURE STORAGE REQUIREMENTS

To determine future storage needs, a capacity analysis was performed with the water demand projected for year 2035. This analysis was performed for each pressure zone group separately. A pressure zone group is a combination of zones served from a common storage tank or supply source. **Table 1** presents the City's pressure zone groups and associated minimum, average and maximum day demands (MinDD, ADD, and MDD). The storage requirement of each pressure zone group is discussed in the following sections. The requirements for storage are comprised of three components: operational, fire, and emergency. The required volume for each of the components is determined based on the demands in Table 1, and is further described below.

**Table 1 Definition of Pressure Zone Groups and Future (2035) Demands**
Water Master Plan
City of Millbrae

| Group | Pressure Zones | MinDD (mgd) | ADD (mgd) | MDD (mgd) |
|---|---|---|---|---|
| 1 | 1, 2S, 3PT | 0.25 | 0.39 | 0.78 |
| 2 | 2L, 2V | 0.12 | 0.18 | 0.36 |
| 3 | 3, 3PR, 3PR South, 3PR North | 0.48 | 0.74 | 1.49 |
| 4 | 4 | 1.12 | 1.72 | 3.45 |
| **Total** | | **1.97** | **3.04** | **6.08** |

## 3.1 Operational Storage Requirements

Operational storage equalizes diurnal demand fluctuations by providing supply during peak demand hours (usually in the early morning and later afternoon) when the demands exceed the peak capacity of the supply source(s). Operational storage is used when adequate supply capacity to meet peak hour demand is not available or peaking off supplies is not desired due to peak water or energy purchase surcharge costs.

The operational storage requirements for Groups 1 and 2 were estimated by comparing diurnal demands and supplies within each group, as shown on **Figure 2** and **Figure 3**. Several factors considerably affect operational storage calculations for these two groups. One factor is the daily supply flow pattern to La Prenda through the operation of the tank's altitude valve. This supply is provided from the Skyline tanks and is estimated to make up more than about 40 percent of the total demand of Group 1. To minimize operational storage need at the Skyline tanks, the La Prenda tank must be filled during the night when demands are low. However, this may not always be possible due to other operational constraints within the system. To provide operational flexibility and to plan for the worst-case scenario to avoid draining the tank, it was assumed La Prenda would be filled during daytime thereby maximizing the operational storage requirement at Skyline tanks. Contrary to the Skyline tanks, the maximum operational storage need at La Prenda occurs when La Prenda is filled during the night. Similarly, for conservative planning reasons, La Prenda's operational storage was determined assuming it would be filled at night.

The operational storage requirements for Groups 1 and 2 are also affected by the operation of Hillcrest and Aura Vista Pressure Regulating Valve (PRV) stations. Zone 3 does not have gravity storage and is served directly from the Helen turnout. However, a small portion of the zone near Hillcrest Blvd and Cirte Princesa is relatively elevated and has lower static pressures. To mitigate low pressures, this area is served from Zone 2L through the operation of the Hillcrest and Aura Vista PRV stations. Therefore, the diurnal pattern and the estimated flows through the PRV stations serving Zone 3 from Zone 2L impact the operational storage needs of the higher zones. The larger the PRV flows, the greater the storage needs in Groups 1 and 2.

Because flows through these PRV stations and their setpoints could not be field verified due to lack of telemetry, an accurate estimate of supply to Zone 3 was not possible. It was estimated that approximately 20 percent of the demands in Zone 3 were supplied from Zone 2L. The remaining demand of Group 3 and the entire demand of Group 4 were assumed to continue to be supplied from Harry Tracy WTP and Hetch Hetchy aqueduct, respectively.

The blue lines in Figure 2 and Figure 3 represent the stored water volume at any given time. In the hours when supplies exceed demands, the tank is filled (the blue line is inclined). Conversely, when demands exceed supplies, the tank is drained (the blue line is declined). The maximum stored volume (i.e., the peak point on the blue line) represents the operational storage of the tank in each figure. As shown, the maximum future (2035) operational storage for Group 1 and Group 2 were estimated to be about 1.02 and 0.32 MG, respectively.

**<u>Combining Skyline and La Prenda Tanks</u>**

As discussed, a conservative approach was taken for sizing the future operational storage of Groups 1 and 2. The sizing of operational storage for Group 1 was based on the assumption that La Prenda would be filled during the day. Conversely, the sizing of operational storage for Group 2 was based on the assumption that La Prenda would be filled during the night. These assumptions result in increased operational storage for both pressure zone groups while providing operational flexibility to avoid draining the tanks.

If Skyline and La Prenda tanks were to be combined, a smaller operational storage would be needed for the Groups 1 and 2 combined. As shown on **Figure 4**, the combined operational storage for Groups 1 and 2 was estimated to be about 0.8 MG, compared to about 1.3 MG when not combined. However, combining the tanks is not recommended for reliability reasons. Moreover, the additional 0.5 MG of operational storage resulting from conservative planning is desired, as it will provide a factor of safety and operational flexibility. The emergency alternative analyses presented in this TM were therefore performed assuming that the operational storage for Groups 1 and 2 would not be combined.

