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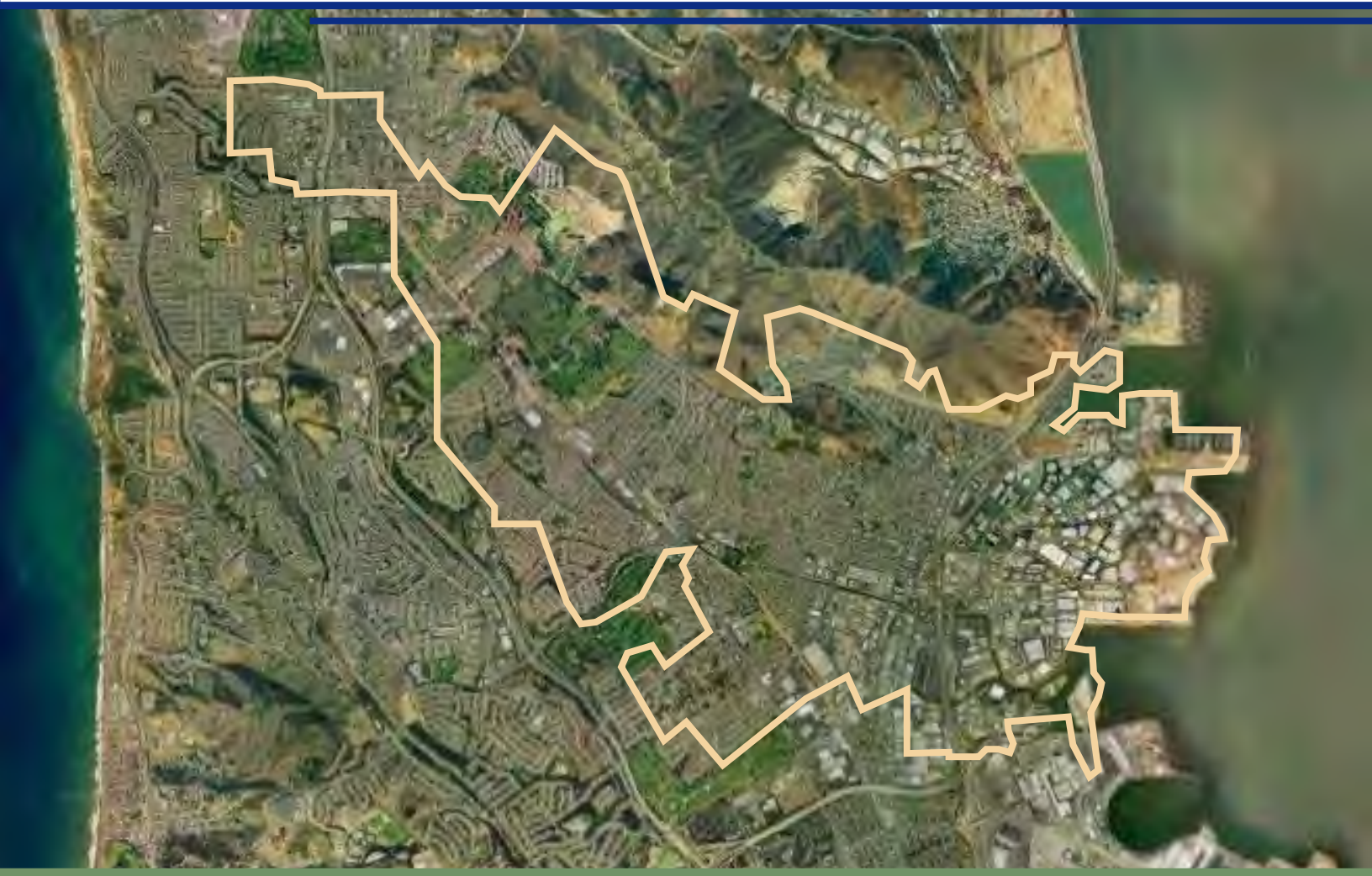

Water Supply and Facilities Master Plan for the South San Francisco System

California Water Service Company

June 2006

FINAL REPORT

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Executive Summary

Purpose of Master Plan

California Water Service Company (Cal Water) has provided water service to the South San Francisco area since 1931. The South San Francisco system serves the City of South San Francisco, the Town of Colma, a small area at the boundary of Daly City, and some unincorporated County of San Mateo lands including Broadmoor and the Colma BART station area.

The objective of this master plan for the South San Francisco system is to meet supply and reliability goals, and cost effectively and collaboratively optimize water supply and system reliability, in order to ensure safe and reliable, high quality water service for existing and future customers. The planning timeframe extends to 2030.

The master plan study integrated several elements, as shown in Figure ES-1, in formulating the plan recommendations.

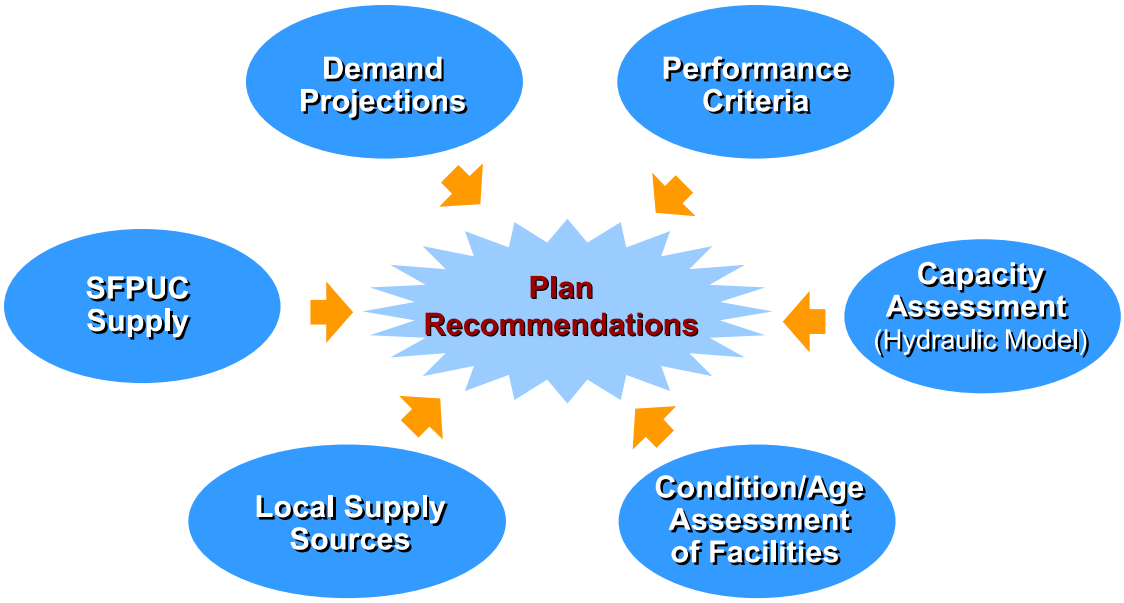


Figure ES-1
Master Plan Elements

Water Demands

Current average day water demand for the South San Francisco system is about 9 million gallons per day (mgd), with a maximum day demand of 13.5 mgd. At ultimate buildout, the projected average day demand is expected to reach 11 mgd, with a maximum day demand of 16.5 mgd.

The demand projections are based on land use and development projections obtained from local planning agencies including the City of South San Francisco, the Town of Colma, Daly City and San Mateo County.

Current Water System

The existing water system consists of 15 pressure zones, with the lowest and largest zone located adjacent to San Francisco Bay. The water system is supplied from San Francisco Public Utilities Commission (SFPUC) turnouts distributed throughout the system, and from a well field located near the center of the system. A transmission grid of larger diameter pipelines moves water through the system from the turnouts and wells. System facilities also include storage reservoirs and pump stations.

All pressure zones can be served from SFPUC turnouts. The well field is in the lowest pressure zone, and well supply can be provided to the zones served through that zone. Some zones are not served through the lowest zone and are now completely reliant on SFPUC supply.

Water Supply

Cal Water will pursue a supply strategy for the South San Francisco District that includes an array of supply components for flexibility and reliability. SFPUC surface water will continue to be the primary supply. In addition, other local supply sources will supplement SFPUC surface water supply.

Groundwater will continue to be a key local supply component, as it has been historically. In the early 1950's, Cal Water's annual pumping rate was as high as 2 mgd. Since 1980, Cal Water has pumped about 1.1 mgd on average, up to a maximum of about 1.4 mgd in any year. The strategy includes measures such as in-lieu recharge and recycled water to improve groundwater production, as well as other local water supply components, such as conservation and desalination.

The water supply components include:

- SFPUC Supply (surface water) will continue to be the primary supply. The recommended strategy assumes supply equal to the planned SFPUC purchase amount of 8 mgd, and provides for up to a 25% reduction in SFPUC surface supply to 6 mgd under emergency or drought conditions.
- Planned Long-Term Conservation Savings are permanent reductions in demand due to implementation of planned conservation measures as described in the Urban Water Management Plan. It is recommended that Cal Water continue with ongoing implementation, which may result in a maximum reduction in demand of up to about 1 mgd by Year 2030. This reduction is considered as a future local supply component to offset demand. However, actual future reductions (and potential supply amount) are subject to many uncertainties since they are contingent on actions of the general public that are beyond Cal Water's control.

Therefore, flexibility for alternate local supply is addressed in the plan, in the event the anticipated reductions cannot be fully achieved within the planned timeframe.

- Additional Temporary Emergency Demand Reductions during SFPUC Shortages assumes more stringent demand reduction measures could be implemented on a temporary basis during droughts or emergencies that reduce SFPUC supply. These temporary demand reduction measures are outlined in Water Shortage Contingency Plan that is part of the Urban Water Management Plan. The recommended strategy also addresses flexibility to provide alternate local supply in the event that the required temporary demand reductions during emergencies/droughts cannot be fully achieved when needed.

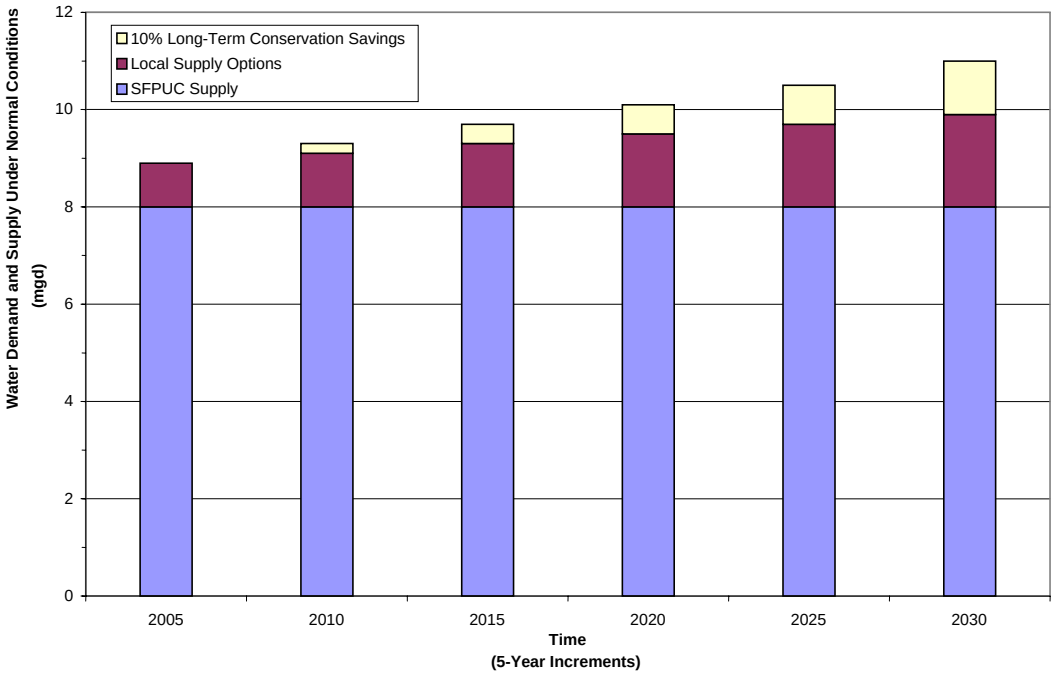
- Groundwater as a local supply component will continue as a key part of Cal Water's supply for the South San Francisco District, as it has been historically, as described further below. Cal Water will continue with ongoing efforts to participate in opportunities to improve groundwater supply, such as in-lieu recharge and recycled water.

- Groundwater Recharge (in-lieu conjunctive use or aquifer storage and recovery) will be necessary maintain groundwater basin levels and enhance supply reliability during droughts. In-lieu recharge may be accomplished individually in the South San Francisco service area, as part of a regional conjunctive use program with SFPUC, Daly City, and San Bruno, or through a combination of local and regional efforts. Aquifer storage and recovery is a longer-term measure that may be considered depending on the outcome of in-lieu conjunctive use efforts.

- Recycled Water supply involves longer-term measures that require regional implementation and participation by other agencies. Potential benefits include maintaining a sustainable groundwater basin by switching private groundwater pumping to use of recycled water, thereby allowing more natural groundwater recharge; and reducing the potable supply requirements by utilizing recycled water for uses (e.g., irrigation, industrial) now served by potable water.

- Desalination (Reverse Osmosis [RO] Treatment) of Bay Water is a longer-term measure that could be implemented in the future if determined to be cost-effective relative to the cost of other components. Implementing this component will require feasibility investigations and considerable lead-time.

Figure ES-2 illustrates the projected growth in demands over time to 2030 under normal demand conditions, and the supplies to meet these demands. As indicated on the figure, local supply will be needed to augment SFPUC surface supply of 8 mgd (year 2030 SFPUC purchase estimate).



(1) Local supplies would consist of conservation savings, groundwater accompanied by measures to improve groundwater basin sustainability, such as in-lieu recharge and recycled water use, and other potential supply such as desalination. The figure indicates the amount of local supply needed so that the year 2030 SFPUC purchase estimate of 8 mgd is not exceeded.

(2) SFPUC supply is at SFPUC's year 2030 purchase estimate. In the near-term until additional local supplies are developed, SFPUC surface supply may provide a larger amount of the total supply,

Figure ES-2
Water Demand and Supply Projections – Normal Conditions

Average annual groundwater use is anticipated to remain similar to historic, at or below 1.5 mgd; and be accompanied by Cal Water's participation in measures such as in-lieu recharge. Depending on the availability of surface water for in-lieu recharge and Cal Water's operating needs, the wells could be operated at lower rates when excess surface water is available to increase groundwater recharge and at higher rates at other times.

The recommended plan includes a service areawide groundwater monitoring program to monitor potential impacts of pumping on the groundwater basin. With implementation of the proposed measures for in-lieu recharge and/or recycled water (either alone or in combination), future pumping may increase over historic levels if it can be supported by the groundwater basin. In the meantime, the recommendations call for additional well capacity to provide short-term emergency supply in critical parts of the system to improve reliability, i.e., the additional well capacity would serve an emergency storage function for certain parts of the system.

Water System Analysis

An analysis of the water system was conducted to determine required improvements. The analysis used a computerized hydraulic model of the water system that was developed and calibrated as part of this study.

The analysis was based on performance criteria as prescribed by California Public Utilities Commission (CPUC) General Order 103 that specifies rules governing water service for private water companies. In addition, the performance criteria considered current American Water Works Association guidelines, current practices of similar water utilities, and engineering experience on similar projects.

Key findings from the analysis are summarized below:

- There is adequate SFPUC turnout capacity for buildout conditions. However, the part of the system that can be served from the lowest zone (Zone 200) has more supply reliability since it has access to groundwater supply as well as SFPUC supply. The part of the system not connected to the lowest zone can be served only by SFPUC supply or standby connections with adjacent communities (Zones 260, 285, 330, 360, 380, 415, 520).

- Pump station capacity is generally adequate for buildout conditions, except for one zone that requires a standby pump for reliability. However, replacement or major rehabilitation at some pump stations will be needed due to the age of the facilities, which are near the end of their useful life.

- Additional storage capacity will be required in some zones (i.e., Zones 200, 265, 330, 360, 380, 390), primarily to provide the required emergency storage and fire reserve. In addition, some tanks are near the end of their useful life and will require major rehabilitation or replacement. For some zones requiring additional emergency storage, well capacity with standby power is an alternative method of providing emergency storage, instead of building new tanks.

Plan Recommendations

The hydraulic capacity of the existing distribution system is adequate for buildout, so there are few capacity improvements needed. Many of the plan recommendations address improving the reliability of water supply to the service area, and the ability to move water from the lower zone to the northwesterly part of the system. The service area also contains many aging facilities that will need replacement over time.

Three timeframes were used to phase the recommendations:

- Near-term (2006 to 2010)
- Intermediate (2011 to 2015)
- Long-Term (2016 to 2030)

Within each timeframe, the projects are prioritized according to the following types of improvements (listed in highest to lowest priority):

- Enhancement of local supply sources to improve supply reliability in the event of short-term reductions in SFPUC surface supply during emergencies or critical droughts. This includes wells with backup power, treatment and other related facilities.
- Additional storage capacity to meet the performance criteria established for emergency storage and fire reserve. The emergency storage capacity would be met by a combination of additional well capacity and new tank storage.
- Additional pumping capacity to provide a standby pump for all zones.
- Long-term implementation of supply measures, such as recycled water and desalination, to improve groundwater production and enhance local supply reliability.
- Replacement of other aging facilities over time including small diameter (less than 6-inch) pipelines, pump stations, and reservoirs.

Table ES-1 summarizes the plan recommendations, as well as corresponding costs and timing. Figure ES-3 indicates the location of the recommended near-term facilities improvements (to 2015).

Table ES-1
Summary of Recommendations for South San Francisco System

Item	Description	Estimated Total Capital Cost June 2006 $)	Distribution of Capital Costs in June 2006 $ (per year for near-term and intermediate, per timeframe for long-term)										
			Near-Term					Intermediate					Long-Term
			2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016 - 2030
Distribution System Reliability (improve system reliability)													
Near-Term (2006-2010):													
Emergency Booster Pump Tie-ins for Northerly Area	Provide three emergency booster tie-ins to lift water from Zone 200 up to the following northerly zones are supplied solely from SFPUC turnouts: 260, 285, 330, 360 and 380. The only linkages between these zones are some PRVs or check valves from higher to lower zones in the cascade. These tie-ins will allow emergency booster pumps to lift water from the Zone 200 well field up to Zone 380 in the event of a loss of SFPUC supply. Each booster site could be sized to boost up to approximately 2000 gpm flow (about 3 mgd). The existing distribution system has adequate hydraulic capacity at the proposed locations (existing larger diameter transmission mains) to convey the recommended flow.	$240,000		$120,000	$120,000								
Station 1 GAC Treatment	Add granular activated carbon (GAC) treatment for trace organics at the Station 1 wellfield treatment facility.	$350,000	$350,000										
Emergency Storage for Zone 200 by means of additional well capacity instead of building new tanks	Construct up to 8 new wells (assuming average capacity of 150 gpm) in the vicinity of Station 1 with piping to connect them to the Station 1 treatment facility, in order to provide total firm capacity of 3 mgd at Station 1 well field with the existing and new wells, assuming one well out of service. Assumes 2 wells at Station 1 and 6 at new sites in vicinity of Station 1.	$9,450,000	$750,000	$1,050,000	$1,800,000	$2,650,000	$1,950,000	$1,250,000					
	Expand existing treatment facility at Station 1 from 1.6 to 3.2 mgd. Add another filter to provide 2,250 gpm (3.2 mgd) sustainable treatment capacity with allowance for backwashing (maximum instantaneous capacity of 2,500 gpm or 3.6 mgd). See Appendix I for detailed description of WTP improvements.	$1,500,000			$200,000	$650,000	$650,000						
	Telemetry and control system upgrades at Station 1: The booster pump station appears to have adequate firm pumping and electrical capacity for this initial expansion; and Station 1 pump station upgrade costs are included as a long-term measure. However, some telemetry and control improvements may be needed for the initial expansion to improve operational flexibility.	$350,000				$350,000							
Station 9 T1 (Reservoir 3) Upgrade	RES 3 (redwood tank) is seismically vulnerable and a high priority for replacement. Existing tank is 0.05 MG; storage capacity of 0.45 MG is required. Cost assumes replacement with a 0.5 MG tank.	$1,300,000			$100,000	$600,000	$600,000						
Pump Station 5 Upgrades	Pump C: Add Backup Pump and Replace Existing Pump. Add backup pump (40 HP) for Pump C supplying Zone 555. There is only one pump now supplying this zone. The other pumps at Station 5 serve other zones that have multiple feeds. Replace existing Pump C (40 HP) which is almost 40 years old as part of the station upgrade.	$200,000	$200,000										
	Pump A Replacement: When station upgrades are done, replace existing Pump A (20 HP) which is 50 years old, and was re-built in 2001. Cal Water to conduct efficiency test prior to replacement to confirm appropriate timing.	$70,000				$70,000							
Storage in Zone 265 for Emergency and Fire Reserve	Provide additional 1.0 MG storage at or in vicinity of RES 4 site. Due to the age of the existing small 0.25 MG tanks, cost assumes that the existing tanks are replaced with two new 0.75 MG tanks to both replace the existing tanks and provide the required additional storage (dual tanks will provide flexibility in operations to help maintain turnover and water quality). Other options that could be considered during predesign include building one tank instead of two, and/or keeping the existing tanks in service.	$3,600,000			$200,000	$1,700,000	$1,700,000						
Storage in 330 Zone for Emergency and Fire Reserve	Provide 3 MG storage at or in vicinity of RES 7 site. Due to the age of the existing tanks, cost assumes that the existing tanks are replaced with two new 1.5 MG tanks (dual tanks are costed to provide operational flexibility to manage turnover and water quality). During predesign, keeping one or more of the existing tanks in service could be considered. Since difference between existing and buildout requirement is very small, it is more cost effective to construct all the storage at once.	$6,800,000				$1,360,000	$2,720,000	$2,720,000					
	In addition, two emergency connections will feed water from surplus storage of 0.5 MG in Zone 430 through Zone 390 into Zone 330. The emergency interconnections should require minimal pipe improvements, since pipes of adequate hydraulic capacity are close to the potential zone connections. An estimated cost for up to 1,000 LF of 12-inch pipe is included for the two connections.	$220,000					$220,000						
Intermediate (2011-2015)													
New Well Field in Zone 380 for emergency supply in north part of system	Construct 6 new wells (assuming average capacity of 200 gpm) in a northerly area well field to provide up to 1.5 mgd supply capacity. These wells will provide emergency supply in the northerly area in the event of loss of SFPUC supply, and provide emergency storage rather than building a reservoir. Costs assume this northerly well field could be constructed, owned and operated by Cal Water. Another option for implementation would be to consider a joint agreement with SFPUC for this well field to be constructed by SFPUC as part of the SFPUC regional conjunctive use program. All would be at new sites.	$9,300,000						$1,860,000	$1,860,000	$1,860,000	$1,860,000	$1,860,000	
	Construct centralized 1.5 mgd treatment facility with clearwell and pump station for the northerly well field. Note: Another option that could be considered during predesign would be to construct a 1.5 MG tank and 2000 gpm pump station in Zone 380, instead of the well field and treatment facility. . This would provide one average day of emergency storage, but would not have the same multiple benefits for emergency/drought supply.	$7,500,000						$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	
Emergency Storage in Zone 360	Provide additional 0.5 MG storage at or in vicinity of RES 11 site. The cost assumes that the existing 1 MG tank is replaced with two new 0.75 MG tanks (due to age of facility when the project is implemented in the long-term). Other options to investigate during predesign include building a new 0.5 MG tank and keeping the existing 1 MG tank, or replacing the existing tank with one 1.5 MG tank.	$3,600,000						$720,000	$720,000	$720,000	$720,000	$720,000	
Long-Term (2016-2030)													
Emergency Storage for Zone 200 by means of additional well capacity to provide short-term emergency and critical drought supply	Increase well capacity in vicinity of Station 1 by an additional 2 mgd to a total of 5 mgd. Construct 9 new wells assuming average capacity of 150 gpm.	$11,925,000											$11,925,000
	Expand and upgrade existing treatment facility at Station 1 from 3 mgd to ultimate capacity of 5 mgd. Conduct pilot and predesign studies to determine if higher capacity could be achieved with higher filter loading rates; in addition, alternative process options could also be considered. Due to age of existing clearwell, cost assumes replacement of the existing 0.5 MG clearwell when the plant is upgraded. Note: The cost estimate is based on providing well capacity for emergency storage and emergency supply (multiple reliability benefits). Another option that could be considered during predesign studies to provide the emergency storage would be to construct new reservoirs. Both existing Zone 200 reservoirs (RES 1 and RES 2) are very old. If they were replaced with new larger tanks, it could provide the required additional storage. A total of 5 MG would be needed at the two sites to replace the existing 3 MG at the existing tanks and to provide the additional 2 MG. The appropriate split of storage would depend on the site constraints.	$7,500,000											$7,500,000
Station 1 Booster Pump Station	Replace the existing pumps and electrical/instrumentation to provide a total of 5 mgd firm pumping capacity (assuming there is 5 mgd of well capacity including the emergency storage for Zone 200).	$1,200,000											$1,200,000

Table ES-1
Summary of Recommendations for South San Francisco System

Item	Description	Estimated Total Capital Cost June 2006 $)	Distribution of Capital Costs in June 2006 $ (per year for near-term and intermediate, per timeframe for long-term)										
			Near-Term					Intermediate					Long-Term
			2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016 - 2030
Local Supply Measures (enhance supply capacity, improve supply reliability, maintain long-term groundwater basin sustainability)													
Water conservation measures													
Long term permanent conservation savings	Continue implementation of planned long-term conservation measures per Urban Water Management Plan. Evaluate implementation and effectiveness of planned conservation measures; modify as needed as part of Urban Water Management Plan update process.	Costs for these measures are not facility capital costs.	Conservation program implementation costs as determined in Urban Water Management Plan.					Conservation program implementation costs as determined in Urban Water Management Plan.					Conservation program implementation costs as determined in Urban Water Management Plan.
Temporary demand reductions	Implement temporary demand reductions during emergencies and droughts as outlined in Urban Water Management Plan (Water Shortage Contingency Plan), as needed to address temporary reductions in total supply.												
Groundwater monitoring	Design and implement a service area wide groundwater monitoring program to monitor impacts of potential in-lieu recharge program and groundwater pumping. Periodically evaluate data collected with respect to overall basin trends. Annual cost includes: developing and managing the program, installing monitoring wells, quarterly water levels (transducers), semi-annual water quality sampling and analysis, and semi-annual data analysis and reporting. Cost assumes 8 existing wells in network for first year (select Cal Water wells and private wells) gradually increasing to 18 wells by the 5th year.	Annual cost estimates for monitoring program are shown.	$150,000	$250,000	$250,000	$250,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	Assume continue at $150,000 per year. Re-assess long-term cost based on monitoring findings.
Groundwater recharge	*Near-Term:* Implement local in-lieu recharge within the service area, assuming an agreement can be reached to purchase in-lieu water at or less than the cost of SFPUC supply.	Annual costs for program-related studies.	$100,000	$100,000	$100,000	$100,000	$100,000	$150,000	$150,000	$150,000	$150,000	$150,000	Re-assess long-term costs in future master plan updates.
	Intermediate: Continue local in-lieu recharge within the service area. Re-evaluate status of regional in-lieu recharge program relative to Cal Water participation. Consider investigating potential benefits of surface percolation for aquifer storage and recovery, e.g., Colma Creek.												
	Long-Term: Continue local in-lieu recharge within the service area. Re-evaluate status of regional in-lieu recharge program relative to Cal Water participation. Evaluate potential for aquifer storage and recovery with injection/extraction wells.												
Regional recycled water program	*Near-Term:* Continue to participate in planning for future recycled water project(s) with South San Francisco, San Bruno, and SFPUC. Consider initiating a joint feasibility study with Daly City to investigate supplying recycled water to Colma cemeteries.	Annual costs included for near-term and intermediate program-related studies. Long-term cost range shown for regional recycled water project under consideration. Cal Water would share cost of regional project..	$100,000	$100,000	$100,000	$100,000	$100,000	$150,000	$150,000	$150,000	$150,000	$150,000	Total cost for regional recycled water project would range from $14,000,000 to $42,000,000 or more depending on level of implementation. Low end is limited implementation; high end is full implementation.
	Intermediate: Continue to participate in planning for future recycled water project(s) within service area: 1) With South San Francisco, San Bruno, and SFPUC; 2) With Daly City. Re-evaluate status and appropriate participation in recycled water projects based on new information that becomes available over time.												
	Long-Term: Determine appropriate participation in regional recycled water project if feasible project is identified. A range of capital costs is shown for the alternatives under consideration. Cal Water would share in these costs with other participants, with the cost share to be determined in future negotiations.												
Desalination	*Near-Term:* As part of regional supply planning for all three Peninsula Districts, scope and conduct a conceptual feasibility study to explore siting, technology, and potential partnering options.	Annual costs for program-related studies in near-term and intermediate timeframe. Long-term cost range shown for implementation of a 2 mgd RO project.	$100,000	$100,000	$100,000	$100,000	$100,000	$150,000	$150,000	$150,000	$150,000	$150,000	$12,000,000
	Intermediate: If feasible options are identified in the near-term feasibility study, evaluate implementing a pilot study as part of regional supply planning for all the Peninsula districts.												
	Long-Term: If confirmed by previous studies and if future conditions indicate it is cost competitive, an RO treatment facility of either 1 mgd or 2 mgd could be constructed in Zone 200 in lieu of some or all of the additional 2 mgd groundwater capacity. Capital costs are included for a 2 mgd facility assumed to be located near the Bay and adjacent to major transmission lines.												
Replacement/Rehabilitation Projects													
Reservoir Replacement	RES 101 replacement or major rehabilitation when hydropneumatic pump station is rehabilitated. Cost assumes replacement.	$750,000						$750,000					
Pump Station Replacement (listed in priority order)	Station 101 replacement of pumps, motors and hydropneumatic tank. A larger hydropneumatic tank should be considered to limit cycling time to 4 to 6 cycles per hour.	$500,000							$500,000				
	Pump Station 2 replacement of pump and motors, and associated electrical and telemetry upgrades. When upgraded, fewer and smaller pumps could be installed. Two pumps approximately equal in size to Pump 5-A (20 hp) would meet the performance criteria, in conjunction with Pump 5-A that also serves the same zone.	$300,000								$300,000			
	Pump Station 4 replacement of pumps and motors, and associated electrical and telemetry upgrades. When upgraded, fewer and smaller pumps could be installed. One pump would meet the performance criteria, in conjunction with Pump 5-B (30 hp) that also serves the same zone.	$250,000									$250,000		
Well Replacement	Major rehabilitation or replacement of the existing wells at Station 1. Cost assumes replacement of 7 wells at average 150 gpm each (no land cost since assumed to be replaced on existing site).	$5,250,000											$5,250,000
Pipeline Replacement	Cal Water has an ongoing program for pipeline replacement. Specific budget amounts for replacement are determined each year based on leak history and system needs. An estimated amount is shown assuming replacement of 1,900 LF per year of small diameter (less than 6-inch) pipe with 6-inch pipe (minimum diameter). This would replace all small diameter pipe over a 50-year period (assumes starting in 2006).	$5,225,000	$209,000	$209,000	$209,000	$209,000	$209,000	$209,000	$209,000	$209,000	$209,000	$209,000	$3,135,000
SCADA Replacement	Cal Water has an ongoing program for SCADA replacement.												
TOTALS			$1,959,000	$1,929,000	$3,179,000	$8,139,000	$8,499,000	$9,609,000	$5,389,000	$5,189,000	$5,139,000	$4,889,000	To be re-assessed in future master plan updates.