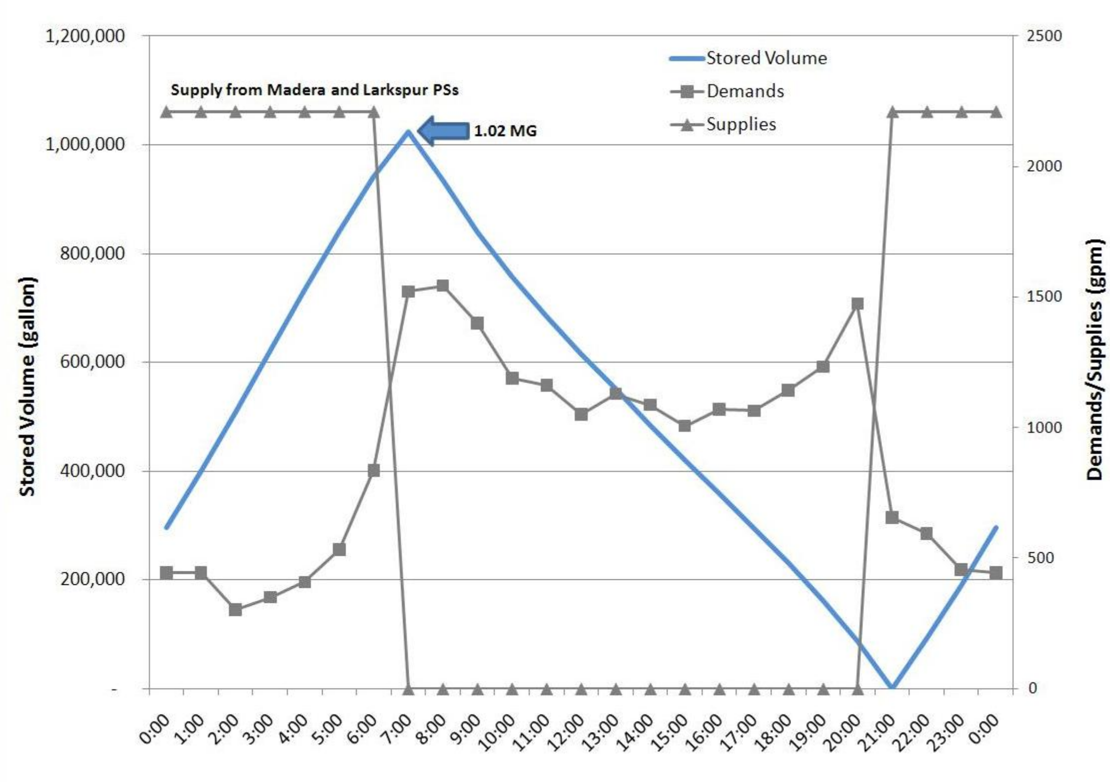



**Figure 2 – Future Operational Storage Sizing for Group 1**

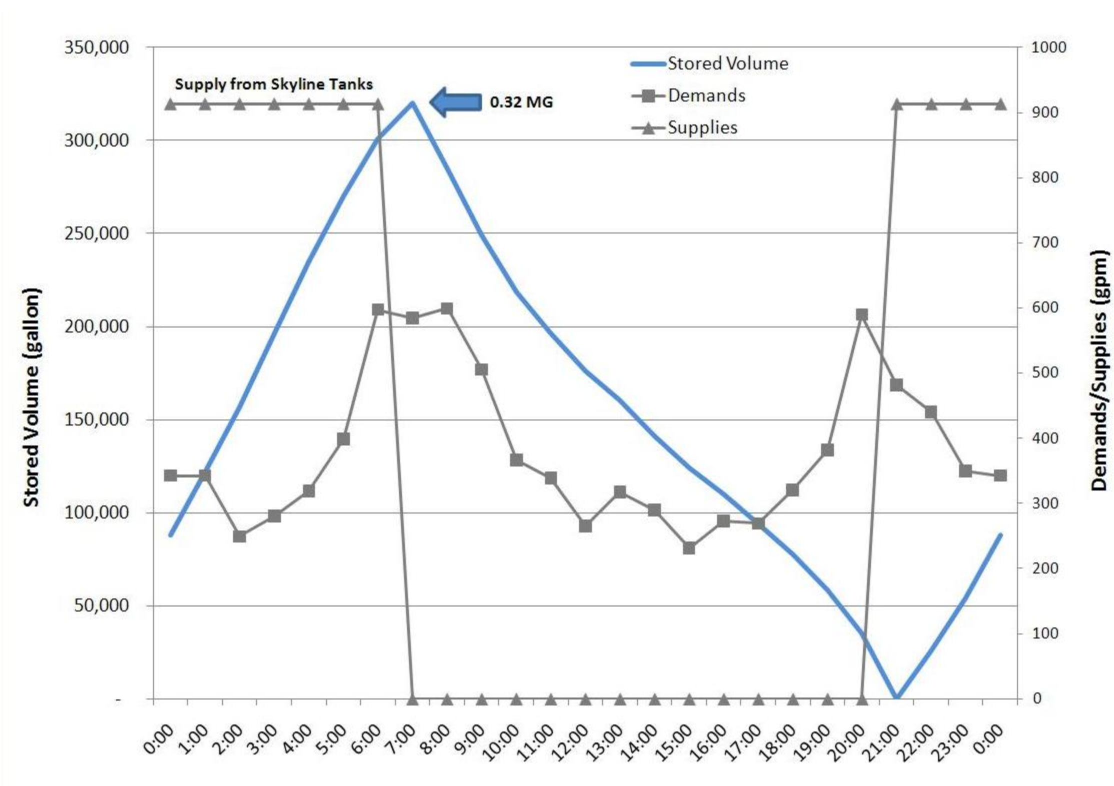



**Figure 3 – Future Operational Storage Sizing for Group 2**

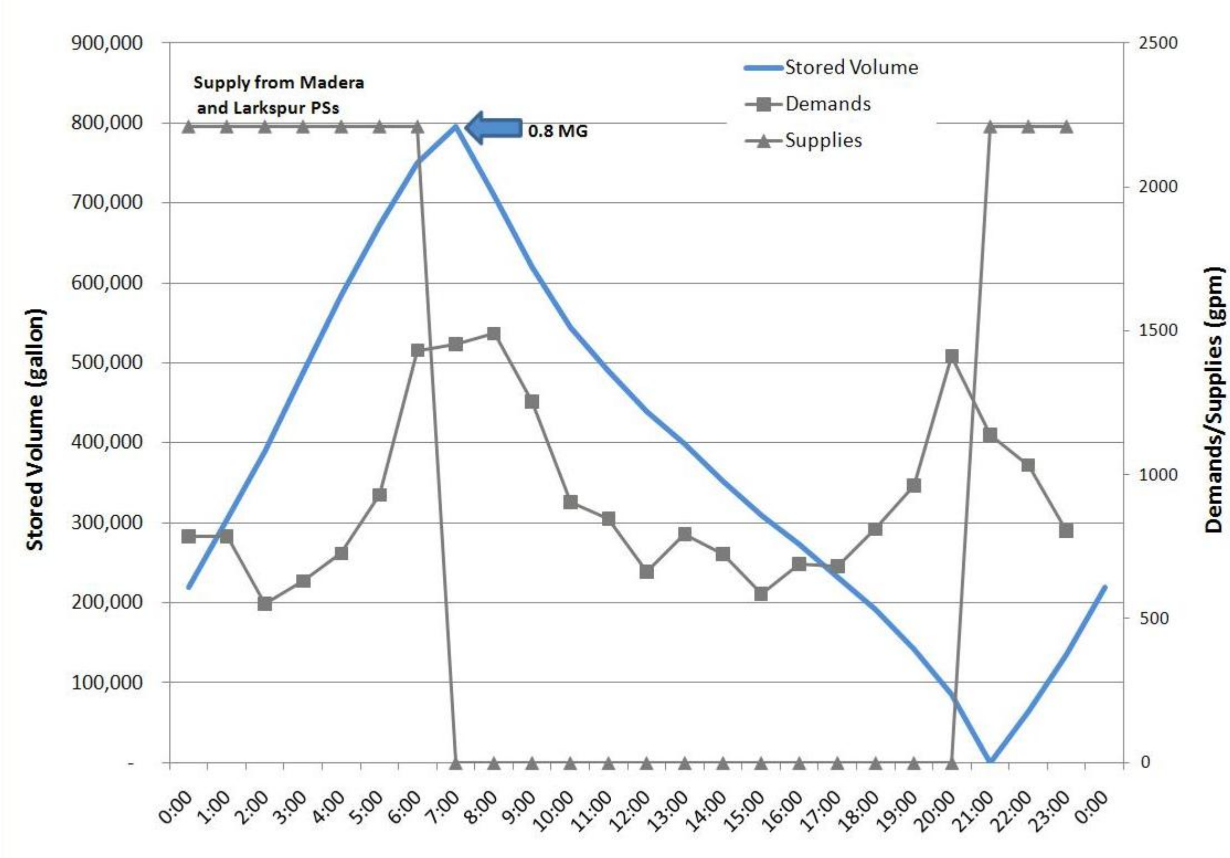



**Figure 4 – Future Operational Storage Sizing for Group 1 and 2 Combined**

## 3.2 Fire Storage Requirements

The required fire storage within each group is determined based on the single greatest fire flow requirement (flow and duration) within each group. **Table 2** presents a summary of governing land use and corresponding fire flow and storage requirements. As shown, the governing land use within Group 1 is general commercial and public facility with a fire flow requirement of 2,500 gpm for 3 hours resulting in 0.45 MG of fire flow storage. The governing land use within Group 2 is low density residential with a fire flow requirement of 1,250 gpm for 2 hours resulting in 0.15 MG of fire flow storage. Due to the absence of existing storage facilities, the fire flow for Groups 3 and 4 were assumed to be directly supplied from Harry Tracy WTP and Hetch Hetchy aqueduct, respectively. Therefore, no fire flow storage was planned for these groups.

**Table 2 Future Fire Flow Requirements and Storage Needs**
Water Master Plan
City of Millbrae

| Pressure Zone Group | Governing Land Use(1) | Required Fire Flows(2) | Fire Flow Storage(3) (MG) |
|---|---|---|---|
| 1 | General Commercial/Public Facility | 2,500 gpm, 3 hrs | 0.45 |
| 2 | Low Density Residential | 1,250 gpm, 2 hrs | 0.15 |
| 3 | Public Facility | 2,500 gpm, 3 hrs | 0(4) |
| 4 | General Commercial/Public Facility/MSA | 2,500 gpm, 3 hr | 0(4) |
| **Total** | | | **0.60** |

Notes:
(1) Per General Plan Land Use Map
(2) Per WMP's Table 5.1
(3) Assumes one fire within each group at any one time, and is based on the single greatest fire flow requirement within each group.
(4) Assumes fire flow is supplied through Harry Tracy WTP or Hetch Hetchy aqueduct.

## 3.3 Emergency Storage Requirements

As discussed in the WMP (section 5), the following four emergency operating conditions evaluated include:

- 24-hour outage of Harry Tracy WTP under Average Day Demand (ADD) conditions
- 24-hour outage of Hetch Hetchy aqueduct under ADD conditions
- 72-hour outage of Harry Tracy WTP under Minimum Day Demand (MinDD) conditions
- 72-hour outage of Hetch Hetchy aqueduct under MinDD conditions

Because the minimum day factor (i.e., the ratio of MinDD to ADD) for the City was estimated to be about 0.65 (WMP's Table 2.8), the 72-hour outage scenarios will require approximately 1.95 times the ADD. Hence, the 72-hour outage scenarios are the governing scenarios.

**Table 3** presents estimated future MinDDs and the required emergency storage volume for each pressure zone. As shown, Group 4 emergency storage requirement (3.4 MG) is larger than the combined emergency storage needs of Groups 1, 2 and 3 (2.6 MG).

**Table 3** **Future (2035) Minimum Day Demands and Emergency Storage Needs**
Water Master Plan
City of Millbrae

| Pressure Zone | MinDD (mgd) | Emergency Storage Needs (MG) | | | |
|---|---|---|---|---|---|
| | | Group 1 | Group 2 | Group 3 | Group 4 |
| Zone 1 | 0.18 | 0.54 | - | - | - |
| Zone 3 PT | 0.04 | 0.11 | - | - | - |
| Zone 2 S | 0.04 | 0.11 | - | - | - |
| Zone 2 V | 0.05 | - | 0.16 | - | - |
| Zone 2 L | 0.07 | - | 0.20 | - | - |
| Zone 3 | 0.31 | - | - | 0.93 | - |
| Zone 3 PR/PR S/PR N | 0.17 | - | - | 0.52 | - |
| Zone 4 | 1.12 | - | - | - | 3.36 |
| **Total** | **1.97** | **0.76** | **0.36** | **1.45** | **3.36** |

## 3.4 Summary of Storage Requirements

The operational, fire and emergency storage needs of various pressure zone groups are summarized in **Table 4** and compared with the currently available storage. As shown, all groups are deficient and in need of additional storage. It can also be concluded that the current storage is sufficient to meet future (2035) operational and fire storage needs and that the emergency storage, which is the largest component, creates the deficiency in each group. To address emergency deficiencies, six alternative improvements were developed. These alternatives are described in the following section.