2005 - 2010

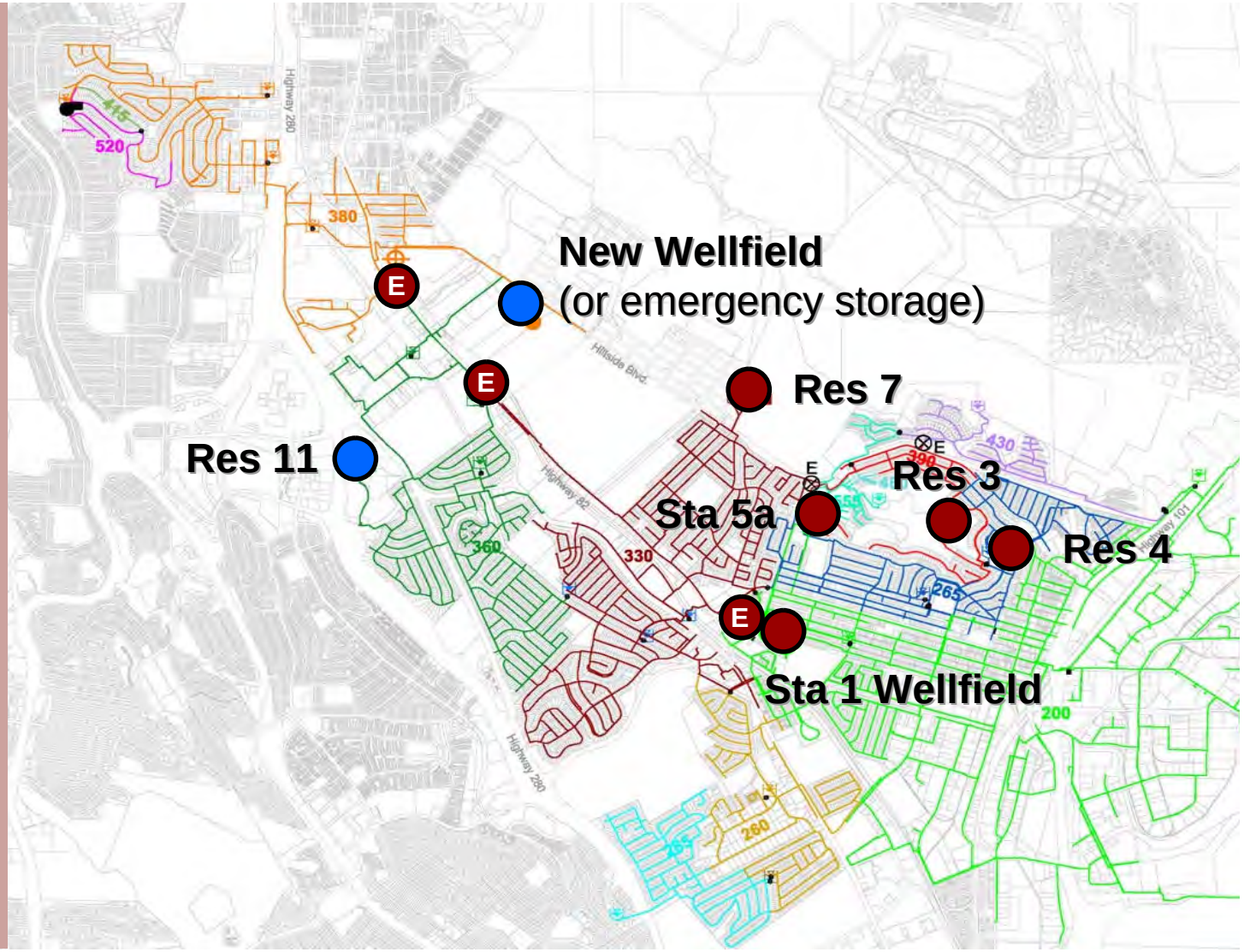
1. Emergency Boosters (E)
2. Station 1 Wells and Treatment = 3 mgd
3. Backup Pump for 5A
4. Storage Improvements

2011 - 2015

1. New Wellfield in 380 Zone with Treatment = 1.5 mgd (or emergency reservoir storage)
2. Emergency Storage in 360 Zone

Notes:

1. Locations of new facilities are conceptual only.
2. In Zone 380, potential conceptual well locations for a future wellfield were identified (Appendix E). Treatment is assumed to be required. Required emergency storage could be provided by a combination of wells and reservoir storage (with pump station).
3. In addition to new reservoirs for Zone 330, emergency interties (⊗E) will utilize surplus Zone 430 storage.



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CDM

Figure ES-3
Near-Term Facilities Recommendations

Section 1
Introduction

This section describes the purpose, organization and scope of the master plan; identifies acronyms and abbreviations used in the report; and lists acknowledgements.

1.1 Purpose of Master Plan

California Water Service Company (Cal Water) is the largest investor-owned water utility in the western United States serving over 1.7 million people in 75 communities, with 28 operating systems throughout California. Cal Water has provided water service to the South San Francisco area since 1931. The South San Francisco system serves the City of South San Francisco, the Town of Colma, a small area at the boundary of Daly City, and some unincorporated County of San Mateo lands including Broadmoor and the Colma BART station area.

Cal Water developed this master plan for its South San Francisco system to meet supply and reliability goals, and cost effectively and collaboratively optimize water supply and system reliability, in order to ensure safe and reliable, high quality water service for both existing and future customers. The planning timeframe for this study extends to 2030, consistent with the Bay Area Water Supply and Conservation Agency (BAWSCA) regional demand study.

1.2 Organization of Master Plan Report

The master plan report highlights the key findings for the master plan. Detailed technical information is provided in the appendices to the report.

Sections 1 through 5 of the master plan report describe the key study area and development characteristics, water demand projections, existing water system facilities, and performance objectives for the water system analysis. Appendix A provides sensitivity analyses of the service and demand projections. Appendix B describes the findings of the field visits conducted at existing facilities. Appendix C describes the evaluation of the existing telemetry system in South San Francisco.

Section 6 discusses the water supply requirements for the South San Francisco system including a comparison of demand and supply projections, and key issues affecting both the surface water and groundwater supplies. Appendix D describes the surface water reliability analysis. Appendices E and F provide detailed descriptions of the groundwater supply and groundwater quality evaluations, respectively.

Section 7 describes the water system evaluations conducted to determine required supply, pipeline, pumping, storage and pressure reducing valve capacities for existing and future demands. Appendix G provides a detailed description of the hydraulic model development, calibration and verification. Appendix H provides fire flow results for the South San Francisco system.

Section 8 describes the recommended water supply strategy for the South San Francisco system, and the supply components included in the strategy. Appendix I describes the evaluation of the existing Station 1 treatment facility and required improvements.

Finally, Section 9 presents an integrated plan of supply and system capacity recommendations to meet current and future water system needs, including estimated costs and phasing.

1.3 Scope of Services

Cal Water retained Camp Dresser & McKee Inc. (CDM) to prepare the Water Supply and Facilities Master Plan for the South San Francisco system. HydroFocus Inc., a subconsultant to CDM, conducted the groundwater investigations.

The scope of work included the following major elements:

- Prepare development and demand projections for the planning period for use in the supply and facilities evaluation.
- Develop alternative water supply sources to meet the recommended water demand projections over the planning period.
- Assess the condition and capacity of the existing system facilities and prepare a system inventory.
- Develop and calibrate a computerized hydraulic model of the distribution system to use planning and operational tool.
- Prepare overall water supply and facilities master plan recommendations for the system

1.4 Acronyms and Abbreviations

The following abbreviations and acronyms are used in this report.

AC	asbestos cement
AF/year	acre feet per year
ARC	American Red Cross
ASR	aquifer storage recovery
AWWA	American Water Works Association
BAWSCA	Bay Area Water Supply and Conservation Agency
Cal Water	California Water Service Company
CCP	concrete cylinder pipe
CDM	Camp Dresser & McKee Inc.
CI	cast iron

CIP	Capital Improvement Program, Cast Iron Pipe
DI	ductile iron
EBMUD	East Bay Municipal Utility District
EPA	Environmental Protection Agency
°F	degrees Fahrenheit
FEMA	Federal Emergency Management Agency
fps	feet per second
ft	foot
GIS	geographic information system
gpd	gallons per day
gpm	gallons per minute
HDPE	high density polyethylene
HGL	hydraulic gradeline
HP	horsepower
HTWTP	Harry Tracy Water Treatment Plant
in	inches
LF	linear feet
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
MG	million gallons
mg/l	milligrams per liter
mgd	million gallons per day
MPN	most probable number
NTU	nephelometric turbidity units
O&M	operation and maintenance
OES	Office of Emergency Services
PRV	pressure reducing valve
psi	pounds per square inch
PUC	California Public Utilities Commission
PVC	polyvinyl chloride
RO	reverse osmosis
SCADA	Supervisory Control And Data Acquisition
SFPUC	San Francisco Public Utilities Commission
SS	stainless steel
UV	ultraviolet
WSIP	Water Supply Improvements Program
WTP	water treatment plant

1.5 Acknowledgements

This report would not have been possible without the valuable assistance of Cal Water staff. In particular, the following staff provided comprehensive information, significant input and important insights throughout the master plan development:

- Jim Simunovich, Engineering Operations Manager
- Jeff Yarne, Project Manager
- Tyrone Robinson, Bayshore District Manager
- Tom Salzano, Water Resources Planning Supervisor
- Mark Johnson, Production Superintendent
- Mike Utz, Distribution Superintendent
- Bob Pagano, Operation & Maintenance Foreman

The CDM team included:

- Phillippe Daniel, Client Officer
- Lisa House, Project Manager
- Polly Boissevain, Project Engineer
- Youssif Hussein, Task Leader, Hydraulic Modeling
- Andria Loutsch, Planner

HydroFocus Inc. (John Fio), a subconsultant to CDM, conducted the groundwater investigations.

Section 2
Study Area

This section describes the study area location and characteristics, and future land uses and development within the study area.

2.1 Location and Characteristics

Figure 2-1 shows the study area for this master plan, which is Cal Water's South San Francisco service area. Cal Water's Bayshore District covers both the South San Francisco service area and the Mid-Peninsula service area. This master plan addresses only the South San Francisco service area.

The South San Francisco service area is located in northern San Mateo County approximately six miles south of the City of San Francisco. It serves the communities of South San Francisco, Colma, a small piece of Daly City, and all of the unincorporated area of San Mateo County known as Broadmoor that lies between Colma and Daly City. The service area encompasses about 10.5 square miles.

The South San Francisco service area is located on the Bay Plain and northern foothills of the Coastal Range. It is bounded on the north by San Bruno Mountain, on the west and northwest by Daly City, on the south by the City of San Bruno and on the east by the San Francisco Bay. The San Andreas Fault rift zone forms the major geologic features of the area as it passes along the western boundary of the service area. Elevations in the service area range from just above sea level on the eastern boundary near Highway 101 to over 500 feet above sea level at its northeastern boundary toward San Bruno Mountain.

The climate within the study area characteristically has mild winters and dry cool summers, with the hills to the west shielding the area from much fog. According to the nearest weather station at San Francisco Airport, temperatures typically range from 40 to 75 degrees Fahrenheit (°F) with a thirty-year normalized temperature of 57.6°F. In July, the average daily temperature ranges from a high of about 72°F to a low of about 54 °F. In January, the average daily temperature ranges from a high of about 56°F to a low of about 42°F. Precipitation in the form of rainfall averages about 20 inches annually.

Table 2-1 shows the estimated number of existing dwelling units, household size and population for each entity in the study area. This information is based on 2000 Census data from San Mateo County.

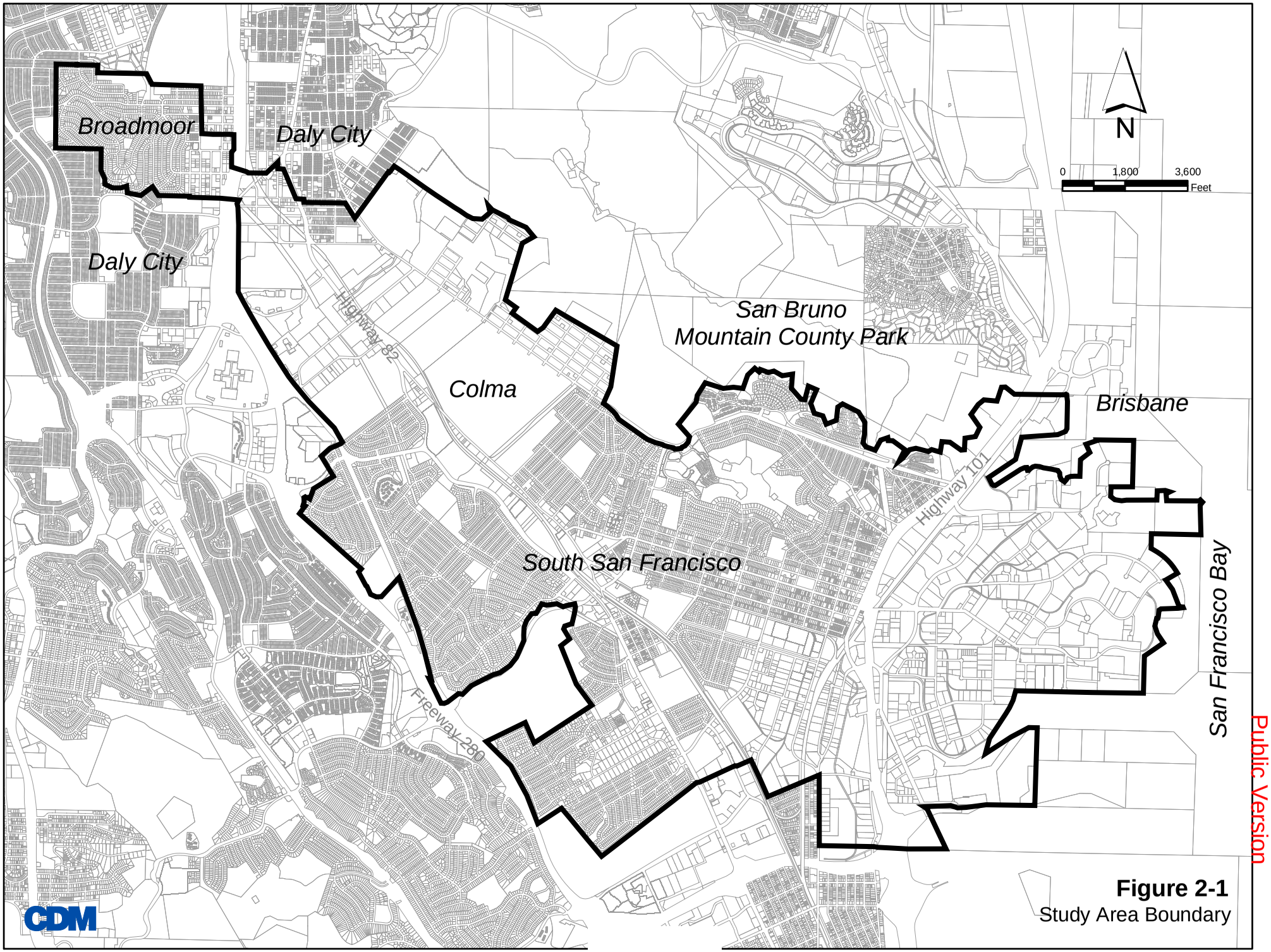

Figure 2-1
Study Area Boundary

Public Version

Table 2-1
Estimated Existing Dwelling Units and Population Within Study Area

Entity	Existing Dwelling Units			Average Household Size (1)	Existing Population (2)
	Single Family	Multi-Family Units	Total		
South San Francisco(3)	12,240	2,450	14,690	3.05	44,800
Colma	250	90	340	3.50	1,190
Broadmoor	1,265	30	1,295	3.11	4,030
Daly City	0	30	30	3.34	100
Total	13,755	2,600	16,355	3.06	50,120

(1) Average household size (persons per unit) is the average of all single family and multi-family units. The average size for each entity is taken from demographic information provided by San Mateo County from the 2000 Census.
(2) Existing population shown in table was estimated using dwelling units times average household size.
(3) South San Francisco area excludes the Westborough Water District area that is not served by Cal Water.

2.2 Future Land Uses and Development

Information regarding future land uses and future growth due to development or redevelopment is needed to estimate future demands. General plan and zoning land uses for the study area was obtained from the following local planning agencies: City of South San Francisco, Town of Colma, Daly City, and San Mateo County.

Figure 2-2 shows the ultimate land uses and the redevelopment areas identified by the local planning agencies. These redevelopment areas in South San Francisco include:

- *El Camino Redevelopment Area and Proposed Expansion Area*: redevelopment with mix of commercial and high density residential.
- *Gateway Redevelopment Area*: redevelopment of former Bethlehem Steel site into a mix of high density housing, hotels, and high technology businesses.
- *Downtown Central Redevelopment Area*: redevelopment to include mix of commercial and residential similar to existing but more intensive.
- *Shearwater Redevelopment Area*: redevelopment of former U.S. Steel site with commercial uses.

The study area has few remaining vacant parcels for development. Much of the future growth will consist of infill development and redevelopment of existing uses. Examples of redevelopment include intensification of residential uses when an area is redeveloped with higher density housing, and replacing old commercial and industrial uses with larger buildings and more intensive uses, such as high tech companies instead of warehouse type businesses.

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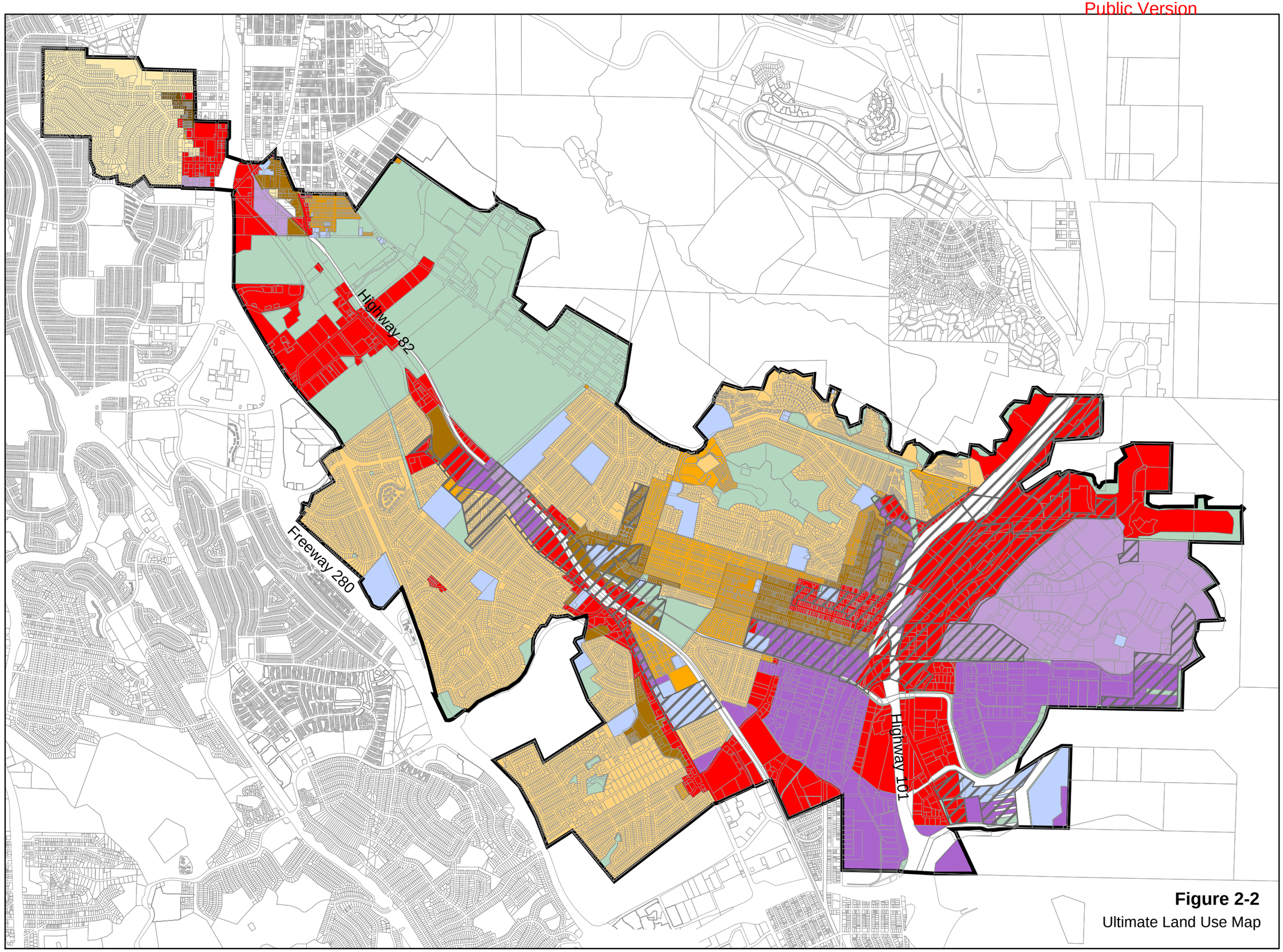


N

0 1,250 2,500 Feet

Legend

Land Use

- County Low Density Residential
- Low Density Residential
- Medium Density Residential
- Medium High Density Residential
- High Density Residential
- Very High Density Residential
- Commercial
- Light Industrial
- Heavy Industrial
- Public Facility, School
- Open Space Type Uses
- Right of way, Canal
- Redevelopment Areas
- Study Area Boundary

CDM

Figure 2-2
Ultimate Land Use Map

The General Plans do not give a specific date for buildout; however, it is assumed for this master plan that buildout will occur at or near year 2030, consistent with the 25-year planning horizon.

The zoning categories used by the local planning agencies were grouped into simplified land use types to facilitate the master plan analysis, as shown in Table 2-2.

Table 2-2
Land Use Types Within Study Area

Master Plan Land Use Type	***Corresponding City of South San Francisco General Plan Land Use Categories***	***Corresponding Town of Colma Zoning Categories***	***Corresponding City of Daly City Zoning Categories***	***Corresponding San Mateo County Zoning Categories***
Residential				
County Low Density Residential	----	----	----	• Broadmoor -Low Density Residential (4.7 units/acre)
Low Density Residential	• Low Density Residential (8 units/acre)	----	----	----
Medium Density Residential	• Downtown Low Density Residential (5.1 to 15 units/acre) • Medium Density Residential (8.1 to 18 units/acre)	----	• R-1 Single Family (14 to 17 units/acre)	----
Medium High Density Residential	• Downtown Medium Density Residential (15.1 to 25 units/acre)	• R Residential and R-S Neighborhood Residential (13 to 30 units/acre)	----	• Medium High Density Residential (12 to 25 units/acre)
High Density Residential	• High Density Residential (18.1 to 30 units/acre) • Downtown High Density Residential (25.1 to 40 units/acre)	----	• R-2 Two Family (29 to 35 units/acre)	• High Density Residential (25 to 55 units/acre)
Very High Density Residential	----	----	• R-3 Multiple Family (87 units/acre)	----
Non-Residential				
Commercial	• Downtown Commercial • Community Commercial • Business Commercial • Coastal Commercial • Office	• E Executive Administrative • PD Planned Development • C Commercial	• C-O Office Commercial • C-1 Light Commercial • BC BART, BOC BART Commercial, Office/Com	• Neighborhood Commercial
Light Industrial	• Business and Technology Park • Transportation Center	• T Transit	• C-2 Heavy Commercial	• Transportation Facilities (stations)
Heavy Industrial	• Mixed Industrial	----	• M Industrial	
Public Facility, School	• Public/Institutional	• P Public	----	• Institutional
Open Space Type Uses	• Park and Recreation • Open Space • Right-of-way, canal	• G Cemetery	• Cemetery • OS Open Space	----

Table 2-3 summarizes acreages of the various ultimate land use types within the study area. Residential uses comprise about 37 percent of the lands within the service area; commercial uses about 18 percent; industrial uses about 17 percent (light industrial – 8 percent; heavy industrial – 9 percent); public/institutional (governmental) about 4 percent; and open space type uses, including parks and cemeteries, the remaining 24 percent of land within the service area.

Table 2-3 also shows the estimated ultimate number of dwelling units within the study area based on the buildout land uses. Dwelling unit estimates are shown for the following conditions:

- At the minimum planned densities;
- At the average planned densities - average of the allowable density range; and
- At the maximum allowable densities - if all residential areas develop/redevelop to their maximum allowable density.

As indicated on Table 2-3, the total number of single family residential units within the study area is anticipated to range from a minimum of 16,475 to a maximum of 18,427 at buildout. The total number of multiple family units is estimated to range from an average of 9,689 to a maximum of 11,174 at buildout.

Table 2-4 shows the projected ultimate dwelling unit and population estimates for the study area at buildout. The buildout projections are based on the land uses in Table 2-3 and assume the same average household size in the future as currently.

At buildout, total dwelling units and population would be anticipated to increase about 35 percent over existing based on the minimum allowable density, and about 65 percent over existing based on the average allowable density, which is the most reasonable assumption for future planning. While it is unlikely that the maximum density assumption would occur, this information can provide a high end to bracket potential growth. Much of the future residential growth will be multifamily residential development/redevelopment, since the local planning agencies are encouraging higher density housing.

Table 2-3
Summary of Ultimate Land Uses Within Study Area

Land Uses	Acreage	Estimated Dwelling Units					
		At Minimum Planned Density		At Average Planned Density		At Maximum Allowable Density	
		Minimum Density (DU/ac)	Number of Units	Average Density (DU/ac) (1)	Number of Units	Maximum Density (DU/ac)	Number of Units
Residential							
County Low Density Residential	268	4.7	1,261	4.7	1,261	4.7	1,261
Low Density Residential	1,685	8.0	13,480	8.0	13,480	8.0	13,480
Medium Density Residential	217	8.0	1,735	12.0	2,606	17.0	3,686
Subtotal - Single Family	***2,170***		***16,475***		***17,347***		***18,427***
Medium High Density Residential	81	12.0	977	20.6	1,670	26.7	2,175
High Density Residential	246	14.5	3,569	29.0	7,144	33.0	8,124
Very High Density Residential	10	87.0	875	87.0	875	87.0	875
Subtotal - Multiple Family	***338***		***5,422***		***9,689***		***11,174***
Total Residential	**2,508**		**21,897**		**27,036**		**29,600**
Non-Residential							
Commercial	1,224						
Light Industrial	531						
Heavy Industrial	641						
Public Facility, School	279						
Open Space							
Park and Recreation	257						
Open Space	108						
Cemetery	952						
Other (right-of-way, canal)	231						
Subtotal - Open Space	*1,547*						
Total Non-Residential	**4,223**						
GRAND TOTAL ACREAGE	**6,730**						

Table 2-4
Study Area Existing and Buildout Population Estimates

Timeframe	Number of Dwelling Units			Estimated Population (1)
	Single Family	Multi-Family	Total	
Existing	13,755	2,600	16,355	50,100
Buildout				
Minimum	16,475	5,422	21,897	67,000
Average Density	17,347	9,689	27,036	82,700
Maximum Density	18,427	11,174	29,600	90,600

(1) Population estimated using an overall average of approximately 3.06 persons per unit. All units are assumed to be occupied.

Information on proposed development projects was also obtained from local planning agencies. Appendix G contains a list of the development projects, as part of the discussion of the hydraulic model demand allocations. These are specific projects that have progressed to the point of development applications, tentative maps, improvement plans, and/or approval for construction. Typically these projects are relatively near-term projects that would be implemented over the next 5 to 15 years. In addition to these projects, future development will also include other projects not yet proposed by developers but that would be allowable by the General Plan at ultimate buildout.

Section 3
Water Demands

This section describes existing services and demands in the South San Francisco system and provides future service and demand projections through year 2030. The information in this section is on a system-wide basis, by customer category.

3.1 Existing Services and Water Demand

Table 3-1 summarizes the existing (2003) customer services based on detailed customer billing records. As of 2003, Cal Water had a total of 16,184 customers (meters). About 85 percent of the services are for single family residential customers, about 1 percent for multi-family residential customers, about 12 percent for commercial and industrial, and the remaining 2 percent for government and other customers. About 85 percent of the meters are standard 5/8-inch meters. Figure 3-1 shows the 2003 distribution of services by customer type, as percentage of total services.

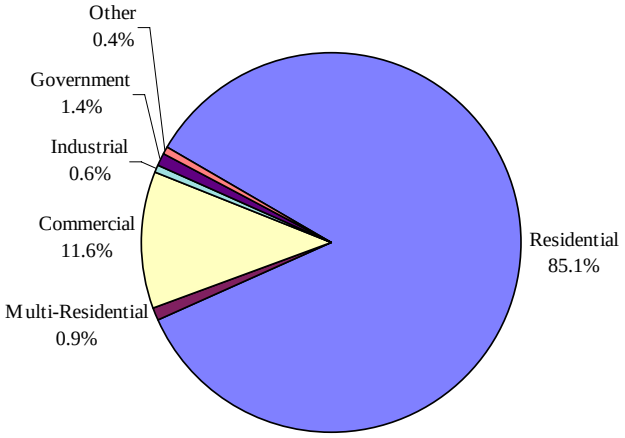


Figure 3-1
2003 Services by Customer Type
(% of Total Services)

Table 3-1
Summary of 2003 Services and Demand by Customer Type[1]

Customer Type	*Number of Services*	*Percent of Total Services*	*Total Annual Demand (MG)*	*Average Day Demand (mgd)*	*Percent of Total Demand*
SF – Single Family Residential	13,754	85.0%	1,169	3.20	37.6%
MF – Multi Family Residential	151	0.9%	139	0.38	4.5%
CM – Commercial	1,881	11.6%	1268	3.47	40.8%
IN – Industrial	68	0.4%	239	0.66	7.7%
GOV - Government	220	1.4%	159	0.44	5.1%
Other	110	0.7%	11	0.03	0.3%
Subtotal from Consumption Billing Records	***16,184***	***100.0%***	***2,985***	***8.2***	***96.0%***
Unaccounted-for Water (estimate)	0	0	124	0.3	4.0%
Total	**16,184**	**100.0%**	**3,109**	**8.5**	**100.0%**

(1) Data obtained from customer billing records provided by Cal Water.

Table 3-1 also summarizes the 2003 water demand. The table shows water usage (consumption) on a system-wide basis by customer type in million gallons. It also shows the unaccounted-for water and total demand for 2003. The total demand equals customer usage plus unaccounted-for water. Figure 3-2 shows the 2003 distribution of demands by customer type, as percentage of total demand.

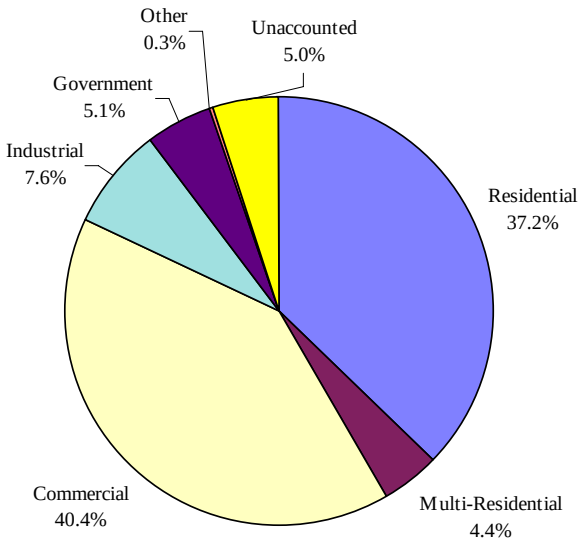


Figure 3-2
2003 Demands by Customer Type
(% of Total Usage)

As indicated in Table 3-1, the total average day demand in 2003 was about 8.5 million gallons per day (mgd) including unaccounted-for water. Residential usage comprises 42 percent of total demand, with non-residential uses about 53 percent, and unaccounted-for water about 5 percent. For non-residential uses, commercial comprises about 40 percent of total demand, and industrial about 8 percent. It should be noted that the land use category of Light Industrial, such as business and technology parks, are considered to be commercial customers, not industrial customers.

With an existing service population of almost 66,000, the per capita water demand for all uses is 130 gallons per capita per day, and for residential uses only is 57 gallons per capita per day. This is relatively low per capita usage and is likely the result of the coastal climate that reduces the need for outdoor water use. Per capita rates in hotter, drier areas are typically much higher.

Unaccounted-for water refers to system losses between production (supply) and consumption (customer usage). These losses may occur from fire flows, construction use, hydrant flushing, leaks, main breaks, metering inaccuracies, illegal connections or usage, and other types of un-metered water use. Unaccounted-for water typically ranges from about 5 to 10 percent of production for most water systems.

Historically, Cal Water's unaccounted-for water has ranged from 2.9 to 6.2 percent in the past 25 years. Since 1992, it has averaged 4.5 percent, but did reach 5.7 percent in 2002. For this master plan, a 5 percent allowance for system losses is recommended as a reasonable estimate for future demand projections.

Table 3-2 provides a more detailed breakdown of the 2003 consumption data by customer type and by meter size. It also shows both the total usage and the average day use (gallons per day [gpd]) per meter for each customer category. Table 3-2 does not include unaccounted-for water.

Table 3-2
Summary of 2003 Water Consumption by Meter Size
(1 of 2)

Customer Type	*Meter Size (in)*	*Total Usage (gallons)*	*Total Number of Services*	*Average Day Use per Service (gpd)*	*% of Total Annual Customer Usage*	*% of Total Services*
SF - Single Family Residential	5/8"	1,102,425,779	12,948	233	37%	80.0%
	3/4"	59,844	1	164	0%	0.0%
	1"	64,221,004	794	222	2%	4.9%
	1.5"	584,229	8	200	0%	0.0%
	2"	1,294,130	3	1,182	0%	0.0%
SF Total		**1,168,584,985**	**13,754**	**233**	**39%**	**85.0%**
MF - Multi Family Residential	1.5"	63,223,102	106	1,634	2%	0.7%
	2"	37,131,800	34	2,992	1%	0.2%
	3"	18,287,625	7	7,158	1%	0.0%
	4"	20,495,126	4	14,038	1%	0.0%
MF Total		**139,137,653**	**151**	**2,524**	**5%**	**0.9%**
CM - Commercial	5/8"	82,998,602	654	348	3%	4.0%
	1"	156,333,870	570	751	5%	3.5%
	1.5"	150,279,886	215	1,915	5%	1.3%
	2"	396,936,536	338	3,217	13%	2.1%
	3"	246,394,831	73	9,247	8%	0.5%
	4"	125,576,969	26	13,233	4%	0.2%
	6"	58,518,604	4	40,081	2%	0.0%
	10"	50,639,373	1	138,738	2%	0.0%
CM Total		**1,267,678,672**	**1,881**	**1,846**	**42%**	**11.6%**
IN - Industrial	5/8"	4,344,685	14	850	0%	0.1%
	1"	3,327,335	13	701	0%	0.1%
	1.5"	2,047,418	6	935	0%	0.0%
	2"	54,360,932	21	7,092	2%	0.1%
	3"	7,845,568	3	7,165	0%	0.0%
	4"	54,259,945	8	18,582	2%	0.0%
	6"	113,090,486	3	103,279	4%	0.0%
IN Total		**239,276,369**	**68**	**9,640**	**8%**	**0.4%**

Table 3-2 Summary of 2003 Water Consumption by Meter Size (2 of 2)						
Customer Type	***Meter Size (in)***	***Total Usage (gallons)***	***Total Number of Services***	***Average Day Use per Service (gpd)***	***% of Total Annual Customer Usage***	***% of Total Services***
	1"	8,669,922	50	475	0%	0.3%
	1.5"	13,681,869	35	1,071	0%	0.2%
	2"	61,058,240	84	1,991	2%	0.5%
	3"	44,651,966	13	9,410	1%	0.1%
	4"	16,463,126	7	6,443	1%	0.0%
	6"	4,419,491	2	6,054	0%	0.0%
	8"	3,319,854	1	9,095	0%	0.0%
	Other	4,976,041	2	6,816	0%	0.0%
GOV Total		**159,023,117**	**220**	**1,980**	**5%**	**1.4%**
Other	5/8"	3,717,818	7	1,455	0%	0.0%
	1"	292,488	1	801	0%	0.0%
	1.5"	483,242	31	43	0%	0.2%
	2"	6,324,779	71	244	0%	0.4%
Other Total		**10,818,327**	**110**	**269**	**1%**	**0.7%**
	Grand Total	**2,984,519,123**	**16,184**	**505**	**100%**	**100%**

Table 3-3 shows the top twenty water users in the South San Francisco system, and their 2003 water usage. These top twenty users accounted for about 20 percent of the total average day water demand in the system. The large users include businesses, the City of South San Francisco, golf courses, hotels, hospitals, school district, nurseries and cemeteries.

The largest user had 9 percent of total average day system demand. The top four users made up 12 percent; and the top 8 users about 15 percent of the total average day system demand.

Table 3-3
Top Twenty Largest Users

	Meter Size	Average Day Usage	
		gpd	gpm
1 (industrial biotechnology)	10"	125,215	87
	6"	281,248	195
	6"	69,265	48
	6"	54,779	38
	3"	60,164	42
	3"	28,249	20
	2"	125,215	87
		Subtotal	*517*
2 (industrial laundry)	3"	126,213	88
3 (industrial laundry	4"	94,772	66
4 (industrial food processing)	2"	74,999	52
5 (public)	3"	31,067	22
	3"	33,984	24
		Subtotal	*46*
6 (golf course)	3"	57,820	40
7 (commercial hotel)	6"	53,258	37
8 (hospital)	3"	45,129	31
9 (schools)	4"	36,702	25
10 (industrial food processing)	3"	36,652	25
11 (industrial food processing)	4"	35,804	25
12 (commercial)	3"	34,583	24
13 (commercial nurseries)	4"	31,366	22
14 (hotel)	4"	29,646	21
15 (commercial)	3"	28,723	20
16 (commercial)	4"	28,324	20
17 (commercial)	2"	28,075	19
18 (commercial hotel)	4"	27,028	19
19 (commercial)	4"	26,629	18
20 (cemetery)	4"	26,479	18
21 (cemetery)	3"	25,357	18
TOTAL FOR TOP LARGE USERS		1,656,745	1,151

3.2 Historic Service Growth and Demand per Service

Information on historic service growth and the demand per service in the South San Francisco system was based on historic customer data from 1981 through 2003.

Table 3-4 summarizes the historic percentage growth in number of services in the South San Francisco system. In addition, the percentage growth in number of multi-family units was also estimated based on the current average ratio of existing multi-family units to existing services (8,050 existing multi-family units divided by 151 multi-family services equals 53 units per service on average).

Table 3-4
Historic Percentage Growth in Number of Services

Period	Average Percent Growth By Customer Type							
	Customer Type							Total Services
	Single Family Residential Services	Multi-Family Residential		Commercial Services	Industrial Services	Government Services	Other Services	
		Services	Units					
20-year Average (1984-2003)	0.64%	0.31%	0.91%	1.23%	-3.02%	1.17%	19.74%	0.72%
15-year Average (1989-2003)	0.74%	0.23%	0.61%	0.94%	-2.01%	0.93%	21.88%	0.79%
10-year Average (1994-2003)	0.85%	0.07%	0.58%	1.07%	-1.47%	0.53%	27.67%	0.92%
5-year Average (1999-2003)	1.02%	0.00%	0.29%	1.27%	-2.18%	0.84%	39.76%	1.12%

Several time periods are considered for growth in services, which reflect economic and demographic conditions: 20-year average growth from 1984 through 2003, 15-year average growth from 1989 through 2003; 10-year average growth from 1994 through 2003, and the recent 5-year average growth from 1999 through 2003.

As indicated in Table 3-4, the average percent growth per year in the number of single family residential and commercial services increased in recent years; and is highest for the past 5-year period. The average percent growth per year in multiple family residential services decreased over the last 20 years, and reached its lowest rate of growth over the past 5-year period.

The average percent growth per year of government services has increased over the past 5 years, but is lower than growth rates over a 15-year or 20-year period. The total number of industrial services has continued to decline, and there has been negative growth in industrial services over the past 20 years. Other services have increased substantially; however, they are a very small percentage (less than 1%) of the total services and have negligible demand.

Table 3-5 summarizes the historic demand per service for the South San Francisco customer classes. Several time periods are considered for demand per service, which reflect climate and drought conditions: 22-year average over the entire period of record from 1981 through 2003, pre-drought period from 1981 through 1987; the last major drought period from 1988-1991, post-drought period from 1991 through 2003, 10-year average growth from 1994 through 2003, and the recent 5-year average growth from 1999 through 2003.

As indicated in Table 3-5, the demand per service has increased for residential and commercial services over the past 5 and 10 year periods, but has decreased or stayed the same for industrial, government and other. The demand per service in all categories has essentially returned to pre-drought levels.

Table 3-5
Historic Demand Per Service (gallons per day)

Period	*Single Family Residential*	*Multiple Family Residential*	*Commercial*	*Industrial*	*Government*	*Other*	*Unaccounted Per Service*	*Total Demand Per Service*
22-year Avg. (1981-2003)	230	2,407	1,520	10,552	1,977	1,067	23	511
Pre-Drought (1981-1987)	246	2,218	1,362	11,724	2,193	1,269	24	534
Drought (1988-1991)	202	2,274	1,405	10,185	1,710	1,710	23	464
Post-Drought (1992-2003)	230	2,561	1,650	9,991	1,939	735	23	513
10-year Avg. (1994-2003)	235	2,629	1,712	9,780	1,970	822	23	524
5-year Avg. (1999-2003)	239	2,676	1,829	9,742	2,072	822	24	542

3.3 Peaking Factors

Water system facilities are generally sized for peak demand periods. The peaking conditions of most concern for water facility sizing are maximum day demand with fire flow and the peak hour demand on the maximum day.

Average day demand refers to the average daily usage of water over a year. Maximum day demand is the maximum water usage for a 24-hour period during a year, which generally occurs during the maximum month of usage in summer. Peak hour demand is the peak flow during a one-hour period on the day of maximum demand.

Table 3-6 summarizes historic demand data on a system-wide basis for the past 5 years including total annual demand, average daily demand, and maximum day demand. Table 3-6 also shows the relationship (peaking factor) between maximum day demand and average daily demand.

Table 3-6
Summary of Historic Demand and Maximum Day Peaking Factors Over Past 5 Years

Year	Annual Demand (MG)	Average Daily Demand (mgd)	Maximum Day Demand (mgd)	Maximum Day Peaking Factor
1999	3,061	8.4	12.2	1.45
2000	3,173	8.7	13.1	1.51
2001	3,130	8.6	12.4	1.44
2002	3,121	8.6	13.0	1.51
2003	3,134	8.6	13.0	1.51
Average Over 5-Year Period	3,124	8.6	12.7	1.48

The maximum day peaking factor relates the maximum day average daily demand to the annual average day system demand. Over the last 5 years, the maximum day peaking factor ranged from about 1.44 to 1.51 (average 1.48 over the 5-year period). For the master plan, a maximum day peaking factor of 1.5 is recommended as a reasonable value for master planning purposes.

The peak hour factor on the maximum day is derived from hourly demand data, which is often very limited or not available. As discussed in Appendix G, a diurnal curve was developed for the hydraulic model based on hourly data for the City of San Francisco system. For this master plan, a peak hour factor of 1.7 times maximum day demand is recommended based on this diurnal pattern.

Monthly demands are also of interest in water system planning, since the level of water use may vary significantly over the course of a year. Figure 3-3 shows the ratios of the monthly average day demand to the annual average day demand. The monthly ratios relate the monthly average daily flow to the annual average daily flow. The ratios are based on the 5-year average usage from 1999 through 2003.

As indicated on Figure 3-3, the monthly average demand ranges from about 0.8 times the annual average day demand in the winter to 1.2 times the annual average day demand in the summer. This variation in monthly demands is relatively small due to the coastal location that moderates summer temperatures, compared with the much wider seasonal changes in demand experienced by inland system with hotter summers.

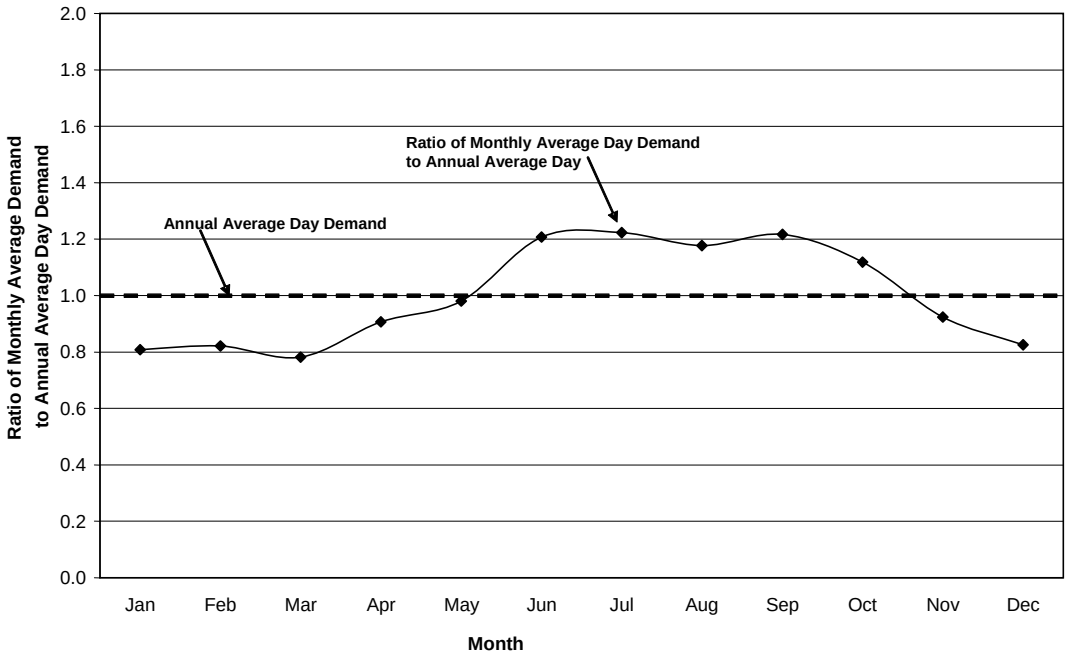


Figure 3-3
Monthly Demand Factors

3.4 Future Service and Demand Projections

Projections of future services and demands have been developed on a system-wide basis. System-wide projections were developed based on the Table 3-4 historic growth rates for services and the Table 3-5 historic demand per service. Individual growth rates and unit demands were used for each customer type. Unaccounted-for water was assumed to be 5 percent of total water use.

Based on the analysis, year 2030 demand will be about 11.0 mgd on average. The demand projections are for normal (non-drought) conditions, and assume no recycled water use. Cal Water has set a goal of 10 percent reduction in future demands due to greater conservation efforts, which would result in a buildout demand at year 2030 of about 10 mgd. Potential impacts of future water conservation and recycled water use to meet the projected demands are discussed in Section 8 - Water Supply Strategy.

Based on a sensitivity analysis (discussed below), demands may range from a low of 10.6 mgd to a high of 11.6 mgd. Sensitivity analyses were done to develop a range of future service and future demand projections. This range of projections is useful to evaluate the potential impact of uncertainties regarding how future development will actually occur, and to identify whether assumptions may significantly affect the estimates. The sensitivity results helped to identify a reasonable estimate for long-term planning purposes.

Table 3-7 summarizes the total service and demand projections for the sensitivity scenarios noted below. Appendix A contains detailed tables that show the breakdown by customer type of the service and demand projections for each scenario.

- *Scenario A*: 10-year growth rates and 10-year average unit demand per service for each customer category. This is the low end of the projection range, and includes both lower and higher parts of the historic cycle.
- *Scenario B*: 10-year average growth rate and 5-year average unit demand per service for each customer category. The 5-year average unit demand is the highest for the period of record, and has returned to pre-drought levels.
- *Scenario C*: 5-year average growth rate and 10-year average unit demand per service for each customer category.
- *Scenario* D: 5-year average growth rate and 5-year average unit demand per service for each customer category.
- *Scenario E*: highest growth rate from Table 3-4 and 5-year average demand per service for each customer category. This is high end of the projection range, since the 5-year average unit demand per service was the highest over the period of record.

Table 3-7
Summary of Sensitivity Analyses for Service and Average Day Demand Projections

Year	Scenario A: 10-year Growth Rate 10-year Unit Demands		Scenario B: 10-year Growth Rate 5-year Unit Demands		Scenario C: 5-year Growth Rate 10-year Unit Demands		Scenario D: 5-year Growth Rate 5-year Unit Demands		Scenario E: Highest Growth Rate 5-year Unit Demands	
	Total Services	Total Average Day Demand (mgd)	Total Services	Total Average Day Demand (mgd)	Total Services	Total Average Day Demand (mgd)	Total Services	Total Average Day Demand (mgd)	Total Services	Total Average Day Demand (mgd)
2003	16,184	8.4	16,184	8.7	16,184	8.4	16,184	8.7	16,184	8.7
2005	16,464	8.6	16,464	8.9	16,520	8.6	16,520	8.9	16,523	8.9
2010	17,184	8.9	17,184	9.3	17,388	9.0	17,388	9.4	17,400	9.4
2015	17,937	9.3	17,937	9.7	18,302	9.5	18,302	9.8	18,324	9.9
2020	18,723	9.7	18,723	10.1	19,266	10.0	19,266	10.3	19,298	10.4
2025	19,544	10.1	19,544	10.5	20,282	10.5	20,282	10.9	20,325	11.0
2030	20,402	10.6	20,402	11.0	21,352	11.0	21,352	11.4	21,407	11.6

The demand projections fall within a very narrow range, regardless of the assumptions used, which increases confidence in the future projections. Buildout average day demands at year 2030 range from 10.6 to 11.6 mgd, or about 11 mgd on average. The narrow range is reasonable for an established area that is close to buildout. Cal Water's extensive database of historic customer information provides an excellent basis for future projections.

Two assumptions regarding customer growth were made that are different than the historic data. Neither assumption, however, affects the result, as noted below:

- It was assumed that the number of industrial customers remains at the current level, even though it has historically shown a negative growth rate. A sensitivity analysis using a negative growth rate for industrial customers showed there would be only a small 0.3 mgd decrease in the projected buildout demand, which does not significantly affect the system-wide estimates. Keeping the number of industrial customers at its current level allows some flexibility for future increases in demand per service, even if the number of industrial customers might continue to decline.

- It was assumed that the "Other" category of customers remains at its current level. This category has historically shown very large fluctuations over the years. It is a negligible percentage of the total demand, so does not significantly affect the system-wide estimates.

Section 4
Existing Water System

This section provides a summary description of the South San Francisco existing water system configuration and facilities.

Appendix B describes the findings from site visits conducted to view existing facility conditions. Appendix C provides detailed information on the existing Supervisory Control and Data Acquisition (SCADA) system.

4.1 System Configuration and Pressure Zones

The existing water system is supplied from San Francisco Public Utilities Commission (SFPUC) turnouts distributed throughout the system, and from a well field located near the center of the system. All the pressure zones can be served from SFPUC turnouts. The well field is in the lowest pressure zone, so well supply can be provided to zones that can be served through that zone. A transmission grid of larger diameter pipelines moves water throughout the system from the supply sources (turnouts, wells).

Figure 4-1 provides an overview of the system's pressure zones; each zone is shown in a different color. Figure 4-2 provides a schematic of the existing system profile. Figure 4-3 shows the pipelines color-coded by diameter, and the locations of the major facilities including reservoirs, pump stations, pressure reducing valves (PRV), and turnouts.

Table 4-1 summarizes the 15 pressure zones in the South San Francisco system, and the major facilities serving each zone. Key features of the major facilities are summarized in the rest of this section. Appendix G on the hydraulic model of the water system provides more detailed information on facility settings.

Table 4-1
Pressure Zones

Zone	Major Facilities Serving Zone
200	
260	
265	
280	
285	
330	
360	
380	
390	

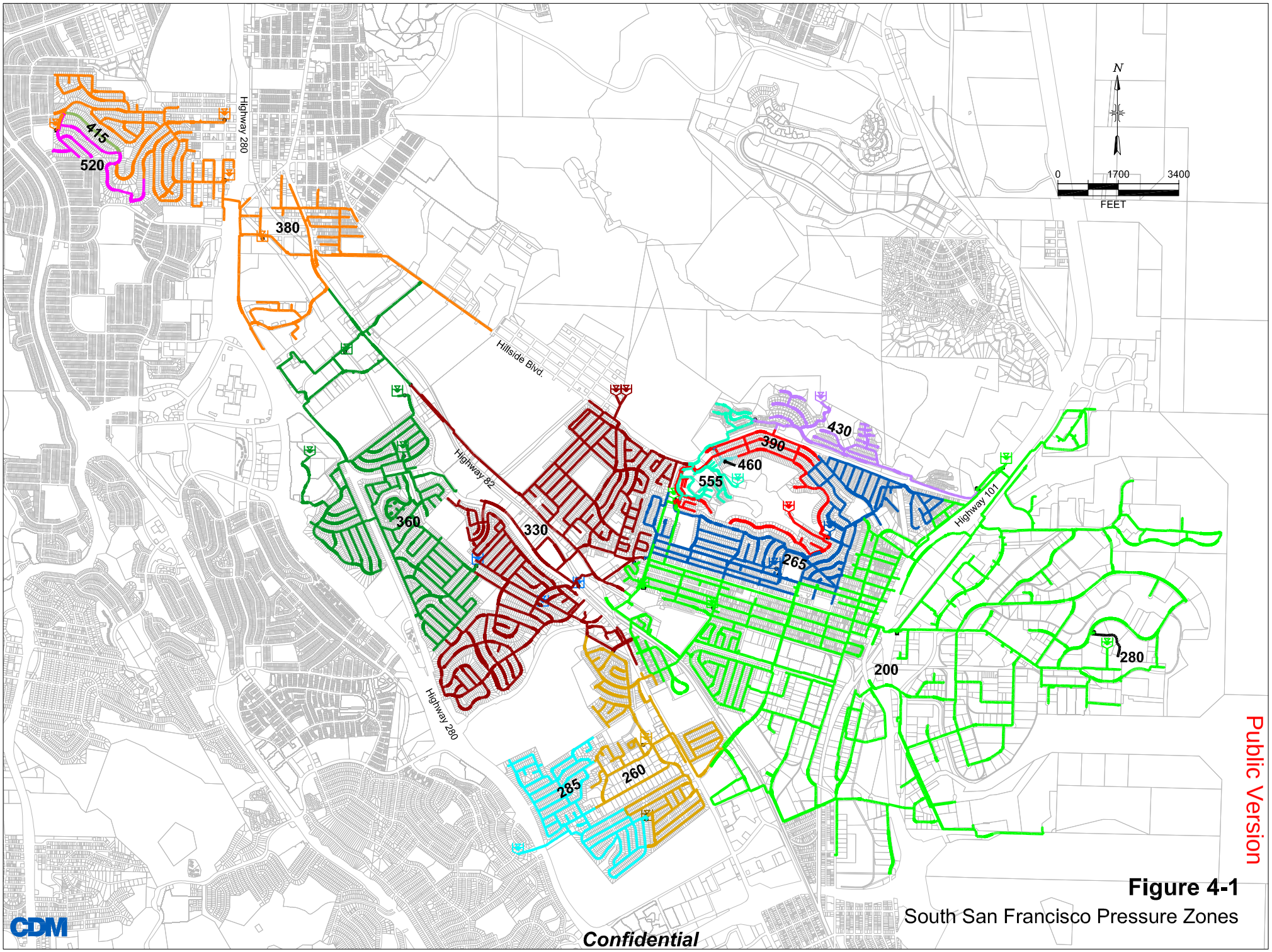


Figure 4-1

South San Francisco Pressure Zones

Figure 4-2
South San Francisco System Schematic

[redacted]

Table 4-1 Pressure Zones	
Zone	**Major Facilities Serving Zone**
415	[redacted]
430	
460	
520	
555	

4.2 SFPUC Turnouts

Table 4-2 summarizes the existing SFPUC connections where treated surface water is delivered to the South San Francisco system.

Table 4-2
SFPUC Connections

Connection Number	Meter Size (inches)	Location	SFPUC HGL	Downstream PRV Station Size and Location	Delivers to Zone
SSF-01	10	[redacted]	439	1-8", 1-10" at Del Paso Dr.	330
SSF-02	10		250	1-10" at Airport Blvd.	200
SSF-03	6, 6		250	None	200
SSF-05	8		439	1-4", 1-6" at Wildwood Dr.	285
SSF-06	6		439	1-4", 1-8" at Duval Dr.	360
SSF-07	6		439	1-6"at San Felipe Ave.	360
SSF-09	6		250	1-8"at Elm Ct.	200
SSF-12	6		439	1-8"at Serramonte Blvd.	360
SSF-13	6		439	None	380
SSF-14	6		439	None	380
SSF-15	6		439	None	380
Standby Connections:					
SSF-08	8		250	1-4" at El Camino Real & Del Paso Dr.	330
SSF-10	8		250	1-4" at El Camino Real north of Arlington	360
SSF-11	8		250	1-6" at Blondin Way	260

4.3 Well Field and Treatment Plant

Tables 4-3 and 4-4 summarize key features of the facilities located at Station 1. The existing wells in the South San Francisco system are located at Station 1. When wells are operating, well water is pumped to an existing treatment facility at Station 1. After treatment, water is held in a clearwell and pumped into the distribution system.

Table 4-3
Station 1 Wells

Well ID (1)	Year Drilled	Depth (ft)	Capacity (gpm)	Pump HP	Operating Efficiency (2)
1-14	1923	547	100	7.5	51%
1-15	1925	539	90	7.5	41%
1-17(3)	1937	438	120	50	14%
1-18	1940	575	400	40	48%
1-19	1947	526	160	20	38%
1-20	1972	620	120	30	38%
1-21	1976	660	215	30	56%

(1) Well 1-02 drilled in 1892 (196 feet deep) is not shown. It is used only as a monitoring well.
(2) Operating efficiencies are from 2003 pump tests, except for Well 1-17 which is from 1998 pump tests (no data on 1-17 from 2003).
(3) Well 1-17 is inactive.

Table 4-4
Other Station 1 Facilities

Facility	Description
Treatment Facilities	Treatment capacity = 1100 gpm (expandable to 2250 gpm). Well water is treated by an iron and manganese system consisting of chlorine oxidation followed by filtration. Facilities include sodium bisulphite chemical system (reduces chlorine concentration) and backwash reclamation system (separates out iron hydroxide and manganese dioxide).
Clearwell	500,000-gallon, circular, steel tank. Bottom elevation = 31 feet; overflow elevation = 55 feet. Stores finished water from treatment facility.
Pump Station	Three pumps to pump from clearwell into the distribution system. Pumps A and B installed in 2001 are each 1700 gpm, 120 HP with operating efficiency of 60% per 1998 pump tests. Pump D installed in 1998 is 1500 gpm, 100 HP.

At Station 1, water can be pumped from seven production wells to an iron and manganese treatment system that consists of chlorine oxidation, followed by filtration. The treatment system also has sodium bisulphite chemical facilities to reduce the chlorine concentration, and a backwash reclamation system to separate precipitated iron hydroxide and manganese dioxide before returning the backwash water back to the head of the treatment plant. After leaving the pressure filters, the treated water flows by under pressure to the 500,000 gallon on-site clearwell. The treated water is pumped to Reservoir 2 from a pump station at Station 1.

4.4 Pump Stations

Table 4-5 summarizes key features of the existing pump stations including number of pumps, pump capacity, pump horsepower, and overall operating efficiency. The pump and efficiency data was obtained from 2003 pump tests in most cases, unless otherwise noted on the table.

Table 4-5
Pump Stations

Pump Station Number	Year Station Constructed	Pumps	Pump Capacity (gpm)	Pump HP	Overall Operating Efficiency	Source of Pump and Efficiency Data	Pump Install Date
2	1950	A	445	30	NA	1998 pump test	1950
		B	300	30	NA	Design data	1950
		C	1,000	40	53%	2003 pump test	1952
3	1950	A	2,100	35	21%	2003 pump test	1950
		B	1,900	30	39%	2003 pump test	1950
4	1958	A	195	15	33%	1998 pump test	1987
		B	505	30	51%	1998 pump test	1958
5	1956	A	320	20	44%	2003 pump test	1956
		B	380	30	56%	2003 pump test	1997
		C	420	50	62%	2003 pump test	1968
6[1]	1979	A	290	10	56%	2003 pump test	1979
		B	220	10	35%	2003 pump test	1979
7	1990	A	500	30	60%	2003 pump test	1990
		B	450	30	59%	2003 pump test	1990
101 [1]	1963	A	240	15	50%	2003 pump test	1963
		B	500	30	55%	2003 pump test	1963

NA = Not Available

[1] Station 6 and Station 101 are hydropneumatic pump stations.

4.5 Reservoirs

Table 4-6 summarizes key features of the existing reservoirs including volume, shape and material, bottom elevation and overflow elevation.