**Table 4** **Future (2035) Storage Requirements and Availability Comparison**
Water Master Plan
City of Millbrae

| Storage Component | Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|
| Emergency | 0.76 | 0.36 | 1.45 | 3.36 |
| Fire Storage Needs | 0.45 | 0.15 | 0 | 0 |
| Operational Needs | 1.02 | 0.32 | 0 | 0 |
| **Total Storage Needs** | **2.23** | **0.83** | **1.45** | **3.36** |
| Total Available Storage | 1.50 | 0.50(1) | 0 | 0 |
| **Surplus/Deficit** | **-0.73** | **-0.33** | **-1.45** | **-3.36** |

Note:
(1) Assuming Vallejo tank is eliminated in the future.

# 4.0 DESCRIPTION OF EMERGENCY ALTERNATIVES

To meet the planning criteria for emergency conditions, six alternative improvement schemes were developed and presented to the City. Each alternative addresses deficiencies by proposing emergency storage tanks or cross connecting the upper and lower zones via transmission mains or both. All alternatives assume a single supply source outage at any one time.

Based on discussion with City staff it was determined that the Vallejo tank would be eliminated in the future to simplify operations. In addition, it was decided by the City staff that Zone 2V would be served from the La Prenda tank. Furthermore, it was assumed that the Skyline and La Prenda tanks would be replaced with new tanks in all alternatives in lieu of seismic retrofits. Other improvements such as further storage optimization or fire flow improvements will be evaluated separately in the WMP once the recommended emergency improvements are identified. Description of various alternatives and proposed facilities are presented below.

## 4.1 Alternative 1 – All Emergency Storage in Higher Zone(s)

This alternative assumed that the City's total emergency storage was located in the higher zones. Connection to Zone 4 was made through a pipeline and several PRV stations to reduce system pressures to levels suitable for Zone 4. Since it was assumed that at any one time only one supply source was offline, the total emergency storage was the greater of combined emergency storage requirements for Zones 1, 2, 3 and their sub zones and the emergency storage requirement for Zone 4.

A summary of total storage needs under this alternative is presented in **Table 5**. As shown, the emergency storage requirement is governed by Zone 4 and that the total storage need, including operational and fire storage components, is about 5.3 MG. Two sub-alternatives were defined with respect to the breakdown of total emergency storage within Zones 1 and 2. These sub-alternatives are described below.

**Table 5 Alternatives 1 and 2 Storage Requirements**
Water Master Plan
City of Millbrae

| Storage Component | Volume (MG) |
|---|---|
| Higher Zones Emergency | 2.57 |
| Lower Zone Emergency | 3.36 |
| Emergency(1) | 3.36 |
| Operational | 1.34 |
| Fire | 0.60 |
| **Total Storage** | **5.30** |

Note:
(1) The emergency storage is the greater of the higher and lower zone emergency storage requirements.

**Sub-Alternative 1A – All Emergency Storage in Zones 1 and 2**

Sub-alternative 1A assumed the existing Skyline tanks would be replaced with a new 4.0 MG tank and the La Prenda tank would be replaced with a new 1.3 MG tank. Approximately 9,400 ft of 12-inch diameter transmission main along Vallejo Drive and Hillcrest Boulevard would provide emergency supplies to all zones as shown on **Figure 5**. The connection to Zone 4 was proposed at the intersection of Hillcrest Boulevard and Palm Avenue.

**Sub-Alternative 1B – All Emergency Storage in Zone 1**

To simplify operations and reduce capital costs, a second sub-alternative was developed to combine all storage at Skyline site. Approximately 7,000 ft of 12-inch diameter transmission main along Vallejo Drive, Madera Way and Murchison Drive were proposed to provide emergency supplies to all zones as shown on **Figure 6**. The connection to Zone 4 was proposed at the intersection of Millbrae Avenue and Palm Avenue.

## 4.2 Alternative 2 – All Emergency Storage in Zone 4

This alternative assumed that the emergency storage for both higher zones and Zone 4 were all located in Zone 4. For the purpose of this alternative analysis, it was assumed that the emergency storage would be located on Bayside Manor Park just south of State Highway 101 as shown on **Figure 7**. The tank was sized based on the emergency storage need of Zone 4 or approximately 3.4 MG. This alternative assumed Skyline tanks would be replaced with a new 1.5 MG tank, the La Prenda tank would be replaced with a new 0.5 MG tank and the Vallejo tank would be eliminated. As shown in Table 4, the combined operational and fire storage needs of Group 2 (Zones 2V and 2L) was estimated at about 0.47 MG. Therefore, a 0.5 MG replacement at La Prenda would suffice.

Connection to higher zones was made through 7,000 ft of 12-inch diameter transmission main along Richmond Drive and a 300 horsepower (hp) pump station located adjacent to the tank. Easements in the commercial area along El Camino Real may have to be obtained to connect the transmission main in Richmond Drive to the storage tank in Bayside Manor Park.

## 4.3 Alternative 3 – Independent Emergency Storage without Higher and Lower Zones Connectivity

This alternative assumed that higher zones and Zone 4 would each hold their own emergency storage and that Zone 4 would not be connected to the higher zones. The total storage requirements under this alternative are summarized in **Table 6**. As shown, the total storage need in the higher zones and Zone 4 is about 4.5 MG and 3.4 MG, respectively. Similar to Alternative 2, it was assumed Skyline and La Prenda tanks would be replaced with new 4.0 and 0.5 MG tanks, respectively, and that Vallejo tank would be eliminated. The new 3.4 MG tank in Zone 4 was tentatively proposed on Bayside Manor Park as shown on **Figure 8**.

Approximately 4,000 ft of 12-inch diameter transmission main and a 200 hp pump station located on the new Zone 4 tank site were proposed to connect the new storage tank to the existing 12-inch diameter main on Broadway Street. Easements in the commercial area along El Camino Real may have to be obtained for the new 12-inch diameter transmission.

**Table 6 Alternative 3 Storage Requirements**
Water Master Plan
City of Millbrae

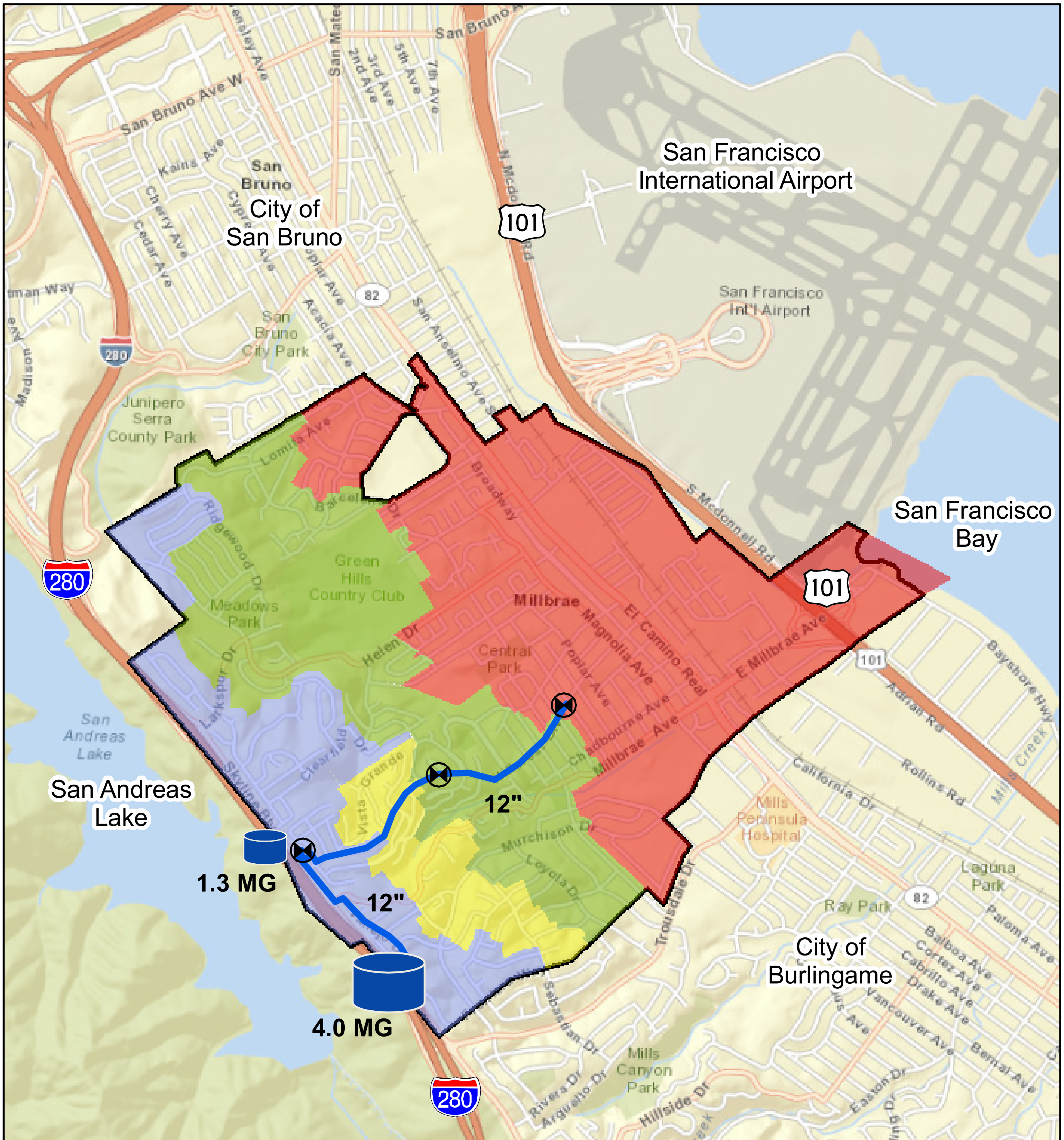
| | Volume (MG) |
|---|---|
| **Zones 1, 2 and 3** | |
| Emergency | 2.57 |
| Operational(1) | 1.34 |
| Fire(1) | 0.60 |
| **Total Storage in Zones 1, 2 and 3** | **4.51** |
| **Zone 4** | |
| Emergency | 3.36 |
| Operational(1) | 0 |
| Fire(1) | 0 |
| **Total Storage Zone 4** | **3.36** |

Note:
(1) The fire and operational demands of zones 3 and 4 are primarily supplied from Hetch Hetchy aqueduct or Harry Tracy WTP.

## 4.4 Alternative 4 – Reduced Storage with Higher and Lowe Zones Connectivity

Similar to Alternatives 1 and 2, this alternative assumed higher zones would be connected to Zone 4. Therefore, the total system storage requirement would be about 3.4 MG (the greater of storage needs of higher zones and Zone 4). Unlike Alternatives 1 and 2 where all emergency storage were either in the higher zones or in Zone 4, the emergency storage under Alternative 4 would be split between the two systems. The total storage requirement under Alternative 4 is about 5.3 MG similar to Alternatives 1 and 2, as shown in Table 5. It was assumed existing Skyline tanks would be replaced with a new 4.0 MG tank and the La Prenda tank would be replaced with a new 0.5 MG tank. In addition, a new 0.8 MG tank would be located in Zone 4 as shown on **Figure 9**.

Approximately 4,000 ft of 8-inch diameter transmission main and a 50 hp pump station located on the new storage site in Zone 4 were proposed to connect the new storage tank to the existing 12-inch diameter main on Broadway Street. Easements in the commercial area along El Camino Real may have to be obtained for the new 12-inch diameter transmission. Moreover, approximately 7,000 ft of 12-inch diameter transmission main along Vallejo Drive, Madera Way and Murchison Drive would provide emergency supplies to all zones as shown on Figure 9. The proposed transmission main would be connected to Zone 4 at the intersection of Millbrae Avenue and Palm Ave.




**Legend**

- New Pipe
- New Tank
- New PS
- New PRV

Pressure Zone Groups

- Group 1
- Group 2
- Group 3
- Group 4
- City Boundary

N

0 0.5 1 Miles

**Figure 5**
**Emergency Improvements**
**Alternative 1A**

City of Millbrae
Water Master Plan

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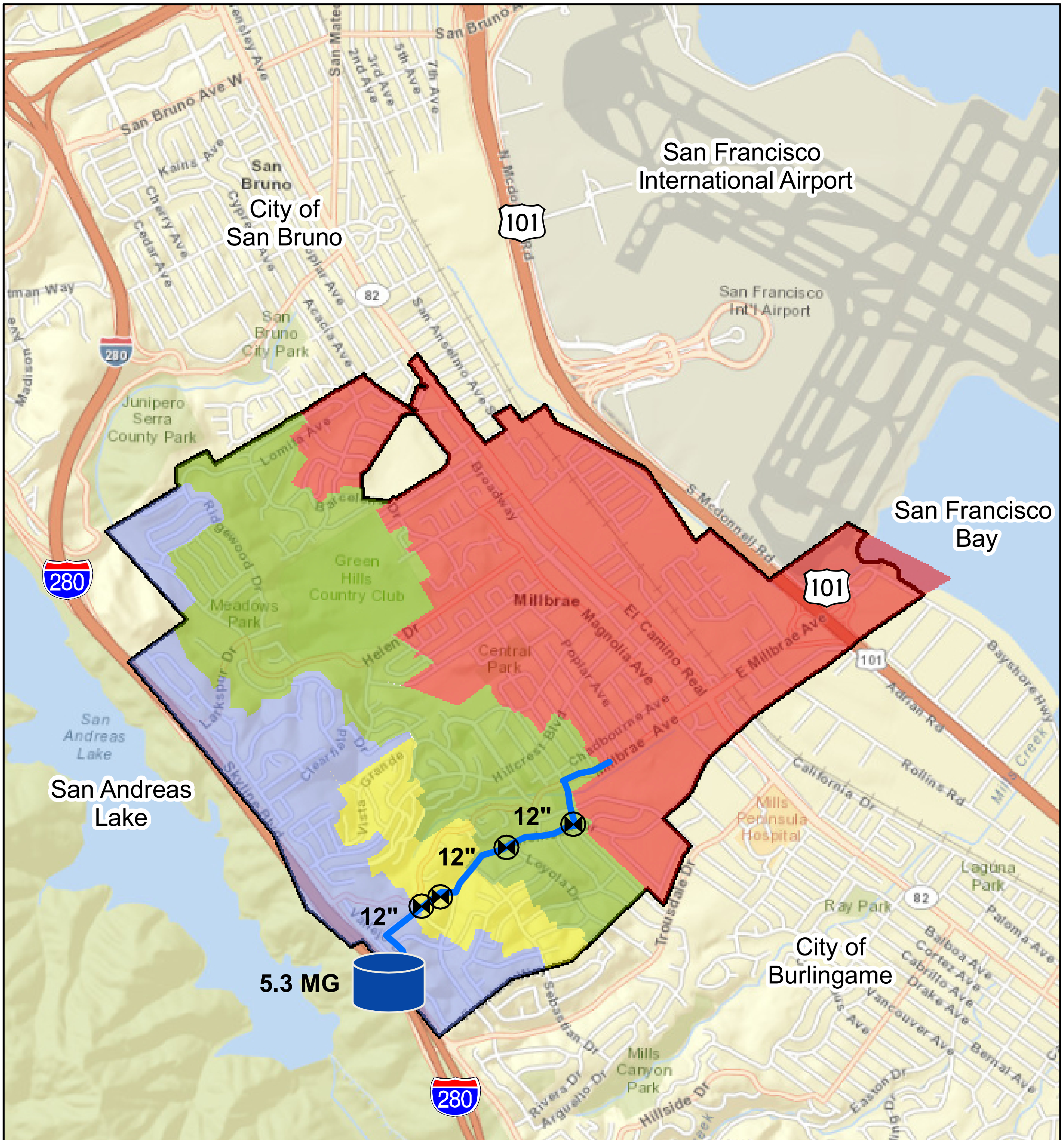