Table 4-6
Reservoirs

Reservoir Number	Volume (gallons)	Shape and Material	Bottom Elevation (ft)	Overflow Elevation (ft)	Year Constructed
Station 8 T1 (Res 1)	1,500,000	Rectangular, Lined Earthen	172	191	1922
Station 5 T1 (Res 2)	1,500,000	Rectangular, Concrete	186	201	1923
Station 9 T1 (Res 3)	50,000	Circular, Redwood	375	391	1945
Station 4 T3 (Res 4-3)	250,000	Circular, Steel	241	267	1947
Station 4 T4 (Res 4-4)	250,000	Circular, Steel	241	267	1951
Station 11 T1 (Res 7-1)	250,000	Circular, Steel	298	327	1953
Station 11 T2 (Res 7-2)	500,000	Circular, Steel	295	327	1956
Station 12 T1 (Res 9)	500,000	Circular, Steel	525	554	1968
Station 13 T1 (Res 10)	500,000	Circular, Steel	259	287	1970
Station 14 T1 (Res 11)	1,000,000	Circular, Steel	323	357	1972
Station 15 T1 (Res 12)	1,000,000	Circular, Steel	400	430	1992
Station 101 T1 (Res 101)	250,000	Circular, Steel	320	350	1949
Clearwell at Station 1	500,000	Circular, Steel	31	55	1940

4.6 Pipelines

Table 4-7 summarizes the existing pipelines in the South San Francisco system by diameter and material. The information was obtained from the GIS database provided by the Engineering Department. There are about 157 miles of pipe in the entire system.

As indicated in Table 4-7, about 10 percent of the system pipelines are 4-inch or smaller in diameter. About 37 percent of existing pipes are 6-inch diameter. About 27 percent are 8-inch and 10-inch diameter, and 20 percent are 12-inch diameter. Less than 5 percent of existing pipelines are greater than 12-inch diameter. Due to the configuration of the system with supply sources from SFPUC at many locations, there has not been the need to have an extensive network of large diameter transmission mains to convey water across the entire system.

About 60 percent of the existing pipelines are asbestos cement (57%) or transite (3%) which is an older form of asbestos cement. About 32 percent of the existing pipelines are cast iron (22%), ductile iron (8%), and steel (2%). Only 6 percent are plastic pipe (PVC, HDPE).

Public Version

Table 4-7
Pipeline Summary by Diameter and Material

Diameter (inches)	Length of Pipe (LF)												
	Material											Total	
	Asbestos Cement (AC)	Concrete Cylinder Pipe (CCP)	Cast Iron (CI)	Copper	Ductile Iron (DI)	High Density Polyethylene (HDPE)	Polyvinyl Chloride (PVC)	Stainless Steel (SS)	Steel	Transite	Unknown (1)	LF	% of Total
1	0	0	118	1,383	0	0	0	145	0	0	0	1,646	0.2%
2	0	0	9,027	232	86	0	0	698	0	0	107	10,150	1.2%
3	0	0	0	0	0	0	0	122	0	0	52	174	0.0%
4	27,039	0	38,260	0	1,258	0	751	1,912	548	5,628	60	75,455	9.1%
6	165,483	0	89,590	0	17,840	0	18,797	30	2,202	15,402	392	309,735	37.3%
8	121,448	0	33,934	0	13,900	407	21,773	479	5,698	2,992	308	200,939	24.2%
10	22,957	0	53	0	888	0	0	0	507	441	3,489	28,333	3.4%
12	130,591	0	2,298	0	27,115	3,215	4,974	36	4,979	0	20	173,229	20.9%
14	0	0	0	0	0	90	0	0	423	0	0	514	0.1%
16	2,949	0	105	0	3,711	2,586	77	0	627	0	20	10,075	1.2%
18	2,954	313	14,876	0	311	0	0	0	490	0	0	18,945	2.3%
Unknown (1)	7	0	0	0	0	0	0	0	0	0	390	396	0.0%
Total LF	473,428	313	188,261	1,615	65,109	6,299	46,372	3,422	15,474	24,462	4,837	829,592	
% of Total	57.1%	0.0%	22.7%	0.2%	7.8%	0.8%	5.6%	0.4%	1.9%	2.9%	0.6%		

(1) Unknown indicates that either diameter or material information was not in the database.

4.7 Pressure Reducing Stations

Table 4-8 summarizes key features of the existing PRV stations.

Table 4-8
PRV Stations Not Located at SFPUC or Emergency Connections

Location	Number and Size of Valves	Supply Zone	Delivery Zone
	1-6"	285	260
	1-6"	330	200
	1-6"	330	260
	1-6"	330	265
	1-8"	360	330
	1-4"	520	415
	1-6"	555	390
	1-6"	555	390
	1-2", 1-6"	555	430
	1-2", 1-6"	555	460

4.8 Standby Connections with Other Systems

Table 4-9 summarizes the existing emergency connections where treated water from other cities can be delivered to the South San Francisco system.

Table 4-9
Emergency (Standby) Connections to Other Cities

Water Supplied From	Location	Connection Size (inches)	Downstream PRV Station Size	Delivers to Zone
Brisbane		16"	None	200
San Bruno		6"	None	200
Daly City		2"	None	380
Daly City		4"	1-4"	520
Daly City		6"	1-6"	360
Daly City		8"	None	380
Daly City		10"	None	360

Section 5
Performance Criteria

As a private water company, Cal Water is regulated by the Public Utilities Commission (PUC) of the State of California. PUC General Order 103 specifies rules governing water service including minimum standards for design and construction. The performance criteria described in this section are based on the PUC requirements, and Cal Water's established water system criteria. In addition, information is provided on current American Water Works Association guidelines, current practices of similar water utilities, and CDM's engineering experience on similar projects.

5.1 Supply to Distribution System

PUC General Order 103 requires that the quantity of water delivered to the distribution system from all source facilities be sufficient to supply adequately, dependably and safely the total requirements of all customers under maximum consumption, while meeting the pressure requirements described below. The combined flow from sources of supply and storage capacity should be adequate for four consecutive days of maximum use.

Many water agencies, particularly those with surface water supply, provide supply capacity equal to the maximum day demand, and then meet peak hour needs from storage. Water agencies supplied solely from groundwater sometimes provide well supply capacity to meet some or all of the peak hour demand in order to reduce reservoir storage requirements.

5.2 Distribution System Pressures

Per PUC General Order 103, the utility must maintain the following operating pressures at the service connection:

- Normal operating pressures of not less than 40 psi or more than 125 psi at the service connection;
- Minimum pressures under peak hourly seasonal demands of at least 30 psi;
- Maximum pressures under minimum hourly demand conditions of not more than 150 psi; and
- Residual pressure of 20 psi in the distribution system under fire flow conditions.

Under normal operating conditions, variations in pressure are not to exceed 50 percent of the average operating pressure, determined as the arithmetical average of at least 24 hourly pressure readings.

For other water agencies, typical minimum service pressures under non-fire conditions are: 30 to 40 psi during peak hour demand and/or 40 to 50 psi during maximum day demand. Under fire flow conditions, 20 psi minimum pressure is the typical criterion for all agencies. The typical maximum pressure is about 100 to 110 psi

to avoid over-pressurizing customer services. The Uniform Plumbing Code requires individual pressure reducing valves if pressures exceed 80 psi for new installations since adoption of this component.

Based on direction from Cal Water, the following criteria will be utilized for the analysis of the South San Francisco system:

- Minimum pressure under average day demands = 50 psi
- Minimum pressures for maximum day and peak hour demands = 40 psi
- Minimum pressure for maximum day demand plus fire flow = 20 psi
- Maximum allowable pressure = 125 psi

5.3 Water Main Sizing

PUC Order 103 requires that new and replacement mains be sized to accommodate the pressure requirements in the order as described above, or a minimum of 6-inch diameter, whichever is larger. The transmission pipelines from sources of supply must be designed to deliver, in combination with related storage facilities and to the limits of the capacity of those sources of supply, the maximum requirements of that portion of the system dependent upon those transmission pipelines. This facilities analysis was based on the above requirements.

Many water agencies typically have main sizing criteria that include system pressures, as discussed above, and pipe velocities. Typical velocity ranges used by other agencies are from a desirable level of 5 feet per second (fps) up to a maximum of 12 fps under peak hour or maximum day plus fire flow.

Many water agencies also specify maximum head losses in pipelines. The typical range for headlosses is from 5 feet per 1,000 feet under maximum day demand up to a maximum of 10 feet per 1,000 feet for peak hour demand. A maximum of 10 feet per 1,000 feet under any non-fire demand condition is the most typically used head loss criterion, and is equivalent to 4.3 psi pressure loss per 1,000 feet.

Typically, high velocities and/or high headlosses may manifest as a reduction in pressure. However, high velocities and corresponding high headlosses are also a concern for water hammer. According to the American Water Works Association's Manual M32 – "Distribution Network Analysis for Water Utilities" (AWWA, 1989), velocities are acceptable up to a maximum of about 10 fps to minimize such problems, while velocities of about 5 fps are desirable. Under fire flow conditions, the most likely cause of water hammer would be from rapid closure of a hydrant following use. This infrequent scenario would not warrant applying the same velocity and headloss criteria for fire flow conditions.

In addition to the pressure criteria and minimum pipe size criteria specified by the PUC, this facilities analysis also considered velocity and headloss criteria in sizing new improvements. Based on input from Cal Water staff, the following criteria were used for sizing new improvements:

- Maximum velocities:
  - Average day demand = 5 fps
  - Maximum day and peak hour demands = 7 fps
  - Maximum day demand plus fire flow = 10 fps
- Maximum headloss
  - Normal (non-fire demands) for average day, maximum day and peak hour = 10 feet per 1,000 feet
  - Maximum day plus fire flow – no limit

Velocity and headloss information from the model simulations was also helpful to identify hydraulic bottlenecks in determining the best locations for hydraulic improvements. Existing pipelines that exceed the velocity and headloss criteria under normal (non-fire) conditions were identified.

Existing pipelines, however, would not be recommended for replacement due only to not meeting velocity and headloss criteria. Existing pipelines would only be replaced in order to meet system pressure criteria. If existing pipelines must be improved to provide adequate pressures, then improvements would be designed to meet the velocity and headloss criteria. New pipelines would be sized according the velocity and headloss criteria.

5.4 Fire Flows

PUC General Order 103 provides fire flow standards considered appropriate on an average statewide basis, but acknowledges that there are widely varying conditions for the urban, suburban and rural areas in the state. The order states that the standards prescribed by the local fire protection agency or other prevailing local governmental agency govern. Such local flow standards are to be provided whether greater or lesser than those set forth in the order, except that mains designed for and capable of providing flows in excess of the requirements set forth are to be considered mains providing excess flow for the purpose of the application of the utility's main extension rule.

The PUC statewide fire flows are shown in Table 5-1 for the types of land uses in the South San Francisco District. The flows shown must be provided for up to 2 hours, in addition to the average daily demand in the area served.

Table 5-1 PUC Statewide Average Fire Flows	
Type of Land Use	**Flow (gallons per minute)**
Single family residential with lot density of three or more units per acre, including mobile home parks	1,000
Duplex residential units, neighborhood business of one story	1,500
Multiple residential, one and two stories; light commercial or light industrial	2,000
Multiple residential, three stories or higher; heavy commercial or heavy industrial	2,500

The majority of the service area is served by the City of South San Francisco Fire Department. South San Francisco has adopted the 2001 California Fire Code. Appendix III-A of the Fire Code contains information on required fire flows for new installations.

Based on review of the Fire Code, the fire flow amounts shown below have been identified for the analysis.

- Single family residential and duplexes
  - Building area < 3,600 square feet (SF): 1,000 gpm for 2 hours
  - Building area > 3,600 SF: 1,500 gpm for 2 hours
- Medium density multiple family residential – 2,000 gpm for 2 hours
- High density multiple family residential and schools – 2,500 gpm for 2 hours
- Commercial – 3,000 gpm for 3 hours
- Industrial – 3,500 gpm for 3 hours

Under PUC rules, facilities to meet fire flow requirements for individual customers are the responsibility of those they are designed to serve. Cal Water's understanding is that the local supply system is only charged with meeting 3,500 gpm for insurance rating purposes. If fire flow exceeds 3,500 gpm and cannot be met by the local water system, the property owner either provides additional on-site fire protection or pays a higher premium.

Water system planning analyses typically assume that only one fire will occur at a time within a pressure zone or service subarea. If the pressure zone or service subarea is very large, two simultaneous fires may be simulated. For the South San Francisco system, it was assumed that only one fire would occur at a time in a zone.

5.5 Reservoir Storage

PUC General Order 103 does not contain any specific requirements regarding storage amounts. The combined flow from sources of supply and storage capacity must be adequate for four consecutive days of maximum use.

Water system storage is typically sized based on the following three components:

- operational storage (also called equalizing or balancing storage);
- fire reserve storage; and,
- emergency storage.

Water storage capacity may also be provided in equivalent ways, other than tanks. For example, some agencies provide backup generators at pump stations to provide some of the reliable emergency supply. In some cases, a water system may be able to peak off the supply source, which can reduce the in-system operational storage requirement. Water systems with groundwater supply can use wells with backup power to provide some or all of these components. The discussion below addresses both the typical criteria, and some alternate means of providing equivalent storage capacity other than tanks.

Operational (equalizing or balancing) storage is the volume of water required to meet daily fluctuations in demand in excess of the water supply production capacity on the maximum day. This storage volume is determined by the variation in the hourly demand during the day of maximum demand. When supply capacity is provided to meet the maximum day demand, operational storage requirements typically range from 25 to 50 percent of the maximum day demand. Well capacity not needed to provide maximum day demand capacity can also be used to meet these operational peaking needs. If peaking capacity is available from the supply system, then the operational storage requirement may be lower. For the South San Francisco system, operational storage at 25 percent of the maximum day demand is recommended, as an industry standard applicable to this system based on the available general San Francisco area diurnal curve patterns, in the absence of actual system-specific diurnal curve data.

Fire reserve storage is the amount of storage volume necessary to supply fire flow for the most critical land use within a pressure zone. The fire reserve storage is typically computed for each pressure zone or service area, based on the most restrictive (highest) fire flow requirement times the duration for which it must be supplied. The fire reserve storage should always be available for fire protection to every part of the distribution system.

Emergency storage is the volume of water required to supply the service area during planned or unplanned equipment outages, power outages, or well shutdowns for unexpected mechanical difficulties or quality issues. This storage needs to be sufficient to provide a reasonable level of uninterrupted service under such circumstances. The minimum recommended emergency storage generally represents a 6-hour power outage on the maximum demand day (25 percent of maximum day demand). A typical assumption for emergency storage is that there may be a supply outage and/or power outage for up to 12 hours on the maximum demand day (50 percent of the maximum day demand). For the South San Francisco system, Cal Water has determined that one average day demand of emergency storage should be provided, which is equivalent to about 67 percent of the maximum day demand.

If standby power is provided at wells, well capacity with standby power may be considered as emergency storage if appropriate for overall system operations. For well capacity to be considered as an emergency water source, the standby power should be available for outage duration of at least 12 hours. Another option would be to provide standby power at pump stations that supply a zone that would avoid potential service interruptions.

The storage criteria for the South San Francisco system are summarized below in Table 5-2. The total storage equals the sum of the operational storage, emergency storage, and fire reserve.

Table 5-2
Reservoir Storage Criteria for South San Francisco System

Storage Component	***Typical Ranges***
Operational Storage (also called equalizing or balancing storage)	25 percent of maximum day demand
Emergency Storage	One average day demand (equivalent to 67% of maximum day demand)
Fire Reserve	Based on most critical land use within zone and required fire flow amount and duration.

The storage criteria also considered minimizing water quality impacts, such as potential for nitrification, at storage reservoirs due to low turnover during low demand periods. Water age is a general indicator for other water quality problems, such as loss of disinfectant residual, or potential for nitrification. Water age in reservoirs is often used to identify those reservoirs with potential problems, i.e., higher water age typically means lower turnover and higher potential for water quality problems.

5.6 Pumping Facilities

PUC General Order 103 does not contain any specific requirements regarding pumping capacities. The transmission system from sources of supply must be designed to deliver, in combination with related storage facilities and to the limits of the capacity of those sources of supply, the maximum requirements of that portion of the system dependent upon those transmission pipelines.

The Task 5 facilities analysis considered the following typical criteria used by other agencies in evaluating the appropriate pumping capacity for the South San Francisco District:

- Zones with reservoir storage would provide firm pumping capacity or gravity supply capacity that is sufficient to meet maximum day demand. For zones with storage, fire reserves are provided from storage.
- Zones without storage in the zone should have firm pumping capacity or gravity supply capacity to meet the peak hour demand on the maximum day, plus a fire pump or other means of providing fire flows to the zone.
- For all zones, the pump station must also have the ability to pump any flow that would be lifted through to supply subsequent higher zones.
- Firm capacity is defined as the capacity with the largest pumping unit at the pump station out of service.

Some agencies size pumps to allow time of use pumping to reduce energy costs. In such cases, pump stations may be sized for 150 percent of the maximum day demand. This sizing allows for operating the pump station during a 16-hour period, and keeping the pumps off for 8 hours during the day (6-hour peak energy cost period plus an hour on either end as an operational cushion). With time-of-use pumping, reservoir storage is needed to store the water for use during the "pumps off" period. Depending on the amount of capital improvements needed to provide the additional booster capacity, additional storage capacity, and/or additional supply peaking capacity needed to allow off-peak pumping, it may not be cost effective relative to the annual savings that might be realized from lower pumping costs.

5.7 Main Replacement Program

Cal Water has an established Main Replacement Program to replace all undersized mains and bare steel mains (uncoated, unlined or both). The goal of the program is to replace all mains of these categories within a 25 to 50 year period. The specific length of the replacement period for a given district is determined by:

1) The total footage of mains that fall within the following replacement program categories:

    - Undersized mains that are smaller than 6-inch diameter

- Steel mains (bare) that are 6-inches or larger in diameter

2) The severity of the leak or fire protection problems in the district.

Undersized mains with a diameter smaller than 6 inches are replaced to improve fire protection, distribution within the system, and service pressure to customers. Under PUC General Order 103, the current policy is to install mains with a minimum 6-inch diameter, in order to provide adequate system pressure and flows to all services. The highest priorities for replacement are the smallest diameter mains which provide the weakest pressure and flow conditions and those mains with the greatest history of leaks. While not required by the PUC General Order, mains that are 6-inch diameter or larger are also evaluated as the need arises to determine if such mains should be considered for replacement with larger diameter mains.

Steel mains that are 6-inch and larger diameter are included in the targeted mains as needed to reduce and control leaks. Many steel mains were originally installed over forty years ago and these mains can routinely, yet randomly, develop leaks. The objective in any one-year is to replace those mains which have generated the greatest leak problems during recent years.

The soils in some regions are more corrosive than in other regions. These soils can accelerate leak occurrence in certain main materials. For example the bay mud found in the San Francisco Peninsula districts is highly corrosive to cast iron mains. Where appropriate, these affected main types are included in the replacement program.

Cal Water has implemented a leak tracking system that uses leak repair report cards submitted by repair crews following any leak repair action. Using these cards, a leak history is generated for individual mains. Cal Water annually determines the number of leak for each district on the basis of leaks per one hundred miles of main. This information along with the actual length of targeted mains in a district is used to set the annual target main replacement length for the district.

Section 6
Water Supply Requirements

This section discusses the existing water supply sources and key issues, and compares demand and supply projections to identify the requirements for future supply. Key issues discussed in this section include the reliability of SFPUC surface supply, the long-term sustainability of the local groundwater basin, and future water quality regulations and potential water quality issues that may affect the South San Francisco supply.

Section 7 discusses the water system analysis that incorporates these supply requirements. Section 8 describes the recommended water supply strategy. Section 9 combines the supply and distribution system recommendations into an integrated plan.

6.1 Existing Water Supply Sources

Currently, most of the supply for the South San Francisco system is surface water purchased from SFPUC from their local reservoir supply. The SFPUC supply is delivered to South San Francisco at turnouts distributed throughout the system, as described in Section 3.

In addition, Cal Water has historically pumped groundwater from its local wells located in South San Francisco. Historically, in the early 1950's, Cal Water's pumping rate was high as 2 mgd. Since 1980, Cal Water pumping has been about 1.1 mgd on average, with a maximum of 1.4 mgd in any one year. Section 3 describes the existing well field and related facilities.

Table 6-1 summarizes the SFPUC purchase projections for Year 2030 for Cal Water's three peninsula systems. These purchase projections are the basis for implementation of the SFPUC Water System Improvements Program. Table 6-1 also shows the current contractual Supply Assurance Amount for Cal Water's three peninsula systems (South San Francisco, Mid Peninsula, and Bear Gulch). The total amount can be allocated among the three peninsula systems as determined by Cal Water.

The current 25-year contract with SFPUC adopted in 1984 will expire in 2009. As indicated on Table 6-1, there is a small combined shortfall of about 1.4 mgd by 2030 that should be addressed when the contract is re-negotiated.

Table 6-1
Year 2030 SFPUC Purchase Estimates under Normal Conditions

Supply Condition	Water Supply (mgd)	Water Supply (AF/year)
Year 2030 SFPUC Purchase Estimates[1]		
South San Francisco service area	7.97	8,928
Mid Peninsula service area	17.24	19,313
Bear Gulch service area	11.60	12,995
Total for All Three Peninsula Service Areas[1]	*36.81*	*41,235*
Supply Assurance Amount – 1984 Supplement to Agreement/Contract (all Cal Water districts)	35.39	39,645
Difference between Current Supply Assurance Amount and Projected Purchase Estimate[2]	(1.42)	(1,591)

(1) Year 2030 SFPUC purchase estimates are for SFPUC surface water supply only. Total demands in the Cal Water service areas will be met by a combination of SFPUC supply and local supplies.

(2) It is anticipated that the difference (deficit) between the current supply assurance amount and the projected Year 2030 purchase estimate will be addressed in Cal Water's renegotiation of the SFPUC contract (i.e., the renegotiated supply assurance amount will be higher to cover the deficit). If this does not occur, the deficit must be covered by additional local supply.

As an investor-owned utility, Cal Water is not permitted to purchase more than a specified maximum amount of 47,400 acre-feet per year of SFPUC surface water due to the provisions of the Raker Act that authorized development of SFPUC's Hetch-Hetchy system. The maximum amount allowable under the Raker Act is larger than the Supply Assurance Amount. The Raker Act quantity is related to the amount of local surface water that may be available to SFPUC. The Supply Assurance Amount, which is based on the existing system capacity of SFPUC's regional water system, is the constraining factor for Cal Water.

6.2 Comparison of Demand and Supply Projections

Table 6-2 summarizes the current and projected Year 2030 water demands for the South San Francisco system that were developed in Section 4. The demand projections in Table 6-2 are for normal conditions (non-drought and non-emergency conditions). These demand projections are compared with those in the regional BAWSCA demand study that provided the basis for the SFPUC purchase projections shown in Table 6-1. The SFPUC purchase projections include only the surface supply that SFPUC is planning to provide; while the BAWSCA projections include all projected demand regardless of the supply source (i.e., some demands would be met from local supply not SFPUC). As indicated in Table 6-2, the recent regional BAWSCA demand study is based on projections that include 10 percent long-term conservation savings for the South San Francisco system.

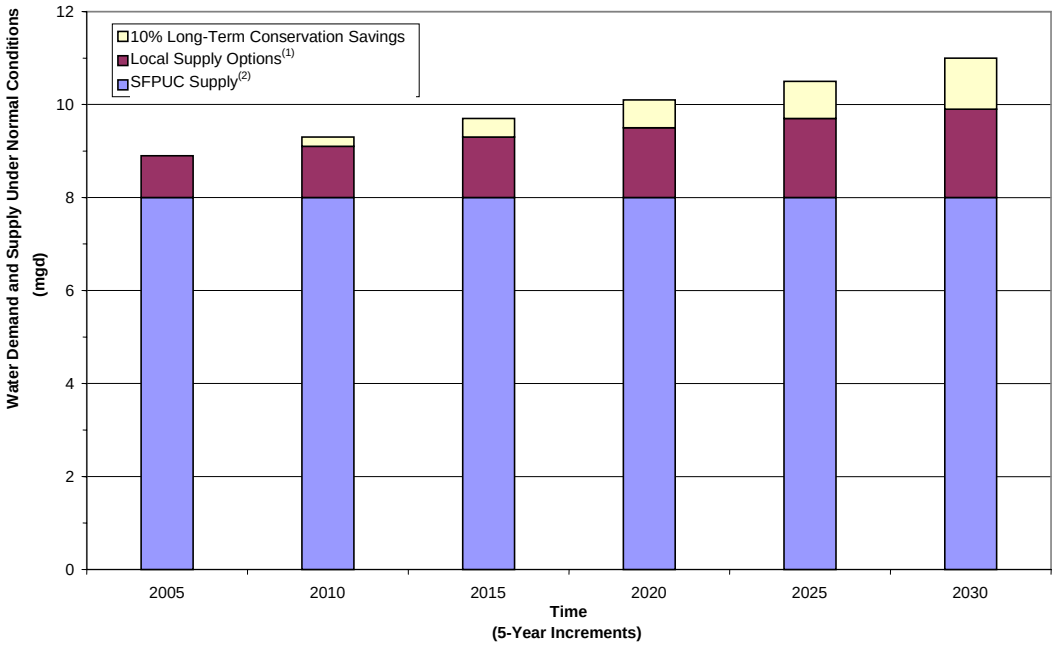
The Year 2030 demand projections show that demand will increase about 28 percent from the current level of 8.6 mgd on an average daily basis up to 11.0 mgd at Year 2030 without accounting for Cal Water's planned conservation program. Implementation of the planned conservation program is expected to result in 10 percent permanent water savings on a long-term basis. With the planned conservation savings, Year 2030 demands are expected to increase only 15 percent over current levels to 9.9 mgd.

Table 6-2
Summary of Demand Projections for South San Francisco System and Comparison to BAWSCA Demand Projections

Demand Condition	*Water Demand*	
	(mgd)	*(AF/year)*
South San Francisco System Demands		
Current Demands	8.6	9,634
Year 2030 Projections (see Section 4 for details)		
Without Conservation	11.0	12,322
With 10% Permanent Long-Term Conservation Savings	9.9	11,090
Year 2030 BAWSCA Demand Projections[(1)]		
South San Francisco system (assumes 10% permanent long-term conservation savings)	9.9	11,090
Mid Peninsula System	18.1	20,276
Bear Gulch System	13.9	15,571
Total for All Three Peninsula Systems[(1)]	*41.9*	*46,937*

(1) BAWSCA demands are the total demands regardless of source of supply. SFPUC derived their purchase estimates (as shown in Table 6-1) based on the information provided by BAWSCA and SFPUC assumptions as to how much would be met from SFPUC versus local supply sources.

Figure 6-1 illustrates the projected growth in demands over time to 2030 under normal demand conditions, and the supplies to meet these demands including SFPUC surface supply at 8 mgd (based on the SFPUC year 2030 purchase estimate in Table 6-1), planned conservation savings of up to 10 percent by Year 2030, and other local supply options that are discussed further in Section 8. In the near-term until additional local supplies are developed, SFPUC surface supply may actually provide a larger amount of the total supply. Figure 6-1 indicates the amount of local supply needed so the year 2030 SFPUC purchase estimate amount is not exceeded.



(1) Local supply would consist of groundwater use plus additional local supply. The figure indicates the amount of local supply needed so that the year 2030 SFPUC purchase estimate is not exceeded.

(2) SFPUC supply is at SFPUC's year 2030 purchase estimate amount. In the near-term until additional local supplies are developed, SFPUC surface water supply may provide a larger amount of the total supply.

Figure 6-1
Water Demand and Supply Projections – Normal Conditions

Table 6-3 summarizes the surface and local supply components under normal conditions at 5-year intervals to 2030, assuming continued reliance on SFPUC supply as a primary source. SFPUC surface supply under normal conditions is assumed to be no greater than the Year 2030 projected purchase estimate of 8 mgd. A baseline level of planned conservation savings to achieve a 10 percent long-term reduction in demand by Year 2030 is assumed from Cal Water's current Urban Water Management Plan. Additional local supply will be needed to meet future demands under normal conditions. In addition, local supply can provide additional reliability in the event of reductions in SFPUC supply during droughts or emergencies.

Table 6-3
Supply Components Required to Meet Normal Demands

Supply Component	Supply Amount									
	Year 2010		Year 2015		Year 2020		Year 2025		Year 2030	
	(mgd)	%	(mgd)	%	(mgd)	%	(mgd)	%	(mgd)	%
SFPUC Supply - assumes constant at year 2030 projected purchase amount, which is a reduction from current levels.	8.0	86%	8.0	82%	8.0	79%	8.0	76%	8.0	73%
Long-Term Conservation Savings from Planned Program (permanent savings - phased in with 10% total reduction by 2030)	0.2	2%	0.4	5%	0.6	6%	0.9	8%	1.1	10%
Local Supply [(1)] (groundwater, recycled water, desalination, higher level of conservation savings, etc.)	1.1	12%	1.3	13%	1.5	15%	1.6	16%	1.9	17%
Total	*9.3*	*100.0%*	*9.7*	*100.0%*	*10.1*	*100.0%*	*10.5*	*100.0%*	*11.0*	*100.0%*

[(1)] Local supply would consist of Cal Water's historic 1.1 mgd annual groundwater use plus additional local supply.

As discussed below, there are issues with respect to the long-term reliability of SFPUC supply, and long-term use of groundwater. These issues are considered in the formulation of the water supply strategy in Section 8. As described in Section 8, future supply will be provided from a combination of SFPUC supply and local supply sources including conservation, groundwater, recycled water, and desalination.

6.3 SFPUC Surface Water Supply Reliability

The reliability of SFPUC surface water supply was evaluated for this master plan, based on available information from SFPUC. Appendix D contains a detailed discussion of this evaluation. Key findings of the evaluation are summarized below.

During emergency or drought conditions, the normal SFPUC surface supply may be reduced. Table 6-4 summarizes the drought/emergency supply reduction amounts, and potential ways to make up the reduction from local supply.

Table 6-4
Emergency/Drought Reductions of SFPUC Supply

Emergency/Drought Supply Cutbacks	***Additional Local Supply Needed to Replace SFPUC Supply*** [(1)]	***Potential Additional Local Supply Options***
Emergency Reductions (critical scenario is major earthquake)		• Emergency conservation measures, water use restrictions. • Additional groundwater supply – assuming implementation of mitigation measures to help maintain groundwater basin sustainability, such as in-lieu recharge and/or recycled water projects. • Desalination (reverse osmosis) to treat Bay or brackish water.
With existing SFPUC supply system – up to 50% reduction for up to 90 days of existing average summer deliveries, which is equivalent to a 50% reduction in Year 2030 average day deliveries. Full service restored after 90 days.	Existing 2 mgd for 90 days	
	Year 2030 4 mgd for 90 days	
After implementation of proposed CIP projects to improve reliability – 30% reduction in Year 2030 average day deliveries for up to 30 days; Year 2030 average day deliveries restored after 30 days. Full service restored after 90 days.	Year 2030 2.4 mgd for 30 days	
Drought Reductions		
With existing SFPUC supply sources – At existing demands, about 13% average reduction over entire 8.5 year design drought period, up to a maximum of 20% during the last 2.5 years. By Year 2030, would be 25% average over the entire 8.5 year period, up to 40% maximum during last 2.5 years.	Existing: 1 to 1.6 mgd (13% on average to 20% maximum)	
	Year 2030: 2 to 3 mgd (25% average to 40% maximum)	
With additional SFPUC supply sources – By Year 2030, up to 20% maximum reduction in SFPUC surface supply during last 2.5 years of the 8.5 year design drought (average of 12% reduction over the entire drought period). Assumes SFPUC obtains additional supply, such as restored Calaveras Dam, desalination, groundwater conjunctive use, recycled water.	Year 2030:1 to 1.6 mgd (12% average to 20% maximum)	

(1) Under the current contract, the percent reduction would be made with respect to the allocation basis. The allocation basis is the average of the following three components: 1) average of the supply assurance amount, 2) average of FY 96-97 thru 98-99 purchase amount, and 3) average of last 3-years purchase just prior to drought.