## Legend

- New Pipe
- New Tank
- New PS
- New PRV

Pressure Zone Groups

- Group 1
- Group 2
- Group 3
- Group 4
- City Boundary

0 0.5 1 Miles

# Figure 6
# Emergency Improvements Alternative 1B

City of Millbrae
Water Master Plan

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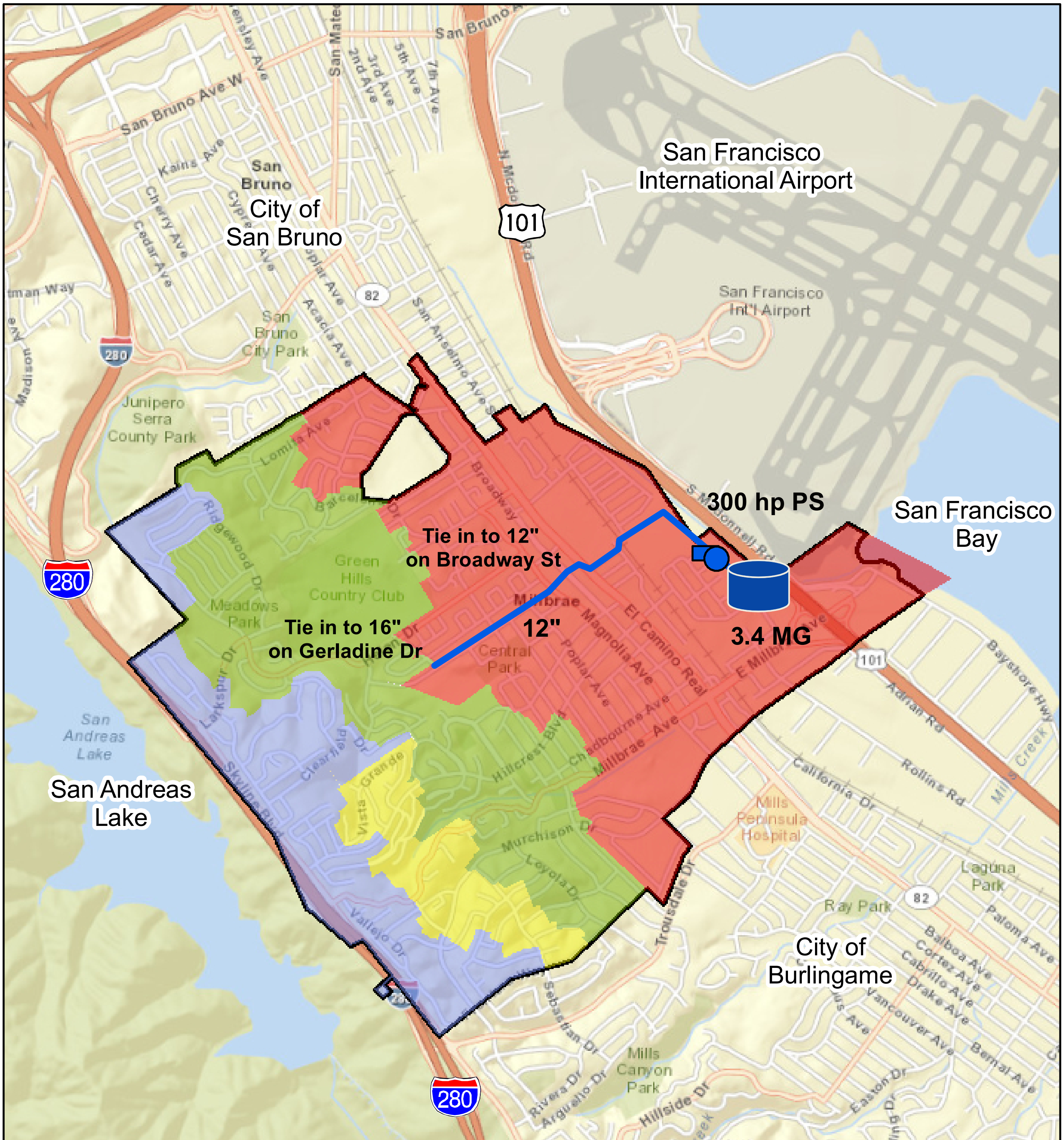


## Legend

- New Pipe
- New Tank
- New PS
- New PRV

Pressure Zone Groups

- Group 1
- Group 2
- Group 3
- Group 4
- City Boundary

0 0.5 1 Miles

**Figure 7**
**Emergency Improvements**
**Alternative 2**

City of Millbrae
Water Master Plan

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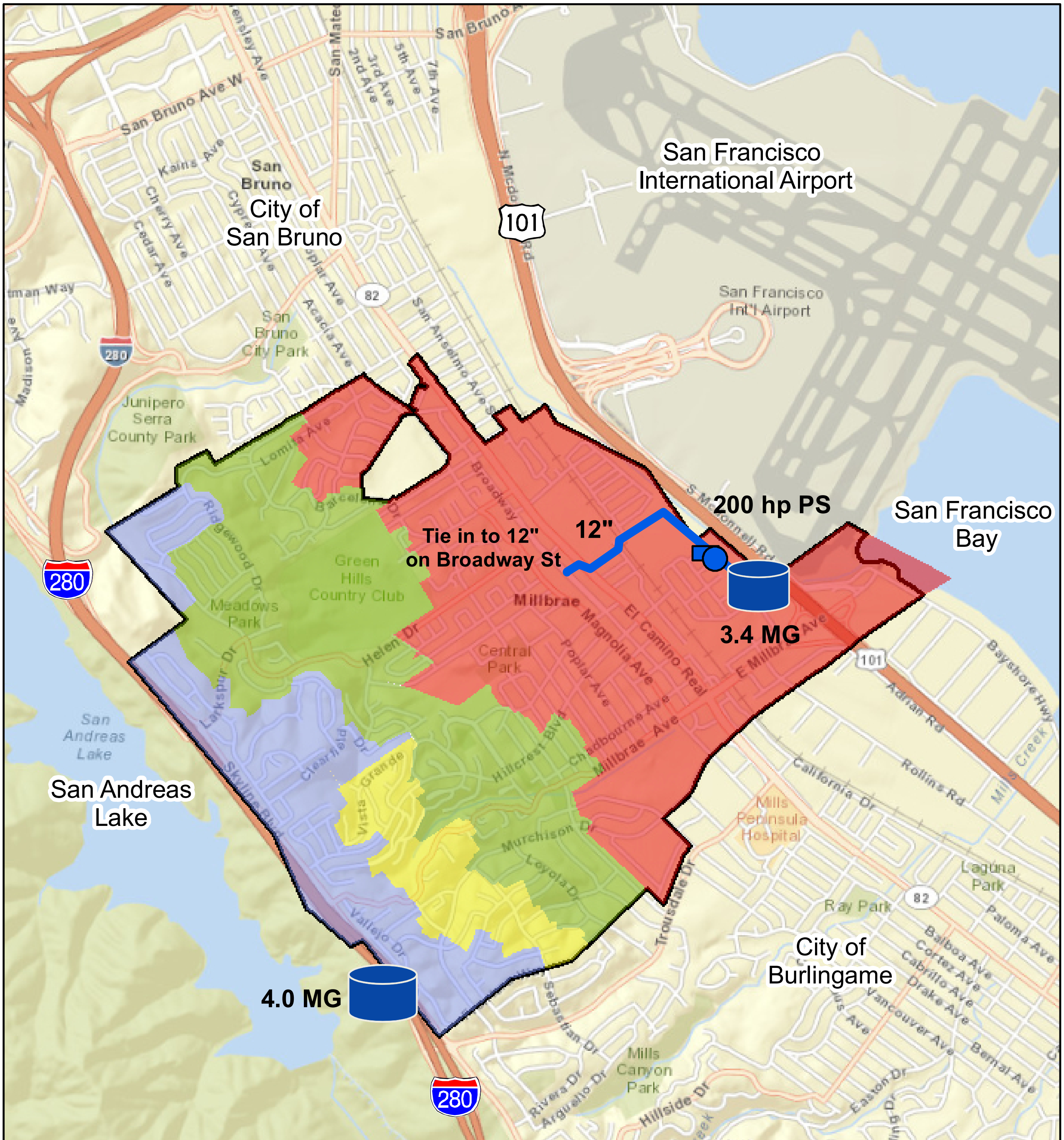