For reliability planning purposes, it is assumed that a minimum of 2 mgd total local supply may be needed to make-up for reductions in SFPUC supply under drought/emergency conditions. This is based on the amount needed for existing demands with the existing SFPUC supply system, and for Year 2030 demands after implementation of the planned SFPUC Water Supply Improvement Program. If the planned SFPUC projects are not implemented, then 3 to 4 mgd of local supply would

be needed by Year 2030 to make-up for reductions in SFPUC supply during droughts or emergencies.

SFPUC findings indicate that it will take two days to initiate some water service after a major earthquake, and 90 days to restore all facilities. Until all facilities are restored, the existing SFPUC supply system will be able to deliver 50% of the current average summer day demand, which is equivalent to 50% of the Year 2030 average day demand of 300 MGD.

SFPUC's current planning goals include drought cutbacks of up to 20%, based on Year 2030 demands. For planning purposes, SFPUC used an 8.5 year "design drought," similar to extended drought 1987 through 1992, followed by a critically dry conditions similar to 1976-1977. SFPUC's cutbacks would increase throughout the drought period, beginning with smaller cutbacks in the early years, and larger cutbacks in later years.

SFPUC has identified proposed CIP projects to improve the reliability of the water supply system in the event of a major earthquake/disaster, and is investigating some potential additional supplies to improve drought reliability. However, as discussed in Appendix D, there are significant uncertainties regarding the timeframe for implementation due to institutional constraints over which Cal Water and the other SFPUC suburban customers have no control.

Cal Water staff had inquired about the minimum level of supply during emergency needed for health and safety purposes, e.g., drinking water and basic hygiene. The American Red Cross (ARC), Federal Emergency Management Agency (FEMA), and California Office of Emergency Services (OES) recommend a minimum amount of 1 gallon per person per day. This recommended critical water supply of 1 gallon per person per day includes drinking water, food preparation, and essential hygiene related to potential health & safety issues such as hand washing for food preparation, essential dish washing, and first aid-related washing. This amount is typically used by state and federal emergency agencies, and also by some other utilities.

For a buildout population of about 80,000 within the South San Francisco service area, this would be about 0.08 mgd. Planning for an emergency supply from local sources of up to 2 mgd to replace SFPUC supply would also provide capacity to meet the minimum level of critical drinking water demand.

The minimum critical drinking water demand at 1 gallon per person per day is only 0.08 mgd at buildout. Providing 2 mgd of local supply would meet more than this minimum critical need. A 2 mgd local supply would provide for basic sanitation needs that assume up to 5 gallons per person per day, which is a total of 0.4 mgd; and still allow for some fire flow capability. People will need to eliminate non-essential uses, such as irrigation or cleaning/washing that is not essential to health and safety.

The 2 mgd local supply would be conveyed in the distribution system. It is assumed that only potable supply would be conveyed in the distribution system. For major fires, water from the Bay or other non-potable sources may need to be conveyed by helicopters and other emergency vehicles.

The critical demand discussion is based on emergency conditions that are anticipated to be of short duration; perhaps a week or two at the most.

6.4 Groundwater Basin Issues

For this master plan, HydroFocus, a subconsultant to CDM, investigated the local groundwater supply within Cal Water's service area from the Westside Basin, and measures to avoid overdrafting the groundwater basin, such as groundwater recharge and/or recycled water projects. [1]

Key findings of the investigations are summarized below, and were considered in the formulation of the water supply strategy described in Section 8. Appendix E provides a detailed discussion of the findings with respect to local groundwater supply. Appendix F provides a detailed discussion of the findings with respect to local groundwater quality.

The groundwater investigation found that storage volumes are predicted to decrease somewhat over time within the South San Francisco service area, even if groundwater pumping by Cal Water and others is maintained at historic levels. Negative changes in groundwater storage correspond to declining regional groundwater levels. Lowering of groundwater levels can create greater pumping lifts for municipal and private wells, and also increases the potential for saltwater intrusion from San Francisco Bay.

Measures analyzed to mitigate potential long-term declines in groundwater levels from pumping included:

- In-lieu recharge, a conjunctive use approach whereby additional surface water is delivered, when available, to replace groundwater extraction that otherwise would have occurred. Surface water is used "in-lieu-of" groundwater during

[1] The groundwater-flow model is undergoing technical review and, where appropriate, input data sets are being updated and revised by a consultant team representing the City of Daly City, SFPUC, and City of San Bruno. Once the input data sets have been reviewed and updated, the group is to re-calibrate the model and evaluate model uncertainty. The purpose for this collaboration is to develop consensus from basin stakeholders on model input and calibration. The bore hole and well construction information, well production records, and historical well water level data set for Cal Water's South San Francisco District well field is the most extensive in the basin. Furthermore, the model employed for this planning document produces simulated water levels that reasonably match observed groundwater levels, and simulated groundwater conditions respond as expected to changes in recharge and pumpage. Substantial changes in model results for South San Francisco District area are therefore not expected as a result of the ongoing update and recalibration. Nevertheless, the groundwater modeling analysis should be updated when model revisions are completed and accepted. The updated model is scheduled for completion in early summer 2006.

those periods when surface supply is plentiful. During periods of supplemental surface water deliveries, groundwater extraction rates are voluntarily reduced (i.e., surface water supply replaces some or all groundwater supply). During periods of reduced surface water supply, such as during droughts, groundwater extraction rates are increased (i.e., groundwater supply is used to replace unavailable surface water supply). When groundwater extraction is reduced during periods of in-lieu recharge, natural groundwater recharge is retained, thereby storing it in the groundwater basin for future use.

- Aquifer storage and recovery (ASR) whereby surface water is injected in the groundwater using injection wells when surface supplies are available during above normal rainfall and dry years, and then extracted (pumped out) when surface supplies are limited. The injected water supplements natural groundwater recharge, and is stored in the groundwater basin for future use.
- Recycled water use by switching major irrigators and/or other users from groundwater pumping to recycled water. This would permanently remove those groundwater demands that would be met instead from recycled water; thereby increasing the natural groundwater recharge stored in the basin. This would be a permanent shift since recycled water would be available even in dry years.

Table 6-5 summarizes the anticipated level of Cal Water pumping for the various options considered in the groundwater modeling. Without mitigation, groundwater levels and storage volumes may continue to decline and adversely impact the groundwater basin. With the proposed measures, either alone or in combination, it appears Cal Water can continue to pump and may even increase its pumping over historic levels without adversely impacting the groundwater basin.

Key findings include:

- With in-lieu recharge (or with recycled water use at 1,531 ac-ft per year level), it may be possible for Cal Water to pump at 1.4 mgd on average with negligible impacts on groundwater levels and storage. This would represent about 13 percent of the year 2030 total supply requirement.

- With a combination of in-lieu recharge plus recycled water use at 765 ac-ft per year level, it may be possible for Cal Water to increase its pumping to 2.2 mgd on average while maintaining groundwater levels. This would represent about 20 percent of the year 2030 total supply requirement.

- With a combination of in-lieu recharge plus recycled water use at 1,530 ac-ft per year level, it may be possible for Cal Water to increase its pumping to 2.5 mgd on average while maintaining groundwater levels. With an aquifer storage and recovery project, it may also be possible to achieve 2.5 to 2.6 mgd pumping rates. This would represent about 23 to 24 percent of the year 2030 total supply requirement.

Table 6-5
Summary of Groundwater Supply Options for Cal Water Service Area

Option	Cal Water Annual Groundwater Supply (AF/year)	Average Annual Flow Rate (mgd)	Percentage of Year 2030 Total Demand	Comments
Historic Cal Water Groundwater Pumping Level				
Historic pumping with no mitigation (base case)	1,220	1.1	10%	Without mitigation, continued pumping even at historic levels will cause some declines in groundwater storage and groundwater levels over a long period of time. Higher pumping levels would cause greater adverse impacts to the groundwater basin.
Recycled Water Use by Major Irrigators[1]				
765 ac-ft per year of recycled water use (called 50% scenario)	1,220 [2]	1.1	10%	Almost eliminates declines in groundwater storage and groundwater levels. Reduces annual storage decline from minus 470 AF/year to minus 60 AF/year (i.e., reduced to a very small decline, an almost balanced condition).
1,531 ac-ft per year of recycled water use (called 100% scenario)	1,570 [2][3]	1.4	13%	Eliminates declines in groundwater storage and groundwater levels, even with a higher level of Cal Water pumping.
In Lieu Recharge - Conjunctive Use (regional) [4]				
Reduce groundwater use when surface supply available	1,570 [2][4] (on an annualized basis, not dry year pumping)	1.4	13%	Almost eliminates declines in groundwater storage and groundwater levels. Reduces annual storage decline from minus 470 AF/year to minus 40 AF/year (i.e., reduced to a very small decline, an almost balanced condition).
Combined Recycled Water and In-Lieu Conjunctive Use (supply shown is on an average annualized basis, not dry year pumping rates)				
In-lieu recharge plus 765 ac-ft per year recycled water used (50% scenario)	2,410 [2][3]	2.2	20%	Eliminates declines in groundwater storage and groundwater levels. Allows a significantly higher level of Cal Water pumping.
In-lieu recharge plus 1,531 ac-ft per year of recycled water use (called 100% scenario)	2,820 [2][3]	2.5	23%	
Aquifer Storage & Recovery				
Injection of surplus surface water during above normal rainfall and wet years	2,940[2][3] Maximum with distributed well network. May be lower at centralized well field.	2.6	24%	Similar results as combined in-lieu recharge and 100 percent recycled water use by major irrigators.

(1) Recycled water use by major irrigators would switch major private groundwater pumpers, such as cemeteries, from groundwater to recycled water. This would permanently remove those groundwater demands that would be met from recycled water, thereby increasing the natural groundwater recharge stored in the basin. This would be a permanent shift since recycled water would be available even in dry years.
(2) Assumes no change in annual pumping rates by other groundwater users in the basin.
(3) Estimated benefit of combined projects by assuming simulated storage increase of individual projects is fully realized (i.e., the simulated storage benefit is additive). Further analysis of specific combined scenarios is recommended.
(4) In-lieu conjunctive use scenarios assumed a regional project with participation by SFPUC, Daly City, and San Bruno.

An investigation was also conducted as to whether a new distributed network of wells (rather than clustering wells in a wellfield) may provide groundwater supply or quality benefits. The groundwater modeling analysis showed negligible benefits from a new distributed network of wells, rather than remaining at the existing well field. A new distributed well network did not improve supply capability (i.e., a distributed well network in itself does not create additional long-term supply), and water quality issues would be similar requiring treatment of groundwater at either the existing or new locations. However, there may be other benefits, such as system reliability, for considering an additional well field location, as discussed in Section 7.

6.5 Future Water Quality Regulations and Potential Issues

Future water quality regulations that may affect SFPUC and potential SFPUC future treatment changes were reviewed to identify water quality issues that could potentially affect Cal Water. The following treatment/water quality issues are discussed:

- Long Term 2 Enhanced Surface Water Treatment Rule
- Fluoridation
- Lead and Copper Rule
- Nitrification
- Groundwater/Surface Water Blending

Table 6-6 summarizes each of these topics and potential impacts for Cal Water. As noted in Table 6-6, the issues expected to have the most potential impact for Cal Water include groundwater/surface water blending issues and nitrification.

As discussed in Appendix D, the Cal Water South San Francisco District receives the majority of its water from turnouts on the San Andreas 2 and 3 Pipelines in the High Gradient Pressure Zone that is supplied from the Harry Tracy WTP. Cal Water also has three active turnouts and some standby turnouts on the Crystal Springs 2 Pipeline in the Lower Gradient Pressure Zone, receiving a Hetch Hetchy/Sunol Valley WTP blend.

Table 6-6 Summary of Potential Water Quality Issues		
Water Quality Issue	**Overview**	**Implications for Cal Water**
Long Term 2 Enhanced Surface Water Treatment Rule	Regulation will require higher treatment standards for inactivation of the protozoan parasite *Cryptosporidium.* SFPUC is considering implementing ozone or UV for Hetch Hetchy / Sunol Valley sources. Likely no treatment changes or implementation of UV at HTWTP. Ozone affects potential for re-growth in customer systems. UV has no discernible effect on water quality.	Not expected to significantly impact water quality for Cal Water. Potential for re-growth in systems receiving water from SFPUC's Crystal Springs Pipeline if SFPUC implements ozone instead of UV at Hetch Hetchy.
Fluoridation	SFPUC currently fluoridates at the Polhemus Fluoride station and the HTWTP. All Cal Water turnouts receive fluoridated water.	No water quality implications.
Lead and Copper Rule	The Lead and Copper Rule minimizes lead and copper in drinking water through corrosion control practices. SFPUC currently provides corrosion control for its Hetch Hetchy supply by lime addition at the Rock River Lime Plant.	Although considered unlikely, Cal Water may need to provide caustic trim in the future in zones that are served by the Crystal Springs Pipelines, which receive a Hetch Hetchy/Sunol blend.
Nitrification	Nitrification occurs as chloraminated water decays and liberated ammonia is converted to nitrite, then to nitrate, which is a public health concern. A significant factor contributing to nitrification is long detention times (high water age).	Cal Water actively manages reservoirs to minimize detention times, and will need to continue this practice.
Groundwater/Surface Water Blending	Customers receiving changing source water, either intermittently, seasonally, or longer-term, may experience water quality changes, as the system re-equilibrates to changing water chemistry. Water quality changes are primarily aesthetic, but lead release is also a possible issue.	In the future, Cal Water may need to evaluate potential blend areas and options to reduce water quality changes as part of implementation of groundwater supplies.

6.5.1 Long Term 2 Enhanced Surface Water Treatment Rule

EPA promulgated the Long Term 2 Enhanced Surface Water Treatment Rule in January 2006 (LT2ESWTR) to reduce disease incidence associated with the protozoan parasite *Cryptosporidium*. Under the LT2ESWTR, systems will conduct source monitoring to determine what treatment requirements need to be implemented. Accepted treatment practices for *Cryptosporidium* inactivation include chlorine dioxide, ozone or ultraviolet (UV) treatment.

For SFPUC's unfiltered Hetch Hetchy supply, SFPUC will be required to provide 2-log or 3-log inactivation of *Cryptosporidium*, depending on results of the monitoring. Current regulations do not require treatment for *Cryptosporidium*, except through watershed control. The regulations call for monitoring in the first 2 years, followed by treatment improvements to be implemented 6 to 8 years following promulgation of the rule.

At the Harry Tracy WTP, SFPUC's current treatment includes direct filtration. The facility uses both ozone and chloramines for disinfection. SFPUC will either rely on

its existing ozone treatment or add UV to meet LT2EWSR. Implementation of UV is not expected to significant impact delivered water quality.

The Hetch Hetchy supply is currently unfiltered and disinfected. SFPUC is currently considering implementing either ozone or UV for its Hetchy supply to meet LT2EWSTR. Implementing ozone could potentially increase the potential for bacterial re-growth in customers systems. However, water quality with ozone treatment is not expected to significantly differ from water quality of the currently ozonated Harry Tracy supply. Implementation of UV is not expected to significantly impact delivered water quality.

Sunol Valley WTP includes conventional filtration to treat source water from San Antonio and Calaveras Reservoirs. Hetch Hetchy and Sunol Valley supplies are blended at the Alameda Siphons in the Sunol Valley, and chloraminated at the Sunol Valley Chloramination Facility.

In general, treatment changes to meet LT2EWSTR are not expected to significantly impact water served to Cal Water or other customers.

6.5.2 Fluoridation

SFPUC currently fluoridates its Hetch Hetchy/Sunol blend at the Polhemus Fluoride Station, located on the Crystal Springs Bypass Tunnel. SFPUC fluoridates supply from Harry Tracy WTP at the plant. SFPUC recently added fluoridation at the Sunol Valley Chloramination Facility, to serve fluoridated water to South Bay customers.

All Cal Water turnouts currently receive fluoridated water from the SFPUC, so there will be no impact to Cal Water from fluoridation changes in the SFPUC system.

6.5.3 Lead and Copper Rule

The Lead and Copper Rule was promulgated in 1991 to minimize lead and copper in drinking water, primarily by reducing water corrosiveness. It has been suggested that chloramines can accelerate corrosion, so corrosion issues are getting more attention as more systems convert to chloramines for residual disinfection. SFPUC converted to chloramines in February 2004 with no apparent change in lead levels. EPA is proposing updates to the Lead and Copper Rule which will mainly address monitoring, customer communication and replacement of lead services.

SFPUC provides corrosion control by adjusting the pH of its Hetch Hetchy supply through lime addition at the Rock River Lime Plant, located along the Foothill Tunnel, upstream of the pipelines that cross the San Joaquin Valley. Because of the low alkalinity of Hetch Hetchy water, customers who receive a Hetch Hetchy/Sunol Valley WTP supply blend see more fluctuations in pH. SFPUC has made provisions for caustic trim at the Sunol Valley Chloramination Facility, if needed, to maintain a more constant pH. Harry Tracy WTP source water has a higher alkalinity, with more buffering capacity, and therefore has less fluctuation in pH.

Although considered unlikely, Cal Water may need to provide caustic trim in the future, for zones served from the Crystal Springs Pipeline, which receive a Hetch Hetchy/Sunol Valley WTP blend. This would not be needed if SFPUC provides caustic trim at the Sunol Valley Chloramination Facility.

6.5.4 Nitrification

With the SFPUC conversion to chloramine for secondary disinfection, there is increased potential for nitrification to occur in SFPUC and customer systems. Chloramine disinfection includes the addition of chlorine and ammonia to form monochloramine. Over time, as monochloramine decays, ammonia is liberated. Ammonia can provide a food source for nitrifying bacteria that convert the ammonia to nitrite, which accelerates the depletion of the disinfectant residual.

Although many factors contribute to nitrification, a key factor is water age. Nitrification is principally of concern when detention times in the system are very long, typically at reservoirs where demand is low relative to the overall storage volume, or where hydraulic performance limits turnover in the reservoir.

Cal Water currently actively manages reservoirs to maintain adequate turnover and limit potential for nitrification to occur. Potential improvements to increase reservoir turnover typically include either structural changes to provide more flexibility to more rapidly drain storage, such as a bypass valves at a pump station supplying the reservoir, or modifying operational practices to reduce detention time.

6.5.5 Groundwater/Surface Water Blending

There are potential water quality issues for customers with changing source water, either intermittently, seasonally, or longer-term (e.g. drought years), such as by blending groundwater with surface water. Key concerns include antagonistic effects (e.g. a ground water containing iron being introduced into a high pH system resulting in iron staining) and re-equilibration issues as the system responds to water with a different chemistry (i.e., lower pH and higher hardness). Distribution system re-equilibration impacts are typically aesthetic (e.g., dirty/colored/red water). However, there is also potential for lead release, which would be a public health concern (as discussed above for the Lead and Copper Rule).

Another potential issue is how groundwater quality may affect industrial customers that require very high quality process water, e.g., biochemical manufacturers, such as Genentech. Such customers, as is the case with Genentech, typically have internal water treatment systems to “finish” water to the high level of water quality required for their processes, regardless of whether treated surface water or groundwater is supplied. For such customers, the potential impact of blending surface and groundwater would be that it may require more passes through their internal treatment system to achieve the desired process water quality.

Potential items that should be considered if using groundwater as part of the supply mix include:

- Review of planned operating scenarios and how these will affect customers in the area receiving groundwater and surface water. The system hydraulic model developed for the Master Plan could be used to perform source tracing calculations to identify water quality sources for various operating scenarios. This is not part of the Master Plan scope of work, but could be done later in subsequent detailed studies.

- Possible blending of surface water and well water prior to introduction to the distribution system to minimize water quality changes.

Section 7
Water System Analysis

This section describes the water system analysis conducted for Cal Water's South San Francisco system, based on the performance criteria in Section 5. Section 8 describes the water supply strategy. Section 9 presents the integrated plan for water supply and distribution system recommendations.

For reference, Section 4 contains Figure 4-1 showing the modeled system color-coded by pressure zone, Figure 4-2 showing a profile schematic of the system, and Figure 4-3 showing all pipelines color-coded by diameter and the location of all major facilities including reservoirs, pump stations, and turnouts.

7.1 Demands by Zone for Water System Analysis

Table 7-1 shows the average day, maximum day and peak hour demands by zone for existing and buildout conditions. As indicated in Table 7-1, the future growth in demands will occur primarily in five zones: 200 (also serving 280), 330, 360, 380 and 430. The other zones are essentially built-out, and significant redevelopment is not anticipated.

7.2 Calibrated Computer Model for Hydraulic Analyses

A computerized hydraulic model of the South San Francisco system was developed for the water system analysis. The model was developed from the ArcGIS geodatabase provided by Calwater, using H20MAP software version 6.0 by MWHSoft. H20MAP is a stand-alone GIS –based program that combines spatial analysis tools and mapping functions with a versatile hydraulic model.

The model was calibrated using hydrant test data provided by Cal Water, and verification runs were conducted for a recent maximum demand day and minimum demand day using system data provided by Cal Water. The model calibration and verification showed that the model provides a reasonable representation of the South San Francisco system, suitable for planning purposes.

Appendix G contains a detailed description of the H2OMAP hydraulic model developed for this master plan and used for the water system analysis. The appendix describes the modeled facilities and the model demand allocations, as well as the model calibration and verification.

The following water system analysis findings are described in this section: SFPUC turnout capacity evaluation; alternative supply options considered for the distribution system analysis; pumping capacity evaluation; storage capacity evaluation; and pipeline system evaluation.

Table 7-1
Demands by Zone for Water System Analysis

Zone	Existing			Buildout			Comments
	Average Day Demand (mgd)	Maximum Day Demand [1] (mgd)	Peak Hour Demand [2] (mgd)	Average Day Demand (mgd)	Maximum Day Demand [1] (mgd)	Peak Hour Demand [2] (mgd)	
200	4.33	6.50	11.26	5.68	8.52	14.77	60% of the future demand increase is in the 200 zone for primarily business and some residential redevelopment areas.
260	0.52	0.78	1.35	0.52	0.78	1.35	Built-out
265	0.51	0.77	1.33	0.51	0.77	1.33	Built-out
280	0.11	0.17	0.29	0.11	0.17	0.29	280 is very small zone served from 200 biotech business park area. Any future increase in 280 zone is included as part of 200 zone.
285	0.25	0.38	0.65	0.25	0.38	0.65	Built-out
330	1.19	1.79	3.09	1.61	2.42	4.19	18% of the future demand increase for business and residential redevelopment.
360	0.74	1.11	1.92	0.81	1.22	2.11	3% of the future demand increase for primarily residential and some business redevelopment.
380	0.62	0.93	1.61	0.87	1.31	2.26	11% of the future demand increase for redevelopment near Colma BART station.
390	0.15	0.23	0.39	0.15	0.23	0.39	Built-out
415	0.01	0.02	0.03	0.01	0.02	0.03	Built-out
430	0.10	0.15	0.27	0.27	0.41	0.70	7% of the future demand increase is in Terrabay area.
460	0.00	0.00	0.00	0.00	0.00	0.00	Built-out
520	0.06	0.09	0.16	0.06	0.09	0.16	Built-out
555	0.12	0.18	0.31	0.12	0.18	0.31	Built-out
Total	**8.7**	**13.1**	**22.7**	**11.0**	**16.5**	**28.5**	

[1] Maximum day demand at 1.5 times average day demand.
[2] Peak hour demand at 2.6 times maximum day demand.

7.3 SFPUC Turnout Capacity Evaluation

Tables 7-2 and 7-3 compare existing and buildout demands by zone with the capacities of the SFPUC turnouts supplying the system. There is adequate existing SFPUC supply capacity for buildout conditions.

The southern part of the system (zones 200, 265, 280, 390, 430, 460, and 555) has more supply reliability with respect to access to all the alternative supply options. The northern part of the system (zones 260, 285, 330, 360, 380, 415, and 520) is served solely from SFPUC turnouts. In the event of a reduction in SFPUC supply, e.g., during droughts, the SFPUC supply should be used preferentially in the northern part of the system. The southern part could use the other local supplies and supplement with SFPUC water as needed to meet demand.

Table 7-2
Comparison of Supplies and Zone Demand - Existing Conditions with SFPUC Supply Only

Supply Delivered To Zone	Zones Included	Average Day Demand (mgd)	Maximum Day Demand (mgd)	Peak Hour Demand (mgd)	SFPUC Supply		
					SFPUC Active Turnouts (without standbys)	Total Capacity [2] (gpm)	Total Capacity [2] (mgd)
200, 265	200	4.33	6.50	11.26	SSF-02 (10")	4900	7.1
	265	0.51	0.77	1.33	SSF-03 (2-6")	3600	5.2
	280	0.11	0.17	0.29	SSF-09 (8")	3100	4.5
	390	0.15	0.23	0.39			
	430	0.10	0.15	0.27	Note: Turnout capacity equal to maximum day demand is required. Peak hour demand met from storage.		
	460	0.00	0.00	0.01			
	555	0.12	0.18	0.31			
	Subtotal:	*5.33*	*7.99*	*13.85*	*Subtotal:*	*11,600*	*16.7*
285	285	0.25	0.38	0.65	SSF-05 (6")	1800	2.6
	260 [1]	0.52	0.78	1.35			
	Subtotal:	*0.77*	*1.16*	*2.00*	*Subtotal:*	*1800*	*2.6*
330	330	1.19	1.79	4.00	SSF-01 (10")	4900	7.1
360	360	0.74	1.10	1.91	SSF-06 (8")	3100	4.5
					SSF-07 (6")	1800	2.6
					SSF-12 (8")	3100	4.5
	Subtotal:	*0.74*	*1.10*	*1.91*	*Subtotal:*	*8000*	*11.5*
380	380	0.62	0.93	1.61	SSF-13 (6")	1800	2.6
	415	0.01	0.02	0.03	SSF-14 (6")	1800	2.6
	520	0.06	0.09	0.16	SSF-15 (6")	1800	2.6
	Subtotal:	*0.69*	*1.03*	*1.79*	*Subtotal:*	*3600*	*7.8*
Total		**8.7**	**13.1**	**23.6**			**45.7**

[1] 260 Zone can be supplied from either 285 or 330 zones.
[2] Turnout capacity based on standard valve sizes and flow calculations.

Table 7-3
Comparison of Supplies and Zone Demand – Buildout Conditions with SFPUC Supply Only

Supply Delivered To Zone	Zones Included	Average Day Demand (mgd)	Maximum Day Demand (mgd)	Peak Hour Demand (mgd)	SFPUC Supply		
					SFPUC Active Turnouts (without standbys)	Total Capacity [2] (gpm)	Total Capacity [2] (mgd)
200, 265	200	5.68	8.52	14.76	SSF-02 (10")	4900	7.1
	265	0.51	0.77	1.33	SSF-03 (2-6")	3600	5.2
	280	0.11	0.17	0.29	SSF-09 (8")	3100	4.5
	390	0.15	0.23	0.39			
	430	0.26	0.40	0.69	Note: Turnout capacity equal to maximum day demand is required. Peak hour demand met from storage.		
	460	0.00	0.00	0.01			
	555	0.12	0.18	0.31			
	Subtotal:	*6.84*	*10.25*	*17.77*	*Subtotal:*	*11,600*	*16.7*
285	285	0.25	0.38	0.65	SSF-05 (6")	1800	2.6
	260 [1]	0.52	0.78	1.35			
	Subtotal:	*0.77*	*1.16*	*2.00*	*Subtotal:*	*1800*	*2.6*
330	330	1.61	2.42	4.00	SSF-01 (10")	4900	7.1
360	360	0.81	1.22	2.11	SSF-06 (8")	3100	4.5
					SSF-07 (6")	1800	2.6
					SSF-12 (8")	3100	4.5
	Subtotal:	*0.81*	*1.22*	*2.11*	*Subtotal:*	*8000*	*11.5*
380	380	0.87	1.31	2.26	SSF-13 (6")	1800	2.6
	415	0.01	0.02	0.03	SSF-14 (6")	1800	2.6
	520	0.06	0.09	0.16	SSF-15 (6")	1800	2.6
	Subtotal:	*0.94*	*1.41*	*2.44*	*Subtotal:*	*3600*	*7.8*
Total		**11.0**	**16.4**	**28.3**			**45.7**

[1] 260 Zone can be supplied from either 285 or 330 zones.
[2] Turnout capacity based on standard valve sizes and flow calculations.

In the event of a complete outage of SFPUC supply, emergency portable booster pumps could provide a way to lift local supplies from the southerly part of the system to the northerly part. In addition, the northerly part of the system has standby connections with Daly City which has local groundwater supply.

Key findings include:

- Zones not supplied through the 200 zone, which comprise the northerly part of the system, have more than enough SFPUC turnout capacity to meet buildout peak hour demands, and to provide maximum day demand plus fire flow. These zones in the northerly part of the system include: 260, 285, 330, 360, 380, 415, and 520.

- The 200 zone and zones supplied through the 200 zone, which comprise the southerly part of the system, have enough SFPUC turnout capacity to meet buildout maximum day demands, and have storage to meet peak hour demands and fire flows. These zones in the southerly part of the system include: 200, 265, 280, 390, 430, 460, and 555.

- The existing well field at Station 1 pumps into the 200 zone and can therefore provide supply to all the zones that can be served from the 200 zone. The wells can not supply the northerly part of the system that does not get water from the 200 zone.

- The northerly portion of the system has less supply reliability than the southerly part, since it is totally dependent on SFPUC supply. The 380 zone, in particular, has no storage and limited means to get supply from other zones. The other zones have storage or are served by PRVs from zones with storage.

- In the event of a reduction in SFPUC supply, e.g., during droughts, the SFPUC supply should be used preferentially in the northerly part of the system. The southerly part could use the other local supplies and supplement with SFPUC water as needed to meet demand.

In the event of a complete outage of SFPUC supply, the northerly part of the system has standby connections with Daly City which has local groundwater supply. It would improve supply reliability in the northerly part of the system if supply could also be provided from the 200 zone system, which has local groundwater supply; or if future local sources could be located in the northerly area for emergency supply. In Section 8, the water supply recommendations include emergency booster pump tie-ins from the 200 zone to the 380 zone, and potential future well supply in the 380 zone to address this issue.