## Legend

- New Pipe
- New Tank
- New PS
- New PRV

Pressure Zone Groups

- Group 1
- Group 2
- Group 3
- Group 4
- City Boundary

N

0 0.5 1 Miles

**Figure 8**
**Emergency Improvements**
**Alternative 3**

City of Millbrae
Water Master Plan

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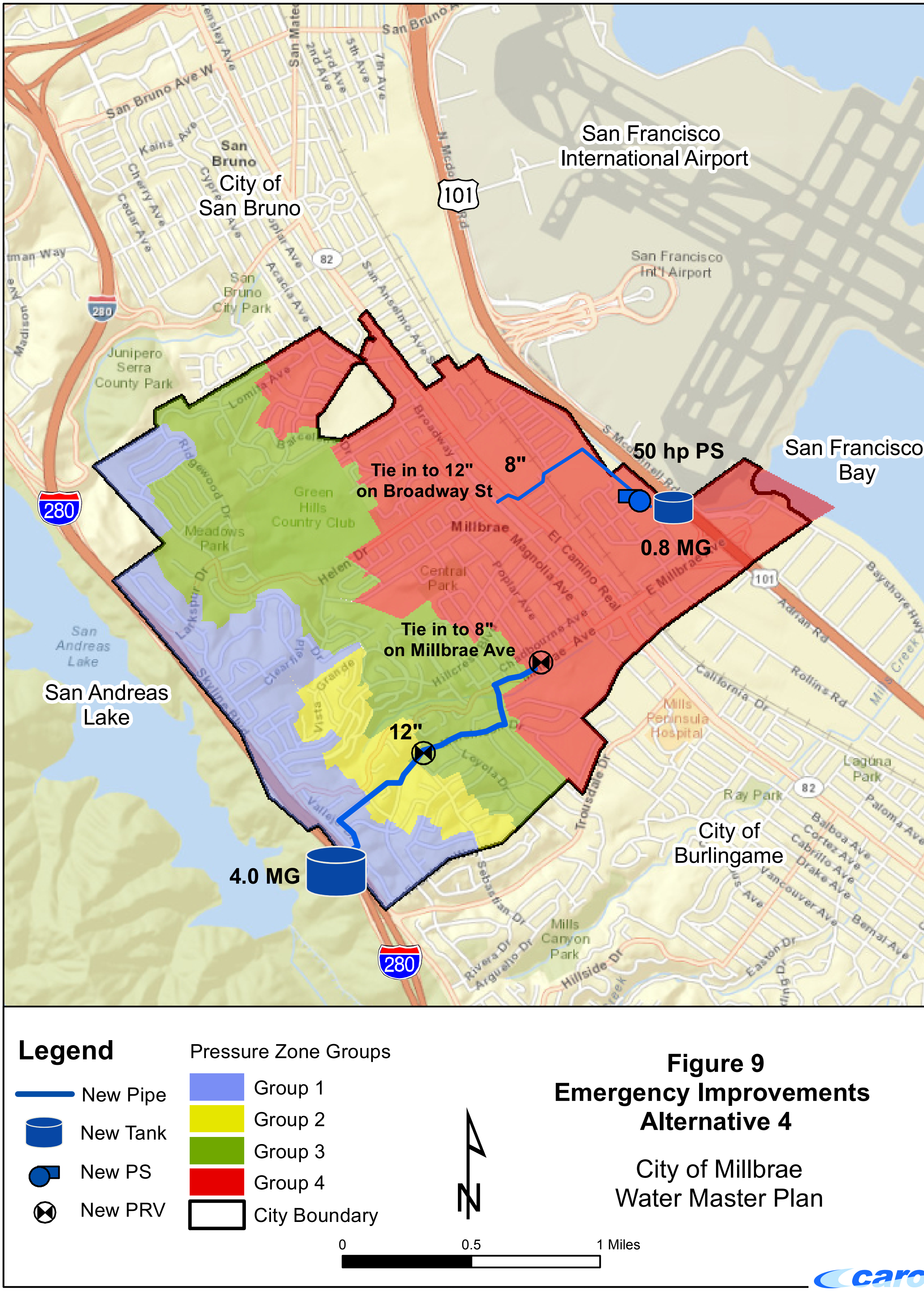


**Figure 9**
**Emergency Improvements**
**Alternative 4**

City of Millbrae
Water Master Plan

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## 4.5 Alternative 5 – Higher and Lowe Zones Connectivity without Emergency Storage

This alternative assumed that no emergency storage was required anywhere in the system. To supply Zone 4 during an outage of Hetch Hetchy aqueduct, approximately 2,500 ft of 12-inch diameter transmission main was proposed to connect the Helen turnout to the existing 10-inch diameter pipeline on Helen Drive near the Helen tank, as shown on **Figure 10**. A PRV station at the tie-in point was proposed to regulate pressures to levels suitable for Zone 4. To supply higher zones during an outage of Harry Tracy WTP, approximately 6,000 ft of 12-inch diameter transmission main along El Camino Real and Richmond Drive would be required. Easements in the commercial area between El Camino Real and Richmond Drive may have to be obtained under this alternative. In addition, a 100 hp pump station near Victoria turnout was proposed. The existing tanks in Zones 1 and 2 would all be replaced with the same size tanks with the exception of Vallejo tank, which would be eliminated.

It should be noted that this alternative requires no emergency storage as infinite amount of imported water could be supplied during an outage of either (but not both) supply source.

## 4.6 Alternative 6 – Zone 4 Gravity Emergency Storage with Higher and Low Zones Connectivity

This alternative assumed that two emergency tanks would be constructed along the greenbelt slopes to provide 3.4 MG of emergency supply to Zone 4. As shown on **Figure 11**, a 2.2 MG tank was proposed along Richmond Drive just south of Berkshire Drive (hereinafter referred to as Richmond Tank) and a 1.2 MG tank was proposed near the corner of Murchison Drive and Castenada Drive (hereinafter referred to as Murchison Tank). Having more than one tank would avoid triggering significant pipeline improvements that would otherwise be required to minimize head loss and provide adequate service pressures.

Both tanks would be 30 ft high and would have bottom elevations of about 230 ft above mean see level (msl) with a corresponding hydraulic grade lien (HGL) of 260 ft msl to provide adequate service pressures. The facilities required to connect the tanks to Zones 3 and 4 are described below.

**Proposed Facilities in Zone 4**

About 150 ft of 12-inch diameter pipeline would be required to connect Richmond Tank to the west end of the existing 8-inch diameter distribution main on Richmond Drive. It was proposed to parallel the 8-inch diameter main with approximately 550 ft of 12-inch diameter pipeline running along Richmond Drive from the end of existing main to the intersection of Richmond Drive and Geraldine Drive. These pipelines were sized to fill/drain the proposed Richmond Tank from/to Zone 4. In addition, approximately 900 ft of 12-inch diameter pipeline was proposed from the intersection of Richmond Drive and Geraldine Drive along Geraldine Drive to connect to the currently abandoned 10-inch diameter pipeline on Helen Drive.

About 1,100 ft of 12-inch diameter pipeline would be required to connect Murchison tank to the intersection of Murchison Drive and Hawthorne Way. The majority of this pipeline would parallel the existing 8-inch diameter main on Murchison Drive. In addition, approximately 2,300 ft of 8-inch diameter main along Murchison Drive was proposed to parallel the existing 8-inch diameter main from the intersection of Murchison Drive and Hawthorne Way to the Murchison turnout.

Because Hetch Hetchy's estimated HGL (approx. 280 to 300 ft above msl) would be higher than the tanks high water level elevations (approx. 260 ft above msl), a PRV station at each of Zone 4 turnouts would be necessary to avoid tanks overflow.

**<u>Proposed Facilities in Zone 3</u>**

Approximately 750 ft of 12-inch diameter main, a PRV station and a 50 hp pump station were proposed to connect Richmond Tank to Zone 3. The pump station would be used to pump from Zone 4 to Zone 3 during Harry Tracy WTP outage and the PRV station would be used to fill the tank from Zone 3 during Hetch Hetchy aqueduct outage. The PRV and pump stations were assumed to be located on Taylor Middle School property just south of Richmond Tank. The new pipeline would connect the tank to the new PRV/pump stations and tie in to the existing 16-inch diameter transmission main along Geraldine Drive in Zone 3.

The facilities to connect Murchison tank to Zone 3 would include a PRV station and a 50 hp pump station located near the existing Murchison PRV. Minor piping would also be required.

## 5.0 SUMMARY OF COSTS

A summary of planning level construction and capital cost estimates are shown in **Table 7**. The costs are organized by alternatives and facility types. A total mark up of 62.5 percent is applied to construction costs to account for construction contingency (30 percent), engineering (10 percent), construction management (10 percent), and environmental and legal (5 percent) costs. As shown, Alternative 5 with an estimated capital cost of about $9 millions is the least costly alternative.

These estimates reflect Carollo's professional opinion of costs at this time and are subject to change as the project details are defined. Carollo has no control over variances in the cost of labor, materials, equipment, services provided by others, contractor's methods of determining prices, competitive bidding, or market conditions, practices, or bidding strategies. Carollo cannot, and does not, warrant or guarantee that proposals, bids, or actual construction costs will not vary for the costs presented as shown.