7.4 Alternative Supply Options for Distribution System

In conducting the water system analysis, several options to supply the distribution system were evaluated to bracket a range of potential conditions. If the distribution system is adequate to handle a variety of sources then Cal Water will have greater flexibility to deal with future supply uncertainties.

The existing distribution system can also accommodate the local supply options that are part of the long-term supply strategy discussed in Section 8, including groundwater, recycled water, and desalination. This will provide Cal Water with flexibility to deal with future supply uncertainties. These options for supplying the distribution system are:

- **All supply from SFPUC turnouts:** This is the current condition and may occur in the future during periods that other local supplies are not being utilized, e.g., during periods when in-lieu recharge may be occurring. There is adequate turnout capacity under existing and buildout conditions. The existing distribution system is also configured to use this option under existing and buildout conditions.

- **With groundwater supply**: Up to 6.0 mgd of groundwater supply can be conveyed through the 200 zone assuming a well field in the vicinity of Station 1, with the remainder of supply from SFPUC turnouts. This hydraulic capacity is more than adequate to convey the anticipated groundwater supply through buildout. The 200 zone and zones served through the 200 zone (southerly part of system) have enough demand to utilize the anticipated groundwater supply. The northerly portion of the system, as currently configured, cannot use groundwater supply.

- **With potential future desalination supply**: Potential future reverse osmosis (RO) supply is a long-term supply option. There are several locations where the existing distribution system can accommodate future RO supply, e.g., potential locations of RO supply delivery points that would be compatible with existing distribution system and minimize/eliminate the need for distribution system improvements. This is discussed further in the Section 8 Water Supply Strategy.

- **With future recycled water supply**: There are two ways that future recycled water may be used, and each would have a different impact on the distribution system, as discussed below:

  1) Using recycled water to replace pumping from private groundwater wells, such as the cemeteries, would greatly benefit groundwater recharge, but will not impact the treated water system requirements, since Cal Water does not supply these demands.

  2) Using recycled water to replace potable use by Cal Water customers for irrigation and industrial uses would reduce potable demands and could impact the treated water system requirements. The timing and extent of

reduction would depend on how a recycled water project is actually implemented. At full implementation, the average day recycled water demand that would replace potable use is about 0.8 mgd, which is a very small percentage of the ultimate demand. Future recycled water use will not affect the recommended improvements.

7.5 Pumping Capacity Evaluation

Tables 7-4 and 7-5 compare the existing pump station capacities with existing and buildout average day and maximum day demands in the zones served by pump stations. Pump station capacity must be sufficient to meet the maximum day demands of the zone it is pumping into and also the maximum day demand for all the zones served through that zone. The tables show the total capacity of the existing pump stations and the firm capacity with the largest pump serving the zone out of service. If there are multiple pump stations serving a zone, only one standby pump is required for the zone.

Key findings from the tables include:

- Existing total pump station capacity is sufficient to meet buildout maximum day demands for those zones served by pump stations.
- Station 1 pumps in the 200 zone are only needed if the groundwater wells are operating or to turn over the reservoir at Station 1. There is existing firm pumping capacity of 4.6 mgd, which is adequate for the anticipated well supply. The Station 1 pump station at the existing well field is also discussed as part of the Section 8 Water Supply Strategy.
- Station 5 has 3 pumps that each pump to a different zone. Two of the zones are supplied by multiple pump stations, so have a backup pump. Pump 5C serving the 555 zone is the only pump now supplying this zone. When station upgrades are done as part of the replacement program, a standby pump should be added to the 555 zone.

Pump Station 3 is not shown on Tables 7-4 and 7-5. It is not needed under normal conditions with the SFPUC turnouts operating. It would only be needed to help boost water across the 200 Zone from Reservoir 1 to Reservoir 2 in the event only the Station 1 wells are operating and large flows are being conveyed across the zone. Section 7.7 discusses the hydraulic analysis findings and recommendations regarding Pump Station 3. As discussed in Section 7.7, no additional capacity is needed. Pump Station 3 is no longer needed with the recommended system configuration.

Table 7-4
Comparison of Pump Station Capacity and Existing Zone Demand

Zone Pumping Into	Zones Included	Existing Average Day Demand (mgd)	Existing Maximum Day Demand (mgd)	Existing Pump Station Capacity				Surplus Capacity for Maximum Day (mgd)
				Pump Station(s)	No. of Units	Firm Capacity [1] (mgd)	Total Capacity (mgd)	
200	200	4.33	6.50	SFPUC turnouts serve the 200 zone directly. Station 1 pumps are only needed if the wells are used. Station 1 firm pumping capacity is 4.6 mgd (total capacity of 7.1 mgd). Station 1 requirements are discussed in the Section 8 Water Supply Strategy.				
	265	0.51	0.77					
	280	0.11	0.17					
	390	0.15	0.23					
	430	0.10	0.15					
	460	0.00	0.00					
	555	0.12	0.18					
	Subtotal:	5.32	7.98					**NA**
260	There are no pump stations serving 260 zone, all supply is from PRVs through 285 or 330 zones served only by SFPUC turnouts.							
265	265	0.51	0.77	Station 2	3	1.1	2.5	
				Station 5-A	1	0.5	0.5	
	Subtotal:	0.51	0.77	**Subtotal:**	4	1.5	3.0	**0.8**
280 [2]	280	0.11	0.17 (0.3 peak hour)	Station 6	2	0.3	0.7	**0**
285	There are no pump stations serving 285 zone, all supply is from SFPUC turnouts.							
330	There are no pump stations serving 285 zone, all supply is from SFPUC turnouts.							
360	There are no pump stations serving 285 zone, all supply is from SFPUC turnouts.							
380	There are no pump stations serving 285 zone, all supply is from SFPUC turnouts.							
390	390	0.15	0.22	Station 4	2	0.28	1.01	
				Station 5-B	1	0.55	0.55	
	Subtotal:	0.15	0.22	**Subtotal:**	3	0.8	1.6	**0.6**
430	430	0.10	0.15	Station 7	2	0.65	1.37	**0.5**
520 [2]	520	0.06	0.09	Station 101	2	0.35	1.07	
	415 (PRV from 520)	0.01	0.02					
	Subtotal:	0.07	0.11 (0.2 peak hour)	Subtotal:	2	0.3	1.1	**0.1**
555	555	0.12	0.17	Station 5-C	1	0.60	0.60	
	460 (PRV from 555)	0.00	0.00					
	Subtotal:	0.19	0.28	Subtotal:	1	0.6	0.6	**0.3**

(1) Firm Capacity = Capacity with largest pump turned off, except for pump stations with only 1 pump which have firm capacity equal to total capacity.

(2) Zones 280 and 520 are hydropneumatic zones. Therefore the pump station must be able to provide the peak hour flow, which is 1.8 times the maximum day demand.

Table 7-5
Comparison of Pump Station Capacity and Buildout Zone Demand

Zone Pumping Into	Zones Included	Buildout Average Day Demand (mgd)	Buildout Maximum Day Demand (mgd)	Existing Pump Station Capacity				Surplus Capacity for Maximum Day (mgd)
				Pump Station(s)	No. of Units	Firm Capacity [1] (mgd)	Total Capacity (mgd)	
200	200	5.68	8.52	SFPUC turnouts serve the 200 zone directly. Station 1 pumps are only needed if the wells are used. Station 1 firm pumping capacity is 4.6 mgd (total capacity of 7.1 mgd). Station 1 requirements are discussed in the Section 8 Water Supply Strategy.				
	265	0.51	0.77					
	280	0.11	0.17					
	390	0.15	0.23					
	430	0.27	0.41					
	460	0.00	0.00					
	555	0.12	0.18					
	Subtotal:	6.84	10.26					**NA**
260	There are no pump stations serving 260 zone, all supply is from PRVs from zones served only by SFPUC turnouts.							
265	265	0.51	0.77	Station 2	3	1.1	2.5	
				Station 5-A	1	0.5	0.5	
	Subtotal:	0.51	0.77	**Subtotal:**	4	1.5	3.0	**0.8**
280 [2]	280	0.11	0.17 (0.3 peak hour)	Station 6	2	0.3	0.7	**0**
285	There are no pump stations serving 285 zone, all supply is from SFPUC turnouts.							
330	There are no pump stations serving 285 zone, all supply is from SFPUC turnouts.							
360	There are no pump stations serving 285 zone, all supply is from SFPUC turnouts.							
380	There are no pump stations serving 285 zone, all supply is from SFPUC turnouts.							
390	390	0.15	0.22	Station 4	2	0.28	1.01	
				Station 5-B	1	0.55	0.55	
	Subtotal:	0.15	0.22	**Subtotal:**	3	0.8	1.6	**0.6**
430	430	0.27	0.41	Station 7	2	0.65	1.37	**0.5**
520 [2]	520	0.06	0.09	Station 101	2	0.35	1.07	
	415	0.01	0.02					
	Subtotal:	0.07	0.11 (0.2 peak hour)	Subtotal:	2	0.3	1.1	**0.1**
555	555	0.12	0.17	Station 5-C	1	0.60	0.60	
	460	0.00	0.00					
	Subtotal:	0.19	0.28	Subtotal:	1	0.6	0.6	**0.3**

(1) Firm Capacity = Capacity with largest pump turned off, except for pump stations with only 1 pump which have firm capacity equal to total capacity.

(2) Zones 280 and 520 are hydropneumatic zones. Therefore the pump station must be able to provide the peak hour flow, which is 1.8 times the maximum day demand.

- All the other zones served by pump stations have sufficient firm capacity to meet maximum day demands at buildout with the largest pump serving the zone out of service. For increased reliability, future upgrades should consider backup pump capabilities.

- There are no pump stations serving the following zones that are supplied solely from SFPUC turnouts: 260, 285, 330, 360 and 380. The only linkages between these zones are some PRVs or check valves from higher to lower zones in the cascade. There is currently no way to move water up the cascade in these zones in the event of loss of SFPUC supply. As discussed in the Section 8 Water Supply Strategy, emergency booster tie-ins are recommended to provide a way to move water from the 200 zone up into the northerly area. In addition, there are standby connections to some zones from the SFPUC Sunset supply line.

Some agencies provide pumping and storage capacity to allow time of use pumping to reduce energy costs. In such cases, pump stations may be sized for 150 percent of the maximum day demand. This sizing allows for operating the pump station during a 16-hour period, and keeping the pumps off for 8 hours during the day (6-hour peak energy cost period plus an hour on either end as an operational cushion). With time-of-use pumping, a larger amount of reservoir storage is needed to store the water for use during the "pumps off" period.

Based on review of existing pumping and storage capacities, there do not appear to be significant opportunities for time of use pumping during summer peak periods with the existing facilities. However, time of use pumping could be used during lower demand periods in the summer when there is available capacity. During the winter, there is typically no significant differential in time of use energy rates. Previous projects have indicated it is generally not cost-effective to build new facilities solely to allow for time-of-use pumping. It is typically a very long payback period before annual energy savings would recover the capital cost expenditures for new facilities.

7.6 Storage Capacity Evaluation

Distribution system storage is comprised of the following three components: operational (balancing) storage, emergency supply, and fire reserves. Depending on the specific system characteristics, the amount of total storage capacity in a system typically ranges from 0.5 to 1.5 of the maximum day demand of a system. For the South San Francisco system, the total recommended storage is about 1.2 times the maximum day demand based on the recommended criteria in Section 5. The total recommended storage is comprised of operational storage at 25 percent of the maximum day demand, emergency storage at one average day demand, plus fire reserve.

Table 7-6 summarizes the additional storage needed by area for existing and buildout demands. Tables 7-7 and 7-8 provide detailed breakdowns by area for existing and buildout of the average and maximum day zone demands, the required storage for

each component (operational, emergency, fire), and the additional storage needed to meet the requirements.

Table 7-6
Summary of Additional Storage Requirements

SEE TABLES 7-7 AND 7-8 FOR DETAILED BREAKDOWNS OF STORAGE COMPONENTS FOR EXISTING AND BUILDOUT
Storage Criteria: Operational at 25% times maximum day demand; Emergency at 1 times average day demand; plus Fire Reserve
Total Storage: 1.8 times average day (1.2 times maximum day)

Service Area	***Reservoir Serving Area***	***Existing Storage (mg)***	***Additional Storage Needed (mg)***		***Comments***
			Existing	***Buildout***	
200	RES 1, RES 2	3.00			Zone 200 and 280 is the largest area, and requires the most storage. Groundwater supply could be used to provide some of the required supply, in lieu of reservoir storage.
	STA 1 Tank	0.50			
280 via hydropneumatic station		0.00			
Subtotal for 200 and 280		***3.50***	***3.2***	***5.1***	
265	RES 4 (two tanks)	**0.50**	**0.8**	**0.8**	
285	RES 10	0.50			In northerly part of system, all supply from SFPUC turnouts.
330	RES 7-1, RES 7-2	0.75			
260 by PRV from 285 or 330		0.00			
Subtotal for 285,330,260		***1.25***	***2.3***	***2.8***	
360	RES 11	**1.00**	**0.6**	**0.7**	
380	No storage	**0.00**	**1.5**	**1.8**	380 Zone has no storage. Served by many SFPUC turnouts.
390	RES 3	**0.05**	**0.40**	**0.40**	
430	RES 12	**1.00**	**0.0**	**0.0**	Has adequate storage to accommodate buildout.
520	RES 101	0.25			Built out and has adequate storage.
415 via PRV from 520		0.00			
Subtotal for 520 and 415		***0.25***	***0.0***	***0.0***	
555	RES 9	0.50			Built out and has adequate storage.
460 via PRV from 555		0.00			
Subtotal for 555 and 460		***0.50***	***0.0***	***0.0***	
Totals		**8.50**	**8.4**	**11.2**	

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Table 7-7
Breakdown of Storage Requirements for Existing Conditions

Storage Criteria: Operational storage at 0.25 times maximum day demand; Emergency storage at 1 times average day demand; plus Fire Reserve
Total Storage = 1.8 times average day demand
1.2 times maximum day demand

Service Area	Reservoir Serving Area	Average Day Demand (mgd)	Maximum Day Demand (mgd)	Maximum Fire Flow Requirement (gpm)	Storage Requirements (mg)				Existing Storage (mg)	Additional Storage Needed		
					Operational (at 25% of max day demand)	Emergency (as one average day demand)	Fire Reserve (mg)	Total Storage Needed (mg)		Storage Deficit (mg)	Storage Surplus (mg)	Total Additional Storage Needed (mg)
200	RES 1, RES 2, STA 1 Tank	4.33	6.50	3500	1.62	4.33	0.63	6.58	3.50	3.08	0.00	
280 via hydropneumatic station		0.11	0.17	3500	0.04	0.11	0.00	0.15	0.00	0.15	0.00	
Subtotal for 200 and 280		***4.44***	***6.66***		***1.67***	***4.44***	***0.63***	***6.74***	***3.50***	***3.24***	***0.00***	***3.24***
265	RES 4 (two tanks)	**0.51**	**0.77**	3500	**0.19**	**0.51**	**0.63**	**1.33**	**0.50**	**0.83**	**0.00**	**0.83**
285	RES 10	0.25	0.38	1500	0.09	0.25	0.18	0.52	0.50	0.02	0.00	
330	RES 7-1, RES 7-2	1.19	1.79	3500	0.45	1.19	0.63	2.27	0.75	1.52	0.00	
260 by PRV from 285 or 330		0.52	0.78	3500	0.20	0.52	In 330 zone	0.72	0.00	0.72	0.00	
Subtotal for 285,330,260		***1.96***	***2.94***		***0.74***	***1.96***	***0.81***	***3.51***	***1.25***	***2.26***	***0.00***	***2.26***
360	RES 11	**0.74**	**1.11**	3000	**0.28**	**0.74**	**0.54**	**1.56**	**1.00**	**0.56**	**0.00**	**0.56**
380	No storage	**0.62**	**0.93**	3500	**0.23**	**0.62**	**0.63**	**1.48**	**0.00**	**1.48**	**0.00**	**1.48**
390	RES 3	**0.15**	**0.23**	2000	**0.06**	**0.15**	**0.24**	**0.45**	**0.05**	**0.40**	**0.00**	**0.40**
430	RES 12	**0.10**	**0.15**	1500	**0.04**	**0.10**	**0.18**	**0.32**	**1.00**	**0.00**	**0.68**	**0.00**
520	RES 101	0.06	0.09	1500	0.02	0.06	0.18	0.26	0.25	0.01	0.00	
415 via PRV from 520		0.01	0.02	1500	0.00	0.01	0.00	0.02	0.00	0.02	0.00	
Subtotal for 520 and 415		***0.07***	***0.11***		***0.03***	***0.07***	***0.18***	***0.28***	***0.25***	***0.03***	***0.00***	***0.00***
555	RES 9	0.12	0.17	2000	0.04	0.12	0.24	0.40	0.50	0.00	0.10	
460 via PRV from 555		0.00	0.00	1500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Subtotal for 555 and 460		***0.12***	***0.18***		***0.04***	***0.12***	***0.24***	***0.40***	***0.50***	***0.00***	***0.10***	***0.00***
Totals		**8.71**	**13.07**		**3.27**	**8.71**	**4.08**	**16.06**	**8.05**	**8.78**	**0.78**	**8.76**

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Table 7-8
Breakdown of Storage Requirements for Ultimate Conditions

Storage Criteria: Operational storage at 0.25 times maximum day demand; Emergency storage at 1 times average day demand; plus Fire Reserve
Total Storage = 1.7 times average day demand
1.2 times maximum day demand

Service Area	Reservoir Serving Area	Average Day Demand (mgd)	Maximum Day Demand (mgd)	Maximum Fire Flow Requirement (gpm)	Storage Requirements (mg)				Existing Storage (mg)	Additional Storage Needed		
					Operational (at 25% of max day demand)	Emergency (as one average day demand)	Fire Reserve (mg)	Total Storage Needed (mg)		Storage Deficit (mg)	Storage Surplus (mg)	Total Additional Storage Needed (mg)
200	RES 1, RES 2, STA 1 Tank	5.68	8.52	3500	2.13	5.68	0.63	8.44	3.50	4.94	0.00	
280 via hydropneumatic station		0.11	0.17	3500	0.04	0.11	0.00	0.15	0.00	0.15	0.00	
Subtotal for 200 and 280		***5.79***	***8.69***		***2.17***	***5.79***	***0.63***	***8.59***	***3.50***	***5.09***	***0.00***	***5.09***
265	RES 4 (two tanks)	**0.51**	**0.77**	3500	**0.19**	**0.51**	**0.63**	**1.33**	**0.50**	**0.83**	**0.00**	**0.83**
285	RES 10	0.25	0.38	1500	0.09	0.25	0.18	0.52	0.50	0.02	0.00	
330	RES 7-1, RES 7-2	1.61	2.42	3500	0.60	1.61	0.63	2.84	0.75	2.09	0.00	
260 by PRV from 285 or 330		0.52	0.78	3500	0.20	0.52	In 330 zone	0.72	0.00	0.72	0.00	
Subtotal for 285,330,260		***2.38***	***3.57***		***0.89***	***2.38***	***0.81***	***4.08***	***1.25***	***2.83***	***0.00***	***2.83***
360	RES 11	**0.81**	**1.22**	3000	**0.30**	**0.81**	**0.54**	**1.65**	**1.00**	**0.65**	**0.00**	**0.65**
380	No storage	**0.87**	**1.31**	3500	**0.33**	**0.87**	**0.63**	**1.83**	**0.00**	**1.83**	**0.00**	**1.83**
390	RES 3	**0.15**	**0.23**	2000	**0.06**	**0.15**	**0.24**	**0.45**	**0.05**	**0.40**	**0.00**	**0.40**
430	RES 12	**0.27**	**0.41**	1500	**0.10**	**0.27**	**0.18**	**0.55**	**1.00**	**0.00**	**0.45**	**0.00**
520	RES 101	0.06	0.09	1500	0.02	0.06	0.18	0.26	0.25	0.01	0.00	
415 via PRV from 520		0.01	0.02	1500	0.00	0.01	0.00	0.02	0.00	0.02	0.00	
Subtotal for 520 and 415		***0.07***	***0.11***		***0.03***	***0.07***	***0.18***	***0.28***	***0.25***	***0.03***	***0.00***	***0.00***
555	RES 9	0.12	0.17	2000	0.04	0.12	0.24	0.40	0.50	0.00	0.10	
460 via PRV from 555		0.00	0.00	1500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Subtotal for 555 and 460		***0.12***	***0.18***		***0.04***	***0.12***	***0.24***	***0.40***	***0.50***	***0.00***	***0.10***	***0.00***
Totals		**10.97**	**16.45**		**4.11**	**10.97**	**4.08**	**19.16**	**8.05**	**11.66**	**0.55**	**11.64**

Table 7-9 summarizes the key findings regarding additional storage required for the South San Francisco system. In some zones, as noted in the table, wells may provide some or all capacity in lieu of emergency storage in tanks. Wells require backup power to be considered as a replacement for emergency storage.

Table 7-9
Summary of Key Findings for Reservoir Storage

Service Area	***Additional Storage Required (MG)***	***Key Findings***
200 (and 280 via hydropneumatic)	3.0 in near-term 2.0 additional by buildout (use wells in lieu of tank storage for emergency storage)	Due to limited available sites for new tanks and the goal to develop local supply to increase supply reliability, provide well capacity for emergency storage in lieu of constructing new tank storage. The wells would be available for emergency supply in the event of an outage of normal supply. This is discussed further in the Section 8 Water Supply Strategy.
265	1.0 (for emergency storage and fire reserve)	Additional storage needed at or in vicinity of RES 4 site. Options to investigate during predesign: – Replace both existing 0.25 MG tanks with new 0.75 MG tanks. – Replace one existing 0.25 MG tank with a new 1.0 MG tank. – Build new 1.0 MG tank in the vicinity of the two existing 0.25 MG tanks.
330 (and 260 by PRV)	1.5 in near-term 0.5 by buildout Plus emergency connections to utilize surplus storage from Zone 430. (for emergency storage and fire reserve)	Additional storage needed at or in vicinity of RES 7 site. Options to investigate during predesign: – Replace existing 0.25 MG tank with a new 2 MG tank, or with two 1 MG tanks. – Build new 2 MG tank in the vicinity of the existing tanks Since difference between near-term and buildout storage amount is very small, it is more cost effective to construct all the required storage at once rather than adding a small amount at a later time. In addition, emergency connections would feed water from surplus storage in Zone 430 through Zone 390 into Zone 330. The emergency interconnections would require minimal pipe improvements, since pipes of adequate hydraulic capacity are close at the potential zone connections. Surplus storage in Zone 430 is 0.7 MG under existing conditions and 0.45 MG at buildout.
360	0.5 (for emergency storage)	Additional storage needed at or in vicinity of RES 11 site. Options to investigate during predesign: – Build new 0.5 MG tank in vicinity of existing tank. – Replace existing 1.0 MG tank with new 1.5 MG tank, or with two 0.75 MG tanks. Another option would be to construct 0.5 mgd well capacity with treatment in Zone 360 to provide the emergency storage. This would require 2 to 3 wells (at 150-200 gpm average capacity for each well) with treatment facility.
380	1.5 Only emergency and fire storage is needed in Zone 380. Operational storage is not needed due to the large number of SFPUC turnouts.	As discussed in Section 8 Water Supply Strategy, wells have been identified to provide emergency supply and emergency storage for the northerly area. This will increase the supply reliability in the area that is currently served only by SFPUC turnouts. To provide the equivalent of 1.5 MG storage would require 5 to 6 wells at average 200 gpm capacity each. Another option would be to construct a 1.5 MG tank in this area. The general area identified for potential well sites would also be suitable hydraulically for tank storage. For this option, a pump station would be needed to boost water from the tank into the zone. Pump station would discharge to existing 12-inch pipeline, which can accommodate a maximum flow of about 2000 gpm.
390	0.40	Existing old 0.05 MG redwood tank should be replaced with new 0.5 MG tank to provide all the required storage in the zone.

7.7 Pipeline System Evaluation

The evaluation of pipeline capacity deficiencies was based on the following pressure criteria under high demand conditions:

- Minimum pressures for maximum day and peak hour demands = 40 psi
- Minimum pressure for maximum day demand plus fire flow = 20 psi

For the analysis of the distribution system pipelines, the following simulations were conducted: peak hour on the maximum day, fire flow on the maximum day, and extended period simulation to check reservoir cycling.

The hydraulic analysis results indicate that no distribution system improvements are needed to provide adequate pressures to meet peak hour demands on the maximum day, even at buildout. This assumes normal supply conditions with SFPUC turnouts operating, pump stations operating, and reservoirs operating within the top 25% of capacity. The system is hydraulically strong due to the many turnouts and reservoirs distributed throughout the zones, which minimizes the need to convey large amounts of water for long distances across the system.

In addition, the analysis also identified pipelines with high velocities or headlosses. The criterion for maximum velocity was 7 ft/sec for maximum day and peak hour demand conditions, and 10 ft/sec for maximum day plus fire flow. The criterion for maximum headlosses was 10 ft/1000 ft for all non-fire demand conditions, and no limit on headlosses for maximum day plus fire flow.

Some pipelines have high headlosses and/or high velocities; however, system pressures are adequate to meet the performance criteria. Existing pipes are not identified for improvement based solely on high headlosses and/or velocities, if the pressures in the system meet the criteria. Figure 7-1 shows the locations of the high headloss and high velocity pipes, i.e., those pipes that exceeded the performance criteria. Cal Water can use this information if the pipes require replacement for leaks or breaks, to evaluate whether a larger diameter pipe may be warranted to reduce headlosses.

A fire flow analysis of the entire system was conducted using the H2OMAP fire flow simulator module. The fire flow amounts are based on the City of South San Francisco's current fire protection ordinance, which are provided in the Section 5 performance criteria. Appendix H contains a report of the results showing the available fire flow at 20 psi residual pressure at all service nodes. This fire flow report is with the reservoirs at 75% full, and with the pump stations and SFPUC turnouts operating. It should be noted that these analysis results are based on model calculations and may not be reasonable or achievable in the field.

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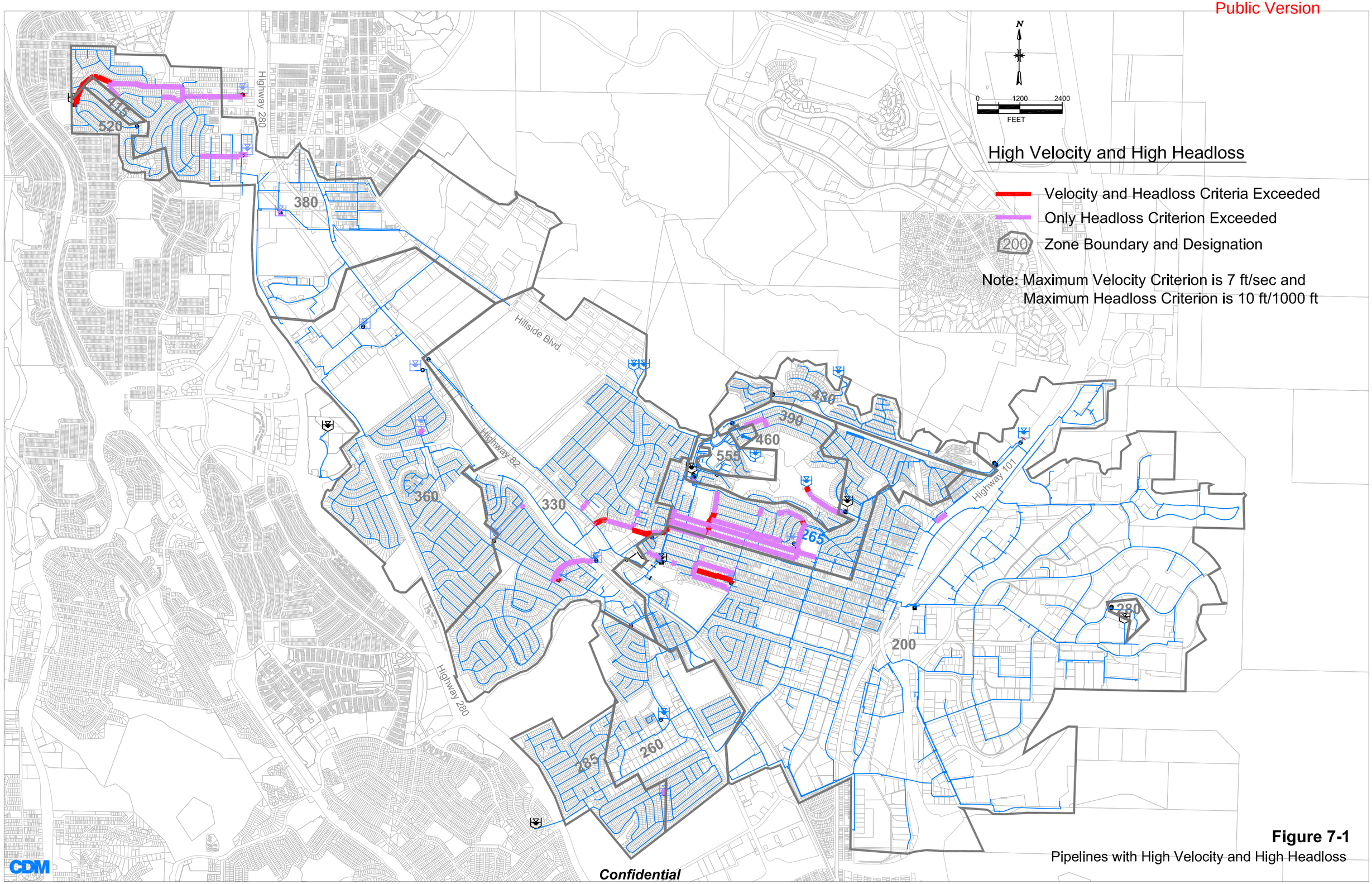

Figure 7-1
Pipelines with High Velocity and High Headloss

Confidential

The existing system was developed prior to the current fire flow standards recently adopted by the City of South San Francisco. Cal Water would not undertake upgrades to the existing system to meet the new standards. However, Cal Water could use the information on the available fire flow as a factor in evaluating future replacement projects.

Pressure at fire flow locations depends on the available head in the zone as well as the head loss in the system and the flow required. However, in general, the required fire flow amounts per the City's current ordinance would likely not be met in areas with:

- Small diameter dead-end pipes, generally less than 6-inch diameter;
- 8-inch diameter dead-end pipes serving high ground elevation areas or very long dead-end segments;
- Loops of 4-inch diameter pipes at the zone periphery located away from supply sources.

The pipeline analysis also investigated the ability to move water across the 200 Zone from the Station 1 wellfield. Pump Station 3 is not needed under normal conditions with the SFPUC turnouts operating. The original purpose of Pump Station 3 was to help boost water across the 200 zone from Reservoir 2 to Reservoir 1 in the event only the wells are operating and large flows are being conveyed across the zone. Based on the hydraulic modeling, flows of up to 5.7 mgd can be conveyed across the 200 Zone from the wells via Reservoir 2 without the use of Pump Station 3. The ultimate maximum capacity of the Station 1 well field would be 5 mgd at most for short-term emergency supply. Therefore, it appears that Pump Station 3 is not needed with the current system configuration.

It is recommended that Cal Water consider abandoning Pump Station 3. It will be necessary to put in valving/controls to limit the amount of flow from Reservoir 1 to serve demands on the east side of the 200 zone, and force more water to be taken from Reservoir 2 (well field) to the east side. Otherwise, demands in the east part of the 200 zone would tend to preferentially take too much water from Reservoir 1 and drop its level too low, since Reservoir 2 is located so much farther away. For example, a valve at Reservoir 1 that would close when the water level dropped to a set minimum level to force demands to be met from Reservoir 2.

Without the SFPUC turnouts, the hydraulic gradeline in the 200 zone is set by Reservoir 2. If a higher hydraulic gradeline is desired under emergency conditions without the SFPUC turnouts in order to convey higher flows than 5.7 mgd without Pump Station 3, it is recommended that Cal Water install a direct pipe connection from the dedicated pipeline between Station 1 to Reservoir 2 to the 18-inch transmission pipeline that runs east-west between Reservoir 2 and Reservoir 1. This would require only a relatively short length of new pipeline. Under normal conditions with the SFPUC turnouts, the valves could be set to isolate the pipeline from the well field to Reservoir 2. Under emergency conditions with all supply from the wells, the

valves could be opened to allow direct flow from the well field to both Reservoir 2 and Reservoir 1.)

7.8 Replacement Guidelines

In general, the South San Francisco facilities are well maintained, although old with respect to typical useful life expectancies. This section summarizes guidelines regarding useful life and replacement priorities for Cal Water's use in their replacement program. Appendix B describes the facilities assessment (site visits) conducted for the master plan, and the findings regarding the condition of existing pumping, storage, treatment, and other facilities. Appendix C evaluates the existing SCADA system.

7.8.1 Useful Life Expectancies

Table 7-10 summarizes the typical range of useful life assumptions for major water system components. One column shows the typical average services lives for water system facilities identified in the CPUC Standard Practice for "Determination of Straight-Line Remaining Life Depreciation Accruals". A second column shows general ranges for useful life based on CDM's review of professional literature, engineering judgment, and our experience with similar water systems.

Based on the age of the water system facilities and the general ranges of useful life expectancies, the remaining useful life of the facilities can be estimated. As discussed in CPUC Standard Practice U-4-W, there are several ways of estimating remaining useful life including direct engineering judgment, forecasts based on typical useful life and age of the facility, and survivor curves of probably remaining life if any are available that are representative of the type of facility.

The remaining useful life estimates are an indicator of when rehabilitation or replacement may be needed. Many variables determine the actual service life of specific facilities, such as the design, installation, maintenance procedures, and local conditions. Utilities typically plan their rehabilitation and replacement programs using not only useful life expectancies, but also information on the actual condition of their facilities, such as leak/break records for pipelines, and maintenance/repair records and field assessments of pump stations and reservoirs.

Table 7-10 Useful Life Expectancies		
Item	***Typical Average Service Lives from CPUC Standard Practice U-4-W (years)***	***General Range for Useful Life from CDM Review of Literature and Other Water Agencies (years)***
Storage Facilities		
Pre-stressed concrete reservoirs	25 - 100	50 - 75
Cast in place concrete reservoirs		60 - 75
Steel tanks		40 – 60 (with periodic repainting)
Pump Stations		
Structures	20 - 60	40 – 50
Pumps & mechanical equipment	15 - 35	20 – 25
Electrical		10 – 20
Instrumentation (telemetry)		7 – 10
Electrical backup generator		20 – 25
Water Treatment Plant		
Structures and improvements	20 - 60	Not available
Water treatment plant equipment	15 - 40	Not available
Wells	20 - 40	Pumps & electrical equipment based on same values as for pump stations.
Pipelines (Ranges shown assume good design, fabrication, installation, and maintenance. These are overall system-wide ranges. Timeframe may be shorter in specific areas, if leak/repair history indicates recurring problems in areas.)		
Asbestos cement (ACP)	50 - 100	50 minimum, could be 80 to 100 under excellent conditions.
Cast iron (CIP)	50 - 100	100 in non-corrosive soil 50 – 75 in moderately corrosive soil with proper cathodic protection 25 – 50 in extremely corrosive soil with proper cathodic protection
Ductile iron (DIP), steel	50 - 100	100 in non-corrosive soil 50 – 75 in moderately corrosive soil with proper cathodic protection 25 – 50 in extremely corrosive soil with proper cathodic protection
Plastic (PVC)	25 - 50	50 minimum, could be100 under excellent conditions.
Appurtenances		
Valves	15 - 40	25
Water Service Meters	20 - 40	15 – 20
Fire Hydrants	25 - 50	25 - 50

7.8.2 Existing Wells and Treatment Facility

Table 7-11 summarizes the ages of the existing wells. Six of the eight active wells are over 50 years old. However, the pumps and motors at all wells are 12 years or less.

Table 7-11
Age of Existing Wells

Well ID	Year Drilled	Well Age (years)	Pump Install Date	Pump Age (years)	Motor Install Date	Motor Age (years)
1-14	1923	83	1998	8	1998	8
1-15	1925	81	2001	5	2001	5
1-17	1937	69	1994	12	1994	12
1-18	1940	66	1998	8	1998	8
1-19	1947	59	2000	6	2000	6
1-20	1972	34	1999	7	1999	7
1-21	1976	30	1995	11	1995	11

The master plan includes recommendations in Section 8 for new wells at the Station 1 well field to provide additional supply reliability. When the new wells are constructed, they can be used preferentially over the older existing wells. The existing wells would remain as backup for supply reliability during times of reduced surface water supply. In the future (long-term), the condition of the existing wells can be evaluated in detail for future rehabilitation or replacement to improve pumping efficiencies.

The master plan also includes recommendations in Section 8 for expansion and upgrades at the existing treatment facility. The existing pump station at Station 1 has relatively new pumps and motors, installed in 1998 and 2001.

As described in Appendix B, the existing plant lacks significant operational flexibility or redundancy, which makes operating various well combinations difficult, or if equipment malfunctions. These issues should be addressed in the future expansion.

7.8.3 Pump Stations

Table 7-12 summarizes the ages of the existing pump stations, and their pumps and motors. Appendix B discusses the field visits to each station.

Table 7-12
Age of Existing Pump Stations

Pump Station Number	Year Station Constructed	Station Age (years)	Pumps	Pump Install Date	Pump Age (years)	Motor Install Date	Motor Age (years)
2	1950	56	A	1950	56	1950	56
			B	1950	56	1950	56
			C	1952	54	1952	54
3	1950	56	A	1950	56	1950	56
			B	1950	56	1950	56
4	1958	48	A	1987	19	1955	51
			B	1958	48	1958	48
5	1956	50	A	1956	50	2001	5
			B	1997	9	1997	9
			C	1968	38	1999	7
6 (hydropneumatic)	1979	27	A	1979	27	1979	27
			B	1979	27	1979	27
7	1990	16	A	1990	16	1990	16
			B	1990	16	1990	16
101 (hydropneumatic)	1963	43	A	1963	43	1963	43
			B	1963	43	1963	43

As noted in Table 7-5, the existing pump stations have adequate pumping capacity to meet ultimate demands. Priorities for rehabilitation/replacement based on age should consider whether zone has backup supply or backup pump, how often the facility is used, and the frequency of maintenance which will affect the condition of the equipment. Typically, the mechanical and electrical equipment will require major rehabilitation or replacement; while often structures can be maintained and repaired.

Priorities for replacement/rehabilitation are noted below in descending order (highest priority first):

- Addition of a standby pump for Pump 5-C at Station 5 is recommended so that there is a backup pump for Zone 555. All the other zones have a backup pump.
- Pump Station 5 had recent replacement of all motors, and one of the pumps. The other pumps should be inspected for replacement in the near future (over the next 5 to 10 years). In particular, Pump 5-C is an old pump that is the only pump to Zone 555, as noted in the bullet above.

- Station 101 serves the small 520 zone (hydropneumatic) and is the only means to supply this zone. When the hydropneumatic tank is replaced, a larger tank should be considered to reduce cycling time to 4 to 6 cycles per hour.

- Pump Station 2 is among the oldest stations with the oldest pumps and motors. Pump Station 2 supplies the 265 zone (Reservoir 4), which is also served by Pump Station 5-A. When the Station 2 pumps and motors are replaced, fewer and smaller pumps could be installed while still meeting the performance criteria for pumping capacity. Currently there are 3 pumps at Station 2. Two pumps approximately equal in size to Pump 5-A would meet the performance criteria for pumping to its service area. One of the pumps would serve as the standby pump. Pump 5-A should also be inspected for replacement since it was installed in 1956, although the motor was recently replaced.

- Pump Station 4 is an older station that supplies the 390 zone (Reservoir 3), which is also served by Pump Station 5-B. When the Station 4 pumps and motors are replaced, fewer and smaller pumps could be installed while still meeting the performance criteria for pumping capacity. Currently there are 2 pumps at Station 4. One pump approximately equal in size to the existing small pump (195 gpm) would meet the performance criteria for pumping to its service area. Pump 4-A (the smaller pump) was replaced in 1987, although the motor was not replaced. Pump 5-B (pump and motor replaced in 1997) would be considered the standby pump, since it is the larger pump.

The other pump stations are discussed below.

- Pump Station 6 has been redesigned by Cal Water and is currently being modified to accommodate the needs of Genentech. This pump station serves only a small area with high elevations on the Genentech campus.

- Pump Station 7 serving the Terrabay area is the newest station built in 1990. This is the lowest priority for rehabilitation/replacement, unless the facilities should experience problems that need correction.

- As discussed in Section 7.7, it is recommended that Cal Water consider abandoning Pump Station 3. It is not needed with the current system configuration.

7.8.4 Reservoirs

Table 7-13 summarizes the age of the existing reservoirs. Appendix C discusses the findings of the field visits to each reservoir. The comments column of Table 7-13 identifies key findings with respect to facility condition and/or need for additional storage capacity in the zone served by the reservoir. If additional storage capacity is needed in a zone with old facilities, these reservoirs would be good candidates for replacement with larger new facilities.

Table 7-13
Age of Existing Reservoirs

Reservoir Number	Material	Year Constructed	Age (years)	Comments
1	Lined, Earthen	1922	84	Additional storage capacity is required in Zone 200. Replacement with larger tanks should be evaluated to determine if there is sufficient site space, due to the age of the existing facilities. A combination of larger tanks and well capacity for emergency storage could be used to meet the ultimate storage needs.
2	Concrete	1923	83	
3	Redwood	1945	61	High priority for replacement or major rehabilitation (new steel rod hoops and seismic upgrade). Existing tank may fail during major earthquake.
4-3	Steel	1947	59	Additional storage capacity is needed for Zone 265. Replacement of existing tanks with new larger tanks should be considered due to age of the existing tanks.
4-3	Steel	1951	55	
7-1	Steel	1953	53	Additional storage capacity is needed for Zone 330. Replacement of existing tanks with new larger tanks should be considered due to age of existing tanks.
7-2	Steel	1956	50	
9	Steel	1968	38	These tanks are relatively new compared to others. Regular maintenance (re-coating, cathodic protection) is needed for steel reservoirs to prolong their life.
10	Steel	1970	36	
11	Steel	1972	34	Additional storage capacity is needed for Zone 360. Existing tank is relatively new compared to others, but could be considered for replacement with a larger tank.
12	Steel	1992	14	Newest tank.
101	Steel	1949	57	When the pump station is rehabilitated, the existing tank should be inspected for major rehabilitation or replacement needs. The existing tank has more than adequate storage capacity for ultimate demands.
Clearwell at Station 1	Steel	1940	66	As part of future expansion of the treatment plant, replacement of the clearwell could be considered.

Rehabilitation/replacement of reservoirs should consider seismic improvements for all reservoirs, measures to maintain water quality (turnover) at all reservoirs, cathodic protection for steel reservoirs, and security at all sites.

Reservoir 3, an old redwood tank, may be severely damaged during an earthquake, e.g., may fall over. This tank would be a high priority for major rehabilitation (new steel rod hoops and seismic upgrade) or replacement. Changes to the controls for Pump Station 4 that feeds Reservoir 3 should be considered in the event of loss of Reservoir 3.

Most of the tanks are not seismically anchored, and rely on friction between the tank and the pad to prevent horizontal movement during a large seismic event. Due to their large diameter relative to height, the tanks are not generally prone to overturning. The primary concern during a seismic event is overall flexing of the tank wall due to sloshing of the water in the tank and some potential movement of the tank. The flexible pipe connections already on most tanks are intended to reduce the potential for failure of the tank connections.

Due to the high hydraulic gradeline at the SFPUC turnouts, many reservoirs tend to have low turnover, particularly during low demand periods. Cal Water has recently implemented modifications to improve turnover such as: installing a small jockey pump to force flow out of the reservoir against the SFPUC hydraulic gradeline, or adding automatic controls at the SFPUC turnouts to temporarily shut down the connection and allow reservoir flow. Other structural design measures recommended by AWWA are to enhance jet flow at the inlet mixing and/or to have separate inlet and outlet pipes if the zone configurations permit.

7.8.5 Pipeline Replacement

Section 4 (Table 4-7) summarizes the existing pipelines by size and material. Age information on pipelines was not available from Cal Water. Section 5.7 describes Cal Water's established Main Replacement Program and the criteria used to determine replacement priorities. As described in Section 5.7, the highest priorities are undersized mains less than 6-inch diameter, as well as bare steel mains with a history of leaks and breaks.

About 10 percent of the system pipelines are 4-inch or smaller in diameter. It is assumed that these small diameter pipes are likely in the older parts of the system. When replaced, a minimum of 6-inch or larger diameter should be used, as needed to provide adequate fire flows. The recommended improvements include an annual amount for main replacement.

7.8.6 SCADA System

Cal Water is implementing a company-wide program to replace aging monitoring system with state-of-the-art SCADA systems. A typical SCADA system will allow remote control of pump and valve operation including modification of operational set points. Typical operational control features include modification of reservoir level controls, remote operation of pressure switches such as pump start/stop, and remote operation of valves such as to isolate a reservoir or pump station. Typical system monitoring parameters include reservoir levels, well water levels, system pressures, status indicators, and water quality indicators.

Appendix C describes the findings of CDM's evaluation of the existing South San Francisco SCADA system, and provides recommendations for Cal Water's consideration as part of its ongoing SCADA replacement program.

Section 8
Water Supply Strategy

This section provides an overview of the water supply strategy and summarizes the water supply recommendations for the South San Francisco system. It then discusses various scenarios for supply, and describes each water supply component.

Section 6 compares the demand and supply projections to identify future supply needs, evaluates the reliability of SFPUC supply, and discusses groundwater basin sustainability issues. Section 7 discusses the water system analysis and capacity improvements. Section 9 combines the supply and distribution system recommendations into an integrated phased plan.

8.1 Overview of Supply Strategy

Cal Water will pursue a supply strategy for the South San Francisco District that includes an array of supply components for flexibility and reliability. SFPUC surface water will continue to be the primary supply. In addition, other local supply sources will supplement SFPUC surface water supply.

Groundwater will continue to be a key local supply component, as it has been historically. In the early 1950's, Cal Water's annual pumping rate was as high as 2 mgd. Since 1980, Cal Water has pumped about 1.1 mgd on average, up to a maximum of about 1.4 mgd in any year. The strategy includes measures to improve groundwater supply such as in-lieu recharge and recycled water, as well as other local water supply components, such as conservation and desalination.

The water supply components are listed below. A detailed description of each component is provided in Section 8.4

- SFPUC Supply will continue to be the primary supply. The recommended strategy assumes normal supply equal to the planned SFPUC purchase amount of 8 mgd, and provides for up to a 25% reduction in SFPUC surface supply to 6 mgd under drought/emergency conditions.
- Planned Long-Term Conservation Savings are permanent reductions in demand due to implementation of planned conservation measures as described in the Urban Water Management Plan. It is recommended that Cal Water continue with ongoing implementation, which may result in a maximum reduction in demand of up to about 1 mgd by Year 2030. This reduction is considered as a future local supply component to offset demand. However, actual reductions are subject to many uncertainties since they are contingent on actions of the general public that are beyond Cal Water's control. Therefore, flexibility for alternate local supply is addressed

if the anticipated reductions cannot be fully achieved within the planned timeframe.

- Additional Temporary Emergency Demand Reductions during SFPUC Shortages assumes more stringent demand reduction measures could be implemented on a temporary basis during droughts or emergencies that reduce SFPUC supply. These temporary demand reduction measures are outlined in Water Shortage Contingency Plan that is part of the Urban Water Management Plan. The recommended strategy also addresses flexibility to provide alternate local supply in the event that the required temporary demand reductions during droughts/emergencies cannot be fully achieved when needed.
- Groundwater as a local supply component will continue as a key part of Cal Water's supply for the South San Francisco District, as it has been historically. Annual groundwater use is anticipated to remain similar to historic, at or below 1.5 mgd; and be accompanied by Cal Water's participation in measures such as in-lieu recharge and recycled water, as discussed below. Depending on the availability of surface water for in-lieu recharge and Cal Water's operating needs, the wells could be operated at lower rates when excess surface water is available to increase groundwater recharge and at higher rates at other times. With proposed measures (either alone or in combination), future pumping may increase over historic levels if it can be supported by the groundwater basin. The recommended plan includes a service areawide groundwater monitoring program to monitor potential impacts of pumping on the groundwater basin. The recommendations also call for additional well capacity to be able to provide short-term emergency supply in critical parts of the system to improve reliability (i.e., emergency storage for certain parts of the system).
- Groundwater Recharge (in-lieu conjunctive use or aquifer storage and recovery) will be necessary to maintain groundwater basin levels and enhance supply reliability during droughts. In-lieu recharge may be accomplished individually in the South San Francisco service area, as part of a regional conjunctive use program with SFPUC, Daly City, and San Bruno, or through a combination of local and regional efforts. The groundwater analysis described in Appendix E assumed a regional effort.
- Recycled Water supply involves longer-term measures that require regional implementation and participation by other agencies. Potential benefits are to help maintain a sustainable groundwater basin by switching private groundwater pumping to use of recycled water, thereby allowing more natural groundwater recharge; and to reduce the potable supply requirements by utilizing recycled water for appropriate uses (e.g., irrigation, industrial) now served by potable water.

- Desalination (Reverse Osmosis [RO] Treatment) of Bay Water or Brackish Groundwater would be a longer-term measure that could be implemented in the future if determined to be cost-effective relative to the cost of other components. Implementing this component will require feasibility investigations and considerable lead-time. This component may be more cost-effective at a regional level for all three Cal Water peninsula districts.

While this master plan focuses on the South San Francisco District supply recommendations independent of the other Cal Water districts on the San Mateo Peninsula (the Mid-Peninsula District and the Bear Gulch District), future planning efforts will consider all three districts as a region to determine the best locations for each source of supply. The appropriate mix of supply sources will then be determined at a regional level to determine the most cost-effective approach.

8.2 Recommendations for Local Supply

To supplement SFPUC supply, Table 8-1 summarizes specific recommendations for local supply for near-term (2005-2010), intermediate (2010-2015), and long-term (2015 to 2030). Section 8.3 describes various scenarios for normal, drought and emergency supply that were used to determine the supply requirements and formulate the recommendations.

Table 8-1
Summary of Recommendations for Local Supply

Item and Timeframe	*Description*
Near-Term (to 2010)	
Provide emergency booster pump tie-ins for northerly area	The following northerly zones are supplied solely from SFPUC turnouts: 260, 285, 330, 360 and 380. The only linkages between these zones are some PRVs or check valves from higher to lower zones in the cascade. These tie-ins will allow emergency booster pumps to lift water from the Zone 200 well field up to Zone 380 in the event of a loss of SFPUC supply. Each booster site could be sized to boost up to approximately 2000 gpm flow (about 3 mgd). The existing distribution system has adequate hydraulic capacity at the proposed locations (existing larger diameter transmission mains) to convey the recommended flow.
Increase well capacity in vicinity of Station 1 to 3 mgd	Construct up to 8 new wells (assuming average capacity of 150 gpm) in the vicinity of Station 1 with piping to connect them to the Station 1 treatment facility.
Expand existing treatment facility at Station 1 to 3.2 mgd	Add another filter to provide 2,250 gpm (3.2 mgd) sustainable treatment capacity with allowance for backwashing (maximum instantaneous capacity of 2,500 gpm or 3.6 mgd). (See Appendix I for detailed description of WTP improvements.)
Groundwater monitoring	Design and implement a service area wide groundwater monitoring program, coordinated with data collection activities of other basin stakeholders, to monitor impacts of potential local in-lieu recharge program and groundwater pumping.
Groundwater recharge	Implement local in-lieu recharge within the service area, assuming an agreement can be reached to purchase in-lieu water at or less than or equal to the cost of SFPUC supply. Consider potential participation in regional in-lieu recharge program.
Regional recycled water program	Continue to participate in planning for future recycled water project(s) with South San Francisco, San Bruno, and SFPUC. Consider initiating a joint feasibility study with Daly City to investigate supplying recycled water to Colma cemeteries.

Table 8-1 ***Summary of Recommendations for Local Supply***	
Item and Timeframe	***Description***
Water conservation measures - Long term permanent conservation savings - Temporary demand reductions during emergencies	Continue implementation of planned long-term conservation measures per Urban Water Management Plan. Implement temporary demand reductions during emergencies and droughts as outlined in Urban Water Management Plan, as needed to address temporary reductions in total supply.
Desalination feasibility study	As part of regional supply planning for all three Peninsula Districts, scope and conduct a conceptual feasibility study to explore siting, technology, and potential partnering options.
Intermediate (2010 – 2015)	
New well(s) in northerly area	Construct 5 to 6 new wells (assuming average capacity of 200 gpm) in the northerly area to provide up to 1.5 mgd supply capacity. Assume treatment similar to Station 1 facility will be required at the new well field. These wells will provide emergency supply in the northerly area in the event of loss of SFPUC supply, and also avoid the need to build a tank for emergency storage. (Note: Appendix E identifies potential well sites in the area). This northerly well field could be constructed, owned and operated by Cal Water. Another option for implementation would be to consider a joint agreement with SFPUC for this well field to be constructed by SFPUC as part of the SFPUC regional conjunctive use program.
Groundwater monitoring	Continue service area wide groundwater monitoring program, coordinated with data collection activities of other basin stakeholders, to monitor impacts of potential local in-lieu recharge program and groundwater pumping. Evaluate data collected with respect to overall basin trends.
Groundwater recharge	Continue local in-lieu recharge within the service area. Re-evaluate status of regional in-lieu recharge program relative to Cal Water participation. Consider investigating potential benefits of surface percolation for aquifer storage and recovery (e.g., Colma Creek storm runoff).
Regional recycled water program	Continue to participate in planning for future recycled water project(s) within service area: 1) With South San Francisco, San Bruno, and SFPUC; 2) With Daly City. Re-evaluate status and appropriate participation in recycled water projects based on new information that becomes available over time.
Water conservation measures - Long term permanent conservation savings - Temporary demand reductions during emergencies	Evaluate implementation and effectiveness of planned conservation measures; modify as needed as part of Urban Water Management Plan process. Implement temporary demand reductions during emergencies and droughts, as outlined in Urban Water Management Plan, as needed to address temporary reductions in total supply.
Desalination pilot study	If feasible options are identified in the near-term feasibility study, evaluate implementing a pilot study as part of regional supply planning for all the Peninsula districts.
Long-Term (2015 to 2030)	
Additional Groundwater Capacity – if future conditions indicate that additional groundwater capacity is feasible. Some or all of the additional 2 mgd may be provided by other sources, such as desalination, as shown in the next item.	
• Increase well capacity in vicinity of Station 1 by an additional 2 mgd to a total of 5 mgd for short-term emergency and critical drought supply	• Construct 9 new wells (assuming average capacity of 150 gpm) in the vicinity of Station 1.
• Expand and upgrade existing treatment facility at Station 1 to ultimate capacity of 5 mgd for short-term emergency and critical drought supply	• After conducting pilot and predesign studies, expand and upgrade existing treatment plant to an ultimate sustainable capacity of 5 mgd (or the ultimate planned groundwater capacity). Depending on outcome of pilot studies, it may be possible to achieve the higher capacity by higher filter loading rates; in addition, alternative process options could also be considered.
Desalination - as option instead of some or all of the additional groundwater capacity	If confirmed by previous studies and if future conditions indicate it is cost competitive, an RO treatment facility of either 1 mgd or 2 mgd could be constructed in Zone 200 in lieu of some or all of the additional 2 mgd groundwater capacity.
Evaluate older wells	Evaluate condition of older wells and assess the need for rehabilitation and/or replacement.

Table 8-1 Summary of Recommendations for Local Supply	
Item and Timeframe	***Description***
Groundwater monitoring	Continue service area wide groundwater monitoring program, coordinated with data collection activities of other basin stakeholders, to monitor impacts of potential in-lieu recharge program and groundwater pumping. Evaluate data collected with respect to overall basin trends.
Groundwater recharge	Continue local in-lieu recharge within the service area. Re-evaluate status of regional in-lieu recharge program relative to Cal Water participation. Evaluate potential for aquifer storage and recovery with injection/extraction wells.
Regional recycled water program	Continue to participate in planning for future recycled water project(s) within service area: 1) With South San Francisco, San Bruno, and SFPUC; 2) With Daly City. Re-evaluate status of recycled water projects based on new information that becomes available over time.
Water conservation measures - Long term permanent conservation savings - Temporary demand reductions during emergencies	Evaluate implementation and effectiveness of planned conservation measures; modify as needed as part of Urban Water Management Plan process. Implement temporary demand reductions during emergencies and droughts, as outlined in Urban Water Management Plan, as needed to address temporary reductions in total supply.

Annual groundwater use is anticipated to remain similar to historic at 1.5 mgd; and be accompanied by Cal Water's participation in measures such as in-lieu recharge and planning for recycled water projects, which can provide the opportunity to increase local groundwater supply and improve supply reliability. Depending on the availability of surface water for in-lieu recharge and Cal Water's operating needs, Cal Water could operate its wells at lower rates when excess surface water is available to increase groundwater recharge, and at higher rates during periods such as droughts when surface supplies are reduced.

The recommended plan includes a service areawide groundwater monitoring program to monitor potential impacts of pumping on the groundwater basin. With implementation of the proposed measures for in-lieu recharge and recycled water, future pumping may increase over historic levels if it can be supported by the groundwater basin.

In the meantime, the recommendations call for additional well capacity to be able to provide short-term emergency supply in critical parts of the system to improve reliability (i.e., the additional well capacity would serve an emergency storage function for certain parts of the system).

Over the next 5 to 10 years, some uncertainties regarding other local supply components, such as recycled water and desalination, should be resolved that will help better identify long-term implementation steps. Then, based on actual conditions in the future, the appropriate pieces can be implemented.

The cost of local supply, including any costs to Cal Water for these efforts, will need to be cost competitive with SFPUC supply for Cal Water's participation to be feasible. Cal Water, as a private utility, must justify rate increases and get

approval from the California Public Utilities Commission (CPUC). Currently Cal Water pays about $500 per acre-foot for wholesale SFPUC water. However, the cost of SFPUC water in the future is anticipated to increase significantly as SFPUC implements its Water Supply Improvement Program (WSIP) to improve the reliability of its regional water supply system.

According to recent information from SFPUC (November 23, 2005 memo to Commissioners regarding Financing of WSIP), it is anticipated that the wholesale cost of SFPUC water will increase to about $600-$650 per acre-foot by 2010, and to over $1500 per acre-foot by 2015 due to the WSIP. The cost thresholds for justifying Cal Water development of local supply would be based on these costs, not the current cost of SFPUC water.

In the near-term to 2015, groundwater is the most cost competitive local option; however, measures must be undertaken to maintain long-term groundwater basin sustainability. In-lieu recharge will also be cost competitive if acceptable terms can be negotiated with SFPUC for either purchase of water for local in-lieu recharge, or for participation in a regional program. Recycled water, aquifer storage and recovery, and desalination are longer term measures that are not expected to be implemented until after 2015, and will require additional investigation to determine their feasibility.

8.3 Supply Scenarios

Table 8-2 summarizes the near term (to 2015) and long-term (2030) requirements for local supply to supplement SFPUC surface supply, under various scenarios. By 2015, the total projected demand is about 10 mgd. By 2030, the ultimate projected demand is 11 mgd. The total demand will be met by a combination of SFPUC and local supplies.

The recommended strategy assumes normal supply equal to the planned SFPUC average annual purchase amount of 8 mgd, and provides for up to a 25% reduction in surface supply under drought/emergency conditions, i.e., only 6 mgd of surface water available during drought/emergency conditions.

Local supply will be needed to meet the total demand under both normal and drought/emergency conditions. The local supply would be provided from a combination of conservation savings, groundwater, in-lieu recharge (conjunctive use), recycled water, and desalination. To provide flexibility for future planning, Table 8-2 brackets the requirements both with the planned conservation savings, and in the event the planned savings are not realized.

Table 8-2 ***Summary of Average Annual Requirements for Local Supply to Supplement SFPUC Supply*** [(1)]		
Condition	***Near-Term (to 2015)***	***Long-Term (2030)***
Local Supply Requirement for Normal Conditions with 8 mgd SFPUC Supply		
If planned long-term conservation savings are realized	1.3 mgd (assumes 0.4 mgd conservation savings achieved by 2015)	2 mgd (assumes 1 mgd conservation savings achieved by 2030)
Without relying on any long-term conservation savings	1.7 mgd	3 mgd
Local Supply Requirement for Reliability During Droughts or Emergencies when SFPUC Supply is Reduced to 6 mgd (25 percent cutback) Note: Range brackets the potential long-term conservation savings. Low end of range is if planned long-term conservation savings of 1 mgd are realized; high end of range is without relying on long-term conservation savings.		
With 20% temporary cutback in customer demands per Water Shortage Contingency Plan	• 2 mgd of temporary reductions by customers • Plus 1 to 2 mgd of additional local supply	• 2 mgd of temporary demand reductions by customers • Plus 2 to 3 mgd of additional local supply
With 10% temporary cutback in customer demands	• 1 mgd of temporary demand reductions by customers • Plus 2 to 3 mgd additional local supply	• 1 mgd of temporary demand reductions by customers • Plus 3 to 4 mgd additional local supply
Without any temporary cutback in customer demand	• 3 to 4 mgd local supply.	• 4 to 5 mgd local supply.
Wells to serve as Emergency Storage rather than Building New Tanks See Section 7 for discussion of storage capacity requirements. This is for emergency storage supply to improve reliability, not for normal conditions. It could also serve as supply during droughts. Providing emergency storage for reliability by means of tanks or wells is a performance criterion typically addressed in water system planning and discussed in Section 5.		
Zone 200	New wells could provide emergency supply capacity equivalent to additional emergency storage volume required for the zone. Capacity of 3 mgd would be needed for the 3 MG emergency storage required for current conditions, and 5 mgd would be needed for the total of 5 MG additional emergency storage required at buildout. Then it will not be necessary to build additional reservoirs for emergency storage in Zone 200. It would be very difficult to find available sites for more reservoirs.	
Zone 380	Wells have been identified as an option to improve supply reliability in the northerly area that is currently served only by SFPUC turnouts. These wells would function as emergency storage for the area. To provide the equivalent of the required 1.5 MG emergency storage would require 1.5 mgd supply capacity.	