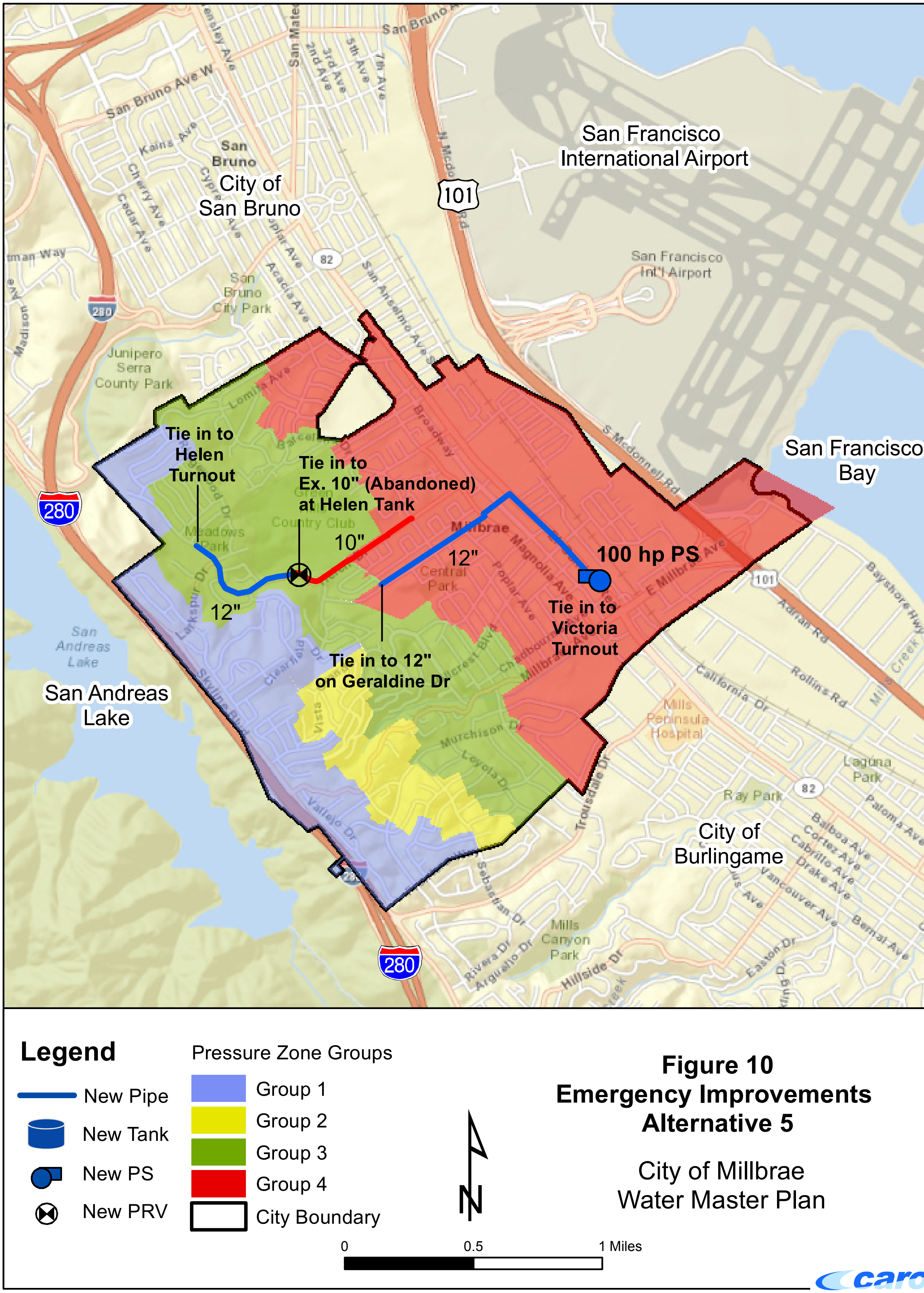


**Figure 10**
**Emergency Improvements**
**Alternative 5**

City of Millbrae
Water Master Plan

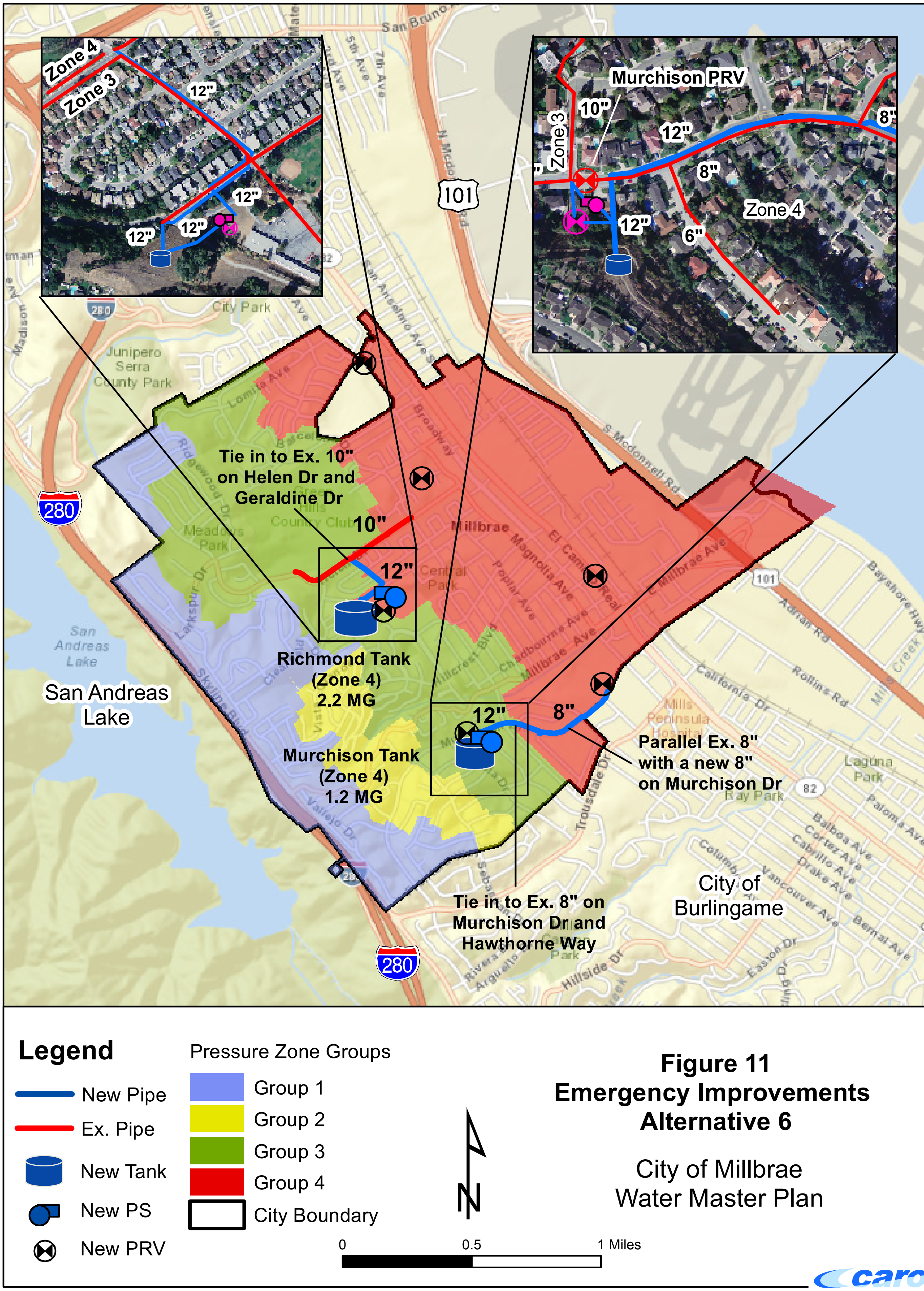


**Figure 11**
**Emergency Improvements**
**Alternative 6**

City of Millbrae
Water Master Plan

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**Table 7 Summary of Construction and Capital Costs of Emergency Improvements Alternatives**
Water Master Plan
City of Millbrae

| Alternative | Storage Construction Cost | Pipeline Construction Cost | Pump Station Construction Cost | PRV Station Construction Cost | Total Construction Cost | Contingency and Markups | Total Capital Cost |
|---|---|---|---|---|---|---|---|
| **1A** | $5,860,000 | $1,980,000 | - | $150,000 | $7,890,000 | $4,940,000 | **$12,990,000** |
| **1B** | $4,680,000 | $1,470,000 | - | $200,000 | $6,300,000 | $3,940,000 | **$10,320,000** |
| **2** | $7,760,000 | $1,470,000 | $960,000 | - | $10,190,000 | $6,370,000 | **$16,560,000** |
| **3** | $9,560,000 | $840,000 | $760,000 | - | $11,160,000 | $6,980,000 | **$18,140,000** |
| **4** | $6,950,000 | $2,110,000 | $190,000 | $100,000 | $9,350,000 | $5,850,000 | **$15,200,000** |
| **5** | $3,320,000 | $1,790,000 | $380,000 | $50,000 | $ 5,540,000 | $3,470,000 | **$9,010,000** |
| **6** | $5,810,000 | $1,110,000 | $380,000 | $300,000 | $7,600,000 | $4,750,000 | **$12,350,000** |

# 6.0 EVALUATION CRITERIA AND ALTERNATIVES RANKING

To provide a common basis for comparison of various alternatives, three major evaluation criteria were defined to reflect the City's goals and objectives:

- Affordability
- Supply availability and reliability
- Implementation potential and constructability

Within each objective, two or more 'performance measures' were defined to characterize the effectiveness of each alternative in meeting that objective. These performance measure and their relative overall weights (importance) are shown in **Table 8**.

**Table 9** compares pros and cons of various alternatives, which are then used to score various performance measures. Each performance measure was scored on a scale of 1 to 5, with 5 being 'excellent' and 1 being 'poor'. The basis of scoring is presented in Table 8.

The major evaluation criteria, performance measures, and basis of scoring are briefly discussed below. Once all performance measures were individually scored, the weighted average score for each alternative was calculated using the assumed relative weights.

## 6.1 Affordability

The affordability objective states that the recommended alternative should have minimal life cycle costs and be affordable. Two performance measures were defined to measure affordability: capital cost and operational and maintenance (O&M) cost, each with a relative weight of 25 percent. The estimated capital costs presented in Table 7 were scored using criteria shown in Table 8. The O&M costs were qualitatively ranked with respect to pumping costs to turn the storage over as shown in Table 8 and Table 9.

## 6.2 Supply Availability/Reliability

The reliability objective states that the recommended alternative should seek to maximize the available supply during the outage of either supply source but not both at the same time. Two performance measures were defined for this objective: the amount of total available supply when Hetch Hetchy aqueduct is offline and the amount of total available supply when Harry Tracy WTP is offline, each with a relative weight of 15 percent.

Total available supply during emergencies was measured in terms of number of days the system could be supplied assuming the demands during the emergency period declined to MinDD conditions. The basis for scoring each performance measure and the comparison of various alternatives with respect to these performance measures are presented in Table 8 and Table 9, respectively.

### 6.3 Implementation Potential and Constructability

The constructability objective states that the recommended alternative must result in the least amount of implementation challenges. The major potential implementation challenges were identified to be disturbances resulting from 1) pipeline construction; 2) implementation issues associated with upsizing Skyline tanks (e.g., coordination with SFPUC, permit approval, space constraint, etc); and 3) the need to purchase land for new storage tanks. The weighting for implementation potential and constructability is 20 percent.

Three performance measures were defined to measure these three challenges and the total relative weight of 20 percent was split between the three measures. The three performance measures include:

(1) Total new pipeline length (4 percent).

(2) Does the alternative require the Skyline tanks to be upsized ( 8 percent), and

(3) will land purchase or acquisition  be required (8 percent).

The basis for scoring each performance measure and the comparison of various alternatives with respect to these measures are presented in **Table 8** and **Table 9**, respectively.

## 7.0 RECOMMENDED ALTERNATIVE AND PHASING

As shown in Table 9, Alternative 5 with a weighted average score of 4.6 out of 5 was the alternative with the highest score. This is because Alternative 5 does not require building additional storage, which results in least capital and O&M costs. It also provides the highest degree of reliability by providing unlimited supply to the disrupted zone(s), under the assumption that both aqueducts are not out of service at the same time. In addition, this alternative makes use of the unused 10-inch diameter pipeline on Helen Drive for conveyance to Zone 4 from the Helen turnout, as shown on Figure 10.

Because Zone 4 has no storage or receiving intertie with neighboring cities, this zone is more vulnerable to a supply outage condition than the upper pressure zones. Therefore, connecting Helen turnout to the existing 10-inch diameter pipeline on Helen Drive has been assigned the highest priority, and is recommended to be completed earlier than the connection of the Hetch Hetchy aqueduct to Zone 3. The phasing of these emergency improvement projects will be refined in the WMP's Capital Improvement Plan (CIP) that will also include other system improvements such as storage optimization and fire flow improvements.).

**Table 8 Evaluation Criteria and Basis for Scoring**
Water Master Plan
City of Millbrae

| Objective | Cost | | Supply Availability/Reliability | | Implementation Potential | | |
|---|---|---|---|---|---|---|---|
| **Performance Measure** | **Capital Cost** | **O&M Cost** | **Supply Availability during HH Aqueduct Outage** | **Supply Availability during HT WTP Outage** | **Length of Pipeline** | **Skyline Upgrade** | **Land Acquisition** |
| **Relative Weights** | **25%** | **25%** | **15%** | **15%** | **4%** | **8%** | **8%** |
| Score of 1 | >$25M | Very High | None | | >10,000 ft | Required | Very High |
| Score of 2 | $20.1-$25M | High | < 3 days | | 7,501-10,000 ft | NA | High |
| Score of 3 | $15.1-$20M | Moderate | 3-4 days | | 5,001-7,500 ft | NA | Moderate |
| Score of 4 | $10.1-$15M | Low | >4 days | | 2,501-5,000 ft | NA | Low |
| Score of 5 | $0-$10M | Very Low | Unlimited | | 0-2,500 ft | Not required | Very Low |

**Table 9 Qualitative Comparison of Emergency Improvements Alternatives**
Water Master Plan
City of Millbrae

| Alternative | Pros | Cons |
|---|---|---|
| **1A** | • Provides continuous supply from upper zones to Zone 4 during Hetch Hetchy aqueduct outage.<br>• Relatively low capital cost. | • Upsizing Skyline tanks requires coordination with SFPUC and permit approval. Availability of adequate space at the site is not currently defined.<br>• Provides limited supply to upper zones during Harry Tracy WTP outage (no pumping ability from Zone 4 to upper zones). |
| **1B** | • Simplifies operations by eliminating La Prenda tank.<br>• Provides continuous supply from upper zones to Zone 4 during Hetch Hetchy aqueduct outage.<br>• Relatively low capital cost. | • Upsizing Skyline tanks requires coordination with SFPUC and permit approval. Availability of adequate space at the site is not currently defined.<br>• Provides limited supply to upper zones during Harry Tracy WTP outage (no pumping ability from Zone 4 to upper zones). |
| **2** | • Provides continuous supply from Zone 4 to upper zones during Harry Tracy WTP outage. | • Land availability in Zone 4 is limited.<br>• Provides limited supply to Zone 4 during Hetch Hetchy outage (no connection from upper zones to Zone 4).<br>• Requires tank turnover to mitigate water quality degradation, which may result in reduced storage availability when emergency occurs.<br>• Relatively high operational cost.<br>• Easement for pipeline construction may be needed. |
| **3** | • During an unlikely event when both supply sources are disrupted, all zones can be supplied for 3 days. | • Upsizing Skyline tanks requires coordination with SFPUC and permit approval. Availability of adequate space at the site is not currently defined.<br>• Land availability in Zone 4 is limited.<br>• Provides limited supply under all emergency conditions.<br>• Requires tank turnover to mitigate water quality degradation, which may result in reduced storage availability when emergency occurs.<br>• Relatively high operational cost.<br>• Easement for pipeline construction may be needed. |

**Table 9 Qualitative Comparison of Emergency Improvements Alternatives**
Water Master Plan
City of Millbrae

| Alternative | Pros | Cons |
|---|---|---|
| **4** | • Provides continuous supply from upper zones to Zone 4 during Hetch Hetchy aqueduct outage. | • Upsizing Skyline tanks requires coordination with SFPUC and permit approval. Availability of adequate space at the site may also be a potential implementation hurdle.<br>• Land availability in Zone 4 is limited.<br>• Provides limited supply to upper zones during Harry Tracy WTP outage (no pumping ability from Zone 4 to upper zones).<br>• Requires tank turnover to mitigate water quality degradation, which may result in reduced storage availability when emergency occurs.<br>• Relatively very high operational cost.<br>• Easement for pipeline construction may be needed. |
| **5** | • No emergency storage is required and water aging is minimal.<br>• Results in the lowest capital and O&M costs.<br>• Provides continuous supply to all zones when either supply is disrupted (not both).<br>• Make use of the currently unused 10-inch diameter pipe on Helen Drive. | • Depends on supply flow and head availability from the opertional aqueduct during an emergency.<br>• |
| **6** | • Significantly reduces pressure fluctuations in Zone 4 during both operational and emergency conditions.<br>• Relatively low capital cost.<br>• Provides continuous supply to all zones when either supply is disrupted (not both).<br>• Make use of the currently unused 10-inch diameter pipe on Helen Drive. | • Land availability in Zone 4 is limited.<br>• Land acquisition for new storage tanks requires coordination with SFPUC and permit approval.<br>• Provides limited supply to upper zones during Harry Tracy WTP outage (unless PRVs at Zone 4 turnouts are disabled).<br>• Requires tank turnover to mitigate water quality degradation, which may result in reduced storage availability when emergency occurs.<br>• Relatively very high operational cost. |

**Table 10 Scoring of Emergency Improvements Alternatives**[1]
Water Master Plan
City of Millbrae

| Objective | Cost | | Supply Availability/Reliability | | Implementation Potential | | | |
|---|---|---|---|---|---|---|---|---|
| **Performance Measure** | **Capital Cost** | **O&M Cost** | **Supply Availability during HH Aqueduct Outage** | **Supply Availability during HT WTP Outage** | **Length of Pipeline** | **Skyline Upgrade** | **Land Acquisition** | **Total Relative Score** |
| **Relative Weights** | **25%** | **25%** | **15%** | **15%** | **4%** | **8%** | **8%** | **100%** |
| **1A** | 4 | 3 | 5 | 3 | 2 | 1 | 5 | **3.5** |
| **1B** | 4 | 3 | 5 | 3 | 3 | 1 | 5 | **3.6** |
| **2** | 3 | 2 | 3 | 5 | 3 | 5 | 1 | **3.1** |
| **3** | 3 | 2 | 3 | 3 | 4 | 1 | 1 | **2.5** |
| **4** | 3 | 1 | 5 | 3 | 1 | 1 | 3 | **2.6** |
| **5** | 5 | 4 | 5 | 5 | 2 | 5 | 5 | **4.6** |
| **6** | 4 | 1 | 5 | 5 | 3 | 5 | 1 | **3.4** |

Note:
(1) Alternatives are scored on the scale of 1 to 5.