(1) Normal supply includes the planned SFPUC average annual purchase amount of 8 mgd, and provides for up to a 25% reduction in surface supply under drought/emergency conditions, i.e., only 6 mgd of surface water available during drought/emergency conditions. Local supply will be needed to meet the total demand, which will be 9.7 mgd by year 2015, and 11 mgd at year 2030.

Under normal conditions, SFPUC supply will provide 8 mgd on an average annual basis. It is assumed that the South San Francisco system will continue to peak off the SFPUC system, i.e., SFPUC flows will be higher during peak demand periods and lower during low demands periods, but the annual average will not exceed 8 mgd. Local supply will make up the remainder to meet demands. Assuming successful implementation of the long-term conservation savings and a 20 percent temporary reduction in customer demands through implementation of the Water Shortage Contingency Plan, additional local supply of 1.3 mgd will be needed in the near-term (by 2015), which is within the range of recent historic pumping level; and about 2 mgd by Year 2030, which is the maximum historic pumping level.

In the event of a 25% cutback in SFPUC supply, e.g., during droughts, SFPUC supply would provide 6 mgd on an average annual basis. Local supply will make up the remainder to meet demands. Depending on the level of conservation savings achieved and the temporary demand reductions imposed, the required additional local supply during droughts will range between 1 to 4 mgd in the near-term, and 2 to 5 mgd by Year 2030. The higher the level of demand reductions, the lower the amount of additional local supply capacity is needed for supply reliability during droughts and emergencies.

During droughts, the South San Francisco system will continue to peak off the SFPUC system. As discussed in the paragraph below, this could be supplemented with some peaking ability from local supply implemented as emergency storage in lieu of new tanks. This well capacity would provide additional supply reliability during droughts and emergencies.

As discussed in Section 7, local supply from groundwater wells (or potential desalination supply) with emergency backup power can also provide emergency supply capacity in lieu of emergency storage, so that new tanks do not need to be constructed. The criterion for the South San Francisco system is to have one average day's demand in storage in the event of a temporary outage of SFPUC supply that might completely disrupt supply for a short time.

Wells with backup power are an excellent substitute for emergency tank storage for temporary supply outages, since they have more flexibility to operate for a longer period if needed, while tank storage once drained cannot be replenished until the SFPUC supply is restored. This emergency supply capacity also provides flexibility to help meet peaking needs from local supply during longer periods of reduced SFPUC supply (e.g., droughts).

8.4 Water Supply Components

Each of the following local supply components are discussed in detail in the remainder of this section:

- Long-Term Permanent Conservation Savings
- Temporary Demand Reductions during Emergencies
- Groundwater Well Supply
- Groundwater Recharge (in-lieu conjunctive use, aquifer storage & recovery)
- Recycled Water
- Desalination

8.4.1 Long-Term Permanent Conservation Savings

Cal Water has a water conservation program in place for the South San Francisco service area, and participates in demand management efforts in

conjunction with the California Urban Water Conservation Council. The 2003 Urban Water Management Plan for South San Francisco outlines the current and proposed best management practices for water conservation. Cal Water has set a goal of a 10 percent reduction in demand by Year 2030. These reductions would be permanent long-term water savings.

Cal Water's current and proposed measures to achieve 10% permanent long-term savings include:

- Residential Audits
- Plumbing Retrofits
- High Efficiency Washing Machine Rebates
- Public Education
- School Education
- Ultra-Low Flow Toilet Rebates
- Large Landscape Program (Evapotranspiration (ET) Controllers)

8.4.2 Temporary Emergency Conservation Savings

In addition to the long-term conservation measures, Cal Water has a Water Shortage Contingency Plan that specifies temporary actions to reduce water use during drought or emergency conditions. These actions are grouped into four stages, depending on the severity of the shortage.

The anticipated maximum cutback in SFPUC supply during droughts or emergencies is up to 25 percent (with existing SFPUC supply sources), which falls between Stage 2 and Stage 3. The appropriate mix of the above temporary measures could be put in place to temporarily reduce demand if needed. Implementing the temporary measures will require greater staff effort for monitoring and enforcement, but will not require any capital improvements.

For a Stage 2 (20%) reduction in supply, the following actions would be undertaken:

- Aggressively continue public education and school education programs.
- Ask customers for 10 to 20 percent voluntary or mandatory water use reductions. CPUC approval must be obtained prior to implementation of mandatory reductions.
- Support passage of drought ordinances by appropriate governmental authorities.

For a Stage 3 (35%) reduction in supply, the following actions would be undertaken:

- Implement mandatory restrictions after receiving CPUC approval.
- Institute rationing programs through fixed allotments based on percentage cutbacks.
- Implement rate changes to penalize use over allotment.
- Maintain rigorous public information campaign explaining water shortage conditions.
- Water use restrictions put into effect. Prohibited uses may include watering resulting in gutter flooding, using a hose without shutoff device filling of pools or fountains, or other similar restrictions.
- Monitor weekly production for compliance with necessary reductions.
- Install flow restrictors on service line of customers who consistently exceed their allocation.

8.4.3 Groundwater Well Supply

All existing groundwater wells are in the vicinity of Station 1, with a total combined capacity of 1.7 mgd (about 1,200 gpm). The wells in the vicinity of Station 1 provide multiple benefits: 1) as local supply under normal conditions; 2) can be considered as providing capacity for emergency storage in lieu of providing emergency storage in tanks; and 3) as emergency supply to improve supply reliability during emergencies or droughts with cutbacks in SFPUC supply.

The supply recommendations include new wells to improve supply reliability in both the northerly and southerly parts of the system. Potential well sites are identified in Appendix E. Individual well capacities range from 150 to 200 gpm per well depending on the area. Since treatment will be needed for groundwater supply, it is anticipated that a well field with a centralized treatment facility will be the most effective configuration. Detailed investigations of potential sites and well field configurations will be needed regarding site availability, site groundwater quality, optimum well spacing, and potential methods to convey groundwater to the treatment facility (e.g., individual wells with discharge pipelines or a system of underground radial collectors to combine groundwater from several well locations).

As discussed in Section 8.2, it is recommended that Cal Water participate in measures such as in-lieu recharge and planning for recycled water projects, which can provide the opportunity to increase local groundwater supply and improve supply reliability. Average annual groundwater use is anticipated to

remain similar to historic, at or below 1.5 mgd until implementation of mitigation measures would support higher pumping rates. Depending on the availability of surface water for in-lieu conjunctive use and Cal Water's operating needs, Cal Water could operate its wells at lower rates during periods when excess surface water is available, to increase groundwater recharge, and at higher rates during periods such as droughts when surface supplies are reduced.

During droughts, the wells could operate at a temporarily higher capacity as necessary to supplement reduced SFPUC supplies. During emergencies, the wells would temporarily operate at a higher capacity as needed to supplement reduced SFPUC supply. Various scenarios for local supply to meet near-term and long-term needs are discussed earlier in this section in Section 8.3.

The recommendations in Table 8-1 include upgrades at the Station 1 well field, including new wells and expanded treatment facilities. Appendix I provides a detailed discussion of the existing treatment facilities at Station 1 and required improvements. A near-term expansion to 3 mgd would be relatively easy to accomplish by adding another filter and related improvements. The long-term expansion to 5 mgd will require more extensive improvements, and a detailed evaluation should be conducted to determine the most cost-effective approach.

Analysis of local groundwater conditions indicate that, under the pumping levels considered, there are no significant water supply or water quality benefits to abandoning the existing well field and installing a new distributed well network. However, locating some new wells in the northerly part of the system could enhance system reliability, as discussed below.

The northern portion of the system, as currently configured, cannot use groundwater supply from the Station 1 well field in the southern part of the system. Therefore, the northern portion of the system has less supply reliability than the southern part, since it is totally dependent on SFPUC supply. Therefore, the supply recommendations include a near-term project to provide emergency booster tie-ins to lift water from the Station 1 well field to the northern part of the system; as well an intermediate project to evaluate construction of a new well field and treatment facility in the northern part of the system that would provide well capacity as emergency supply (emergency supply) to that part of the system.

A northerly well field could be constructed, owned and operated by Cal Water. Another option for implementation would be to consider a joint agreement with SFPUC for this well field to be constructed by SFPUC as part of the SFPUC regional conjunctive use program. This implementation option is discussed further below under "Groundwater Recharge".

The recommended plan assumes that the Station 1 well field and any wells in its vicinity would not be part of the regional conjunctive use program and would remain solely under the control of Cal Water. Under current recharge and groundwater use conditions, it appears that Station 1 is somewhat hydraulically separated from the northerly area by the pumping depression associated with cemetery wells, which may create a hydraulic divide between the north and south. Under current groundwater use conditions, short-term groundwater level changes in the northern area are more readily influenced by cemetery and Daly City pumping than by pumping at Station 1. Furthermore, recharge in the Daly City and northern area is more likely intercepted by pumping cemetery wells than by pumping Station 1 wells.

It is recommended that Cal Water implement service-area wide groundwater monitoring for the purpose of tracking groundwater changes due to pumping. This would include monitoring conditions in the Station 1 well field, and also at other representative locations throughout the service area to provide a service-area wide indication of potential impacts. These activities can be coordinated with data collection activities of other basin stakeholders to provide overall basin trends.

The recommended strategy includes continuing with ongoing efforts to participate in opportunities for in-lieu recharge and recycled water use, consistent with the efforts of other entities in the area, as discussed further below. Opportunities for partnering on implementation of regional in-lieu recharge and recycled water projects should be re-evaluated as such projects become better defined over time.

8.4.4 Groundwater Recharge

In-Lieu Recharge

In-lieu recharge refers to a conjunctive use approach whereby additional surface water is delivered, when available, to replace groundwater extraction that otherwise would have occurred. The use of this supplemental surface water retains natural groundwater recharge that otherwise would have been extracted for use, thereby storing this recharge in the basin for future use during periods of reduced surface water supply. During periods of supplemental surface water deliveries, groundwater extraction rates are voluntarily reduced (i.e., surface water supply replaces some or all of groundwater pumping that would otherwise have occurred). During periods of reduced surface water supply, groundwater extraction rates are increased (i.e., groundwater supply used to replace unavailable surface supply).

The near-term recommendations include implementing a local in-lieu recharge program, if an agreement can be reached with SFPUC to purchase in-lieu water at or less than the cost of SFPUC supply. Cal Water would use surface water

when available, to replace some or all groundwater pumping depending on its operating needs. Generally, due to basin characteristics and under current pumping conditions by other users, the majority of recharge benefit due to not pumping within a service area typically accrues within that service area, so a local effort by Cal Water would provide the greatest recharge benefit to the Cal Water service area.

A regional conjunctive use program, as envisioned by the SFPUC, will take significant coordination and negotiation to implement. An intermediate recommendation in Table 8-1 is to construct a well field in the northerly area (Zone 380), if detailed siting studies indicate it is feasible. This northerly well field may be a potential candidate for partnering with SFPUC, as part of a regional conjunctive use program, if acceptable arrangements with SFPUC can be negotiated. These wells are needed for water supply reliability for the northerly area, as described in Section 7.3 and Section 8.2.

At this time, SFPUC is anticipating that the terms established in a recent agreement with Daly City would be followed by other participants. Under the terms of the SFPUC and Daly City agreement, SFPUC pays for the cost of well installation, operation and maintenance, with the provision that the well is used as part of the regional conjunctive use network. Daly City owns and operates the well. SFPUC retains sole discretion to decide whether to provide supplemental surface water in a given year and to order pumping of previously stored groundwater during droughts or emergencies. If the well is operated for conjunctive use purposes, SFPUC would pay all O&M and power costs. If the well is used for non-conjunctive uses purposes, Daly City pays a pro-rata share of O&M and all power costs. Daly City will not pay for water at the time it is stored in the basin. When stored SFPUC water is extracted, Daly City will pay the same wholesale rate for pumped groundwater as for SFPUC surface water.

With the proposed agreement, SFPUC is offering significant financial incentives to participate, but will also retain control of any wells constructed under this program for use as part of regional drought/emergency supply. A well field in the northerly area would be primarily for drought/emergency supply so may be a candidate to consider for this program if acceptable terms can be negotiated. The agreement should be structured to clearly state that Cal Water retains full control of its Station 1 well field and any other wells in its system for its own use at its own discretion.

Aquifer Storage and Recovery

If in the long-term, in-lieu recharge is ineffective in maintaining groundwater levels, aquifer storage and recovery (ASR) with injection and extraction wells could be considered. With ASR, surface water is injected in the groundwater using injection wells when surface supplies are available, and then extracted (pumped out) when surface supplies are limited, such as during a drought. Cal

Water would purchase supplemental surface water from SFPUC for injection (similar to in-lieu recharge).

The ASR option could also investigate the possibility of off-stream percolation ponds. For example, Colma Creek is located about ½ mile upstream of Cal Water's Station 1 well field. It seems like the channel could be engineered at one or more key locations to divert storm runoff into percolation ponds. These ponds could possibly be integrated into open areas, such as parks. It might be a way to recharge more water in Cal Water's service area using an environmentally friendly approach to restoring the health of the basin and increasing local water supplies.

An ASR program would be more costly and difficult to implement than an in-lieu recharge program. This possibility should be re-evaluated and further investigated in future updates of the master plan.

As part of the groundwater analysis conducted by HydroFocus, an ASR scenario was analyzed as described in Appendix E. This analysis can provide a starting point for more detailed studies and investigation should this option appear viable in the future.

The ASR Scenario described in Appendix E assumes that Cal Water conducts in-lieu recharge as described above plus injects additional surface water into the aquifer during periods of supplemental surface water deliveries, and assumed a network of new wells designed for dual injection and extraction operations. The existing well field could conceivably be converted to ASR use, although the total recharge may be lower since the wells will be closer together than with a widely distributed network.

There are potential water quality benefits of injection over in-lieu, if the injected water is SFPUC surface water. The water quality of the well water produced may increase over time, as the higher quality surface water mixes in the aquifer with the lower quality groundwater creating an intermediate quality "bubble" of water. The intermediate quality water that is extracted can be of higher quality than what would be obtained with the in-lieu program.

However, ASR projects will likely be more difficult to implement than in-lieu recharge. EBMUD experienced public perception issues with people believing so much water was going to get injected into the aquifer that the project would cause structural damage to nearby buildings and homes. Additionally, there have been some instances where regulators prohibit drinking water from being injected into the aquifer because they ruled it negatively impacted the beneficial use of the existing, lower quality groundwater.

8.4.5 Recycled Water

There is currently no recycled water use in the South San Francisco service area. The supply recommendations include continuing to participate in near-term planning and long-term implementation of a recycled water project that would replace groundwater pumping or potable water use for irrigation or industrial uses with recycled water. Such a project will involve partnering with the Cities of South San Francisco and San Bruno, and/or Daly City.

Recycled water use potentially benefits Cal Water's groundwater supply in two ways:

1) When groundwater now being pumped by other entities within the service area, such as major irrigators, is instead supplied from recycled water, the reduced pumping by others then allows Cal Water to pump higher amounts.

2) If recycled water is used in the future by customers in the Westside Basin instead of potable supply, it would make more surface water available which could be used as part of the in-lieu recharge program discussed below.

Cal Water is participating in a Water Recycling Feasibility Study with the Cities of South San Francisco and San Bruno, and SFPUC. A recycled water project, as envisioned in the Recycled Water Feasibility Study, will require significant infrastructure improvements, and there are many entities, both municipal and private (customers), that must be involved in implementation.

Table 8-3 summarizes information developed to date in the Feasibility Study (draft report dated September 2004) regarding potential recycled water customers and the anticipated amount of recycled water use. Potential customers are grouped into "clusters" based on general location. The potential uses are primarily for irrigation, and some commercial and industrial uses.

In addition, an array of conceptual alternatives were identified and evaluated. The study participants have selected a preferred alternative, which will require detailed analysis in the next phase of the project which is just getting underway.

Table 8-4 summarizes the key information to date on the preferred alternative selected by the study participants, which is to upgrade the existing wastewater treatment plant with tertiary treatment and disinfection. A recycled water system would be constructed to convey water to customers. Depending on the extent of the recycled water system, customers would be served in South San Francisco, Colma, and San Bruno.

Table 8-3 Summary of Potential Recycled Water Use South San Francisco and San Bruno				
Potential Customers and Current Source of Water	**Description**	**Number of Individual Customers**	**Estimated Average Annual Demand (acre-feet per year)**	
			(ac-ft per yr)	**(mgd)**
Colma Cluster				
Now on Wells	Cemeteries	7	569	0.51
Now Cal Water Supply	Cypress Lawn Memorial Park, Cypress Hills Golf Course, Greenlawn Memorial Park, Eternal Home, Serbian Cemetery	5	389	0.35
Now Cal Water Supply	Parks, schools, remaining cemeteries	6	44	0.04
Subtotal - Colma Cluster		*18*	*1,002*	*0.90*
I-280 Cluster				
Now on Wells	California Golf Club	1	204	0.18
Now Municipal Supply	Golden Gate National Cemetery	1	206	0.18
Mix of Cal Water and Municipal Supply	Parks, schools	8	68	0.06
Subtotal - I-280 Cluster		*10*	*478*	*0.42*
Industrial Cluster				
Now Cal Water Supply	Oyster Park Marina, Oyster Point Park, Gateway Business Park, Gateway Commons Business Park, Genentech (irrigation only)	5	198	0.18
Year-Round				
Now Cal Water Supply	Central Concrete Supply, Wastewater Treatment Plant, American Etc Laundry, Complete Linen Service	4	190	0.17
South San Bruno Cluster				
Now Cal Water Supply	Parks, schools	8	114	0.10
Total		**45**	**1,982**	**1.77**

Note: The Feasibility Study (draft September 2004) also investigated the Sign Hill Cluster, the West San Bruno Cluster, and some Non-Clustered Sites scattered throughout San Bruno, South San Francisco, and Daly City. An additional 24 potential customers consisting of parks, schools and some public facilities were identified. These potential customers had a total average annual demand of only 0.12 mgd. Due to the very small demand, these potential customers were dropped from further consideration.

Table 8-4
Preferred Alternative for Recycled Water Project for Cities of South San Francisco and San Bruno [1]

Potential Phasing of Preferred Alternative	Average Annual Demand (AF per year)	Customers Served	Major Infrastructure Improvements			Total Project Capital Cost ($ Million) [2]	Total Water Production Cost ($ per AF) (3)
			Conveyance Pipeline (miles)	Storage (MG)	Pump Stations		
Preferred Alternative 1: Upgrades at existing plant for tertiary treatment and disinfection							
1A – full implementation	1,982	Colma Cluster, I-280 Cluster, Industrial Cluster, Year-Round, South San Bruno Cluster	8.2	3.5	3	$41.7	$1650
1B – partial implementation	980	I-280 Cluster, Industrial Cluster, Year-Round, South San Bruno Cluster	6.9	1.5	2	$24.6	$1860
1C – limited implementation	668	I-280 Cluster, Year-Round	2.6	0.8	1	$13.8	$1640
Recycled Water Consultant was directed by participants to also include an Alternative 1D limited option with San Bruno customers.							

(1) Information was obtained from the "Draft Recycled Water Feasibility Study" dated September 2004, subsequent minutes of project progress meetings provided with the draft report, and additional information provided by the consultant at the progress meeting in August 2005. Per discussion with City of South San Francisco, this is the most current information available at this time. Costs in the table are in 2004 dollars.

(2) Total project cost is the preliminary conceptual estimate from the work to date referenced in Footnote 1 above. Total project cost includes capital costs for the design and construction of the treatment facility improvements, pumping stations, transmission piping, and finished water storage.

(3) Water production cost per AF includes the annualized capital costs for the project improvements plus operating and maintenance costs. It is a preliminary conceptual estimate from the most recent information provided by the consultant for the Recycled Water Feasibility Study as noted in Footnote 1 above.

Note: The 50% Recycled Water Scenario analyzed in Appendix E with respect to groundwater recharge requirements assumed 765 acre-feet per year of recycled water use by major irrigators; and the 100% Recycled Water Scenario assumed 1,531 acre-feet per year. Full implementation (1A) of the preferred alternative would be more than the 100% scenario; partial implementation (1B) would be more than the 50% scenario.

With the preferred alternative, the existing South San Francisco/San Bruno Water Quality Control Plant located in southeast South San Francisco, just north of San Francisco International Airport, will be upgraded to allow Title 22 unrestricted use. This will require that effluent be filtered to a daily average turbidity of 2 NTU and disinfected for median coliforms of 2.2 MPN/100 ml.

Storage will be required to meet the flow needs for irrigation and other uses, since these cannot be matched directly from the treated wastewater flow rates. Major conveyance pipeline and pump stations will be required in order to convey recycled water to customers. In order to serve more customers, a larger amount of infrastructure is needed. For example, the Colma Cluster has the largest potential recycled water use for cemetery irrigation, but is located significantly higher and farther from than the treatment plant than other clusters.

As noted in Table 8-4, several variations of the preferred alternative will be further evaluated in the next phase of the recycled water project to investigate potential phasing and better define the project costs and implementation factors.

In the groundwater analysis conducted for Cal Water (as described in Appendix E), replacing a total of 765 acre-feet per year of groundwater pumping for irrigation with recycled water use would support a sustainable Cal Water groundwater pumping rate of 1.1 mgd. This would require partial implementation of the preferred alternative. Replacing a total of 1531 acre-feet per year of groundwater pumping for irrigation with recycled water use would support a sustainable Cal Water groundwater pumping rate of 1.4 mgd. This would require full implementation of the preferred alternative. The actual facilities that might switch to recycled water use in the future are not important, so long as the same reduction in groundwater pumping is achieved.

Cost issues that must be better defined in the next study phases in order to determine Cal Water's timing and level of future participation include:

- What are full costs to implement that will be recovered in the recycled water cost? More detailed cost estimates are needed to include treatment, conveyance, distribution, land acquisition, environmental, engineering, inspection, and other factors affecting construction such as utility conflicts and unforeseen conditions, e.g., encountering contaminated soil or groundwater.
- What type of grant or loan funding may be available for construction of the required facilities to help reduce costs?
- What is cost of recycled water while the project capital costs are being paid? What will cost of recycled water be after the project capital costs are paid for?

At this time the study and its participants have not explored institutional issues, such as who will own and operate the recycled water delivery system. These issues must be further investigated as part of the study, and a mutually agreeable arrangement negotiated among the participants. In addition, issues related to customer incentives and public acceptance must also be addressed.

The experience of other utilities (see description below of Daly City recycled water project) indicates that supplying recycled water is not a profitable proposition at this time, and requires significant subsidies to implement as a public goal. Therefore, it appears that a public agency would be better positioned to take the lead on implementing the recycled water delivery system. Cal Water's participation, due to its nature as a private business, must consider cost effectiveness relative to other supply sources, in order to get approval from the CPUC. As a private entity, Cal Water also does not have access to all the

funding options available to public agencies. Some options that Cal Water may consider include:

- Take or pay contract to purchase a certain amount of recycled water at a set price that would be used to replace potable water use by its customers, or private pumping by groundwater wells within its service area. This option assumes that Cal Water does not own any part of the recycled water project. The price would be negotiated with the recycled water supplier at a rate at or less than the cost to Cal Water of developing other local supply sources. This option would provide the recycled water provider with revenue to help subsidize the cost of providing recycled water to customers. There would be benefits to Cal Water of reduced potable use, groundwater recharge benefits from reduced pumping, and increasing its local supply reliability.
- Potential public/private joint ownership of the recycled water project with South San Francisco (and/or others), if it is determined that the long-term cost and benefits would be competitive with other Cal Water supply sources. This option will require more detailed investigation as the recycled water project is further defined.

Another potential option involves Daly City. Daly City's wastewater plant produces 2.77 mgd of recycled water. SFPUC contributed about $1 million upfront for implementation of the current system as part of their regional supply program due to its benefits for Lake Merced, but has no ownership in the system. Daly City is currently subsidizing recycled water production to provide it to customers at about half the cost to produce.

Past planning by Daly City for the current recycled water project considered potential long-term service to the cemeteries in Colma, which are located within the Cal Water service area. Cal Water will need to coordinate with Daly City on the potential future feasibility of this option, especially since the recycled water would be provided primarily to replace private groundwater pumping by the cemeteries. Cal Water should undertake a joint feasibility study with Daly City to further investigate this option and expand the available information summarized in the following paragraphs.

Recycled water from the Daly City plant is currently used by several golf courses in the Lake Merced area as part of an agreement with the City of San Francisco to help reverse declining Lake Merced levels. The project has only been operating for a short time, and all of its capacity has not yet been contracted for. However, the golf course recently constructed recycled water storage to facilitate use of recycled water, and there have been discussions between SFPUC and Daly City to supply available water for wetlands restoration around Lake Merced. It is uncertain how much capacity may be available for other uses.

Daly City has a pipeline crossing across Highway 280 to potentially supply recycled water to users such as the cemeteries located in Colma. Infrastructure would still be needed to get recycled water from the plant to the Highway 280 crossing and then to the customers on the other side of Highway 280. There has been some preliminary discussion in the past about constructing a package treatment plant south of Highway 280 that could treat raw Daly City sewage and deliver the treated water to irrigate cemeteries.

A key issue with providing the recycled water to the cemeteries in Colma is that private groundwater wells are currently used for most irrigation at a much lower cost than the cost of providing recycled water. It will difficult to convince private groundwater pumpers, such as the cemeteries, to switch to recycled water unless there are significant cost incentives, regulatory pressures, or other drivers. This is especially true since using recycled water can create public perception issues and require education efforts for public acceptance, which would make recycled water use in publicly accessible areas more difficult than using groundwater.

The cost of recycled water will likely need to be subsidized to, or below, the cost for groundwater in order for the cemeteries to agree to use it; unless there are other factors that force its use. Such factors may include regulatory pressures such as state mandates to reduce groundwater pumping, e.g., if the groundwater basin is adjudicated, which agencies within the basin would like to avoid; or if the cemetery wells become unusable, e.g., dry up, which may be an indicator of overall groundwater basin problems.

8.4.6 Desalination (Reverse Osmosis)

As a long term measure, Bay water could be used as a future supply source with desalination to remove salts using a treatment process such as reverse osmosis (RO). With RO treatment, pressurized water is run through a series of membranes at high pressures that remove dissolved solids, aqueous salts, viruses, and bacteria. Additional investigation will be needed to confirm its feasibility and costs. This component should be considered as part of Cal Water regional supply planning for its three Peninsula districts.

As identified on Table 8-1 for the long-term 2015 to 2030 timeframe, additional local supply of 2 mgd is recommended from either groundwater or RO, or a combination of the two. RO package treatment facilities (skid-mounted units) are typically available in standard sizes of 0.5 mgd, 1.0 mgd, and 2.0 mgd capacities.

With RO, water is forced through a semi-permeable membrane by pressure differential, and dissolved salts pass through the membrane due to concentration differential. The RO process can remove more than 99 percent of

all dissolved minerals and organic compounds from water, as well as biological and colloidal suspended matter.

Typically about fifty percent or less of Bay water would be recovered as potable; while a higher percentage of brackish groundwater could be recovered. The specific recovery rate would depend on the quality of the source water and the design parameters of the RO processes. One or more passes may be needed through the RO membranes depending on the source water quality and the desired finished water quality. The remaining waste stream (salty brine) would require disposal.

The raw water needed for desalination would be pumped directly from the bay, so a filtration system would be needed before the water reaches the RO unit. If brackish wells are used as source water, no filtration would be needed before the RO process; however, this option does not appear viable for the South San Francisco system. Based on the information developed to date in the groundwater investigation, there does not appear to be a significant source of brackish groundwater within the service area. Pumping brackish groundwater near the bay also does not seem feasible as the aquifer is thin due to the high bedrock, and the shallow groundwater at the Bay has a significant probability of being influenced by existing contamination sources. However, more detailed investigation could be undertaken to further explore this as part of a future feasibility study.

In addition, increased groundwater pumping without mitigation, whether the extracted water is brackish or "fresh", will exacerbate declines in groundwater storage. In other words, pumping brackish groundwater for RO treatment has essentially the same adverse effect on groundwater storage as pumping higher quality groundwater at the Station 1 well field, so there is no long term storage benefit to developing and treating poorer quality water with RO.

Post-treatment will be needed after the RO process. RO processes produce corrosive finished waters because they lower the pH and remove too much calcium and alkalinity. The pH is lowered to about 5.5 to 7 during the RO process to prevent calcium carbonate from precipitating in the membrane. The acidification causes a significant amount of alkalinity to convert to carbon dioxide. Post treatment may include:

- pH and alkalinity recovery – raising the pH will also convert carbon dioxide into alkalinity.
- Gas stripping – may be needed to remove gases, such as hydrogen sulfide, that may cause taste and odor problems, if groundwater or other sources are used that contain them.

- Disinfection – disinfection will be needed to destroy pathogenic microorganisms and provide an adequate residual in the distribution system.

As discussed in the Section 7 water system analysis, there are several locations where the existing distribution system can accommodate future RO supply, e.g., potential locations of RO supply delivery points that would be compatible with existing distribution system and minimize/eliminate the need for distribution system improvements. These potential locations take advantage of the hydraulic capacity of the existing large diameter transmission grid in the 200 zone. Specific locations would be identified as part of more detailed feasibility and siting studies for RO supply. Potential locations include:

- On the east side of the system near the Bay, at locations close to existing large diameter pipelines in the 200 zone, e.g., the 16-inch pipeline from the Brisbane standby connection is located adjacent to the Bay and feeds directly into the 200 zone's major transmission grid. This location would require minimal raw water and treated water improvements. The cost would be essentially for the treatment facility.
- At any location in the 200 zone that would allow the treated water to be discharged into the large diameter transmission grid that conveys water across the 200 zone. Raw water conveyance costs would depend on the specific location selected.
- At or in the vicinity of Station 1 which could utilize the same large transmission grid that delivers groundwater to the system. This option would require a raw water pipeline to convey Bay water to the facility. It would also require space at Station 1 for the RO facility.

The total annual cost for RO supply is estimated to be approximately $1800 to $2000 per AF for treatment of Bay water (treatment of brackish groundwater would be less). The annual cost per AF includes the following components: (1) capital cost of $1,000 to $1,200 per AF (assuming Cal Water's standard assumption at 15% of capital costs for the initial revenue requirement; this component would decrease over time due to depreciation); and (2) annual O&M cost of $800 per AF. The annual cost assumes that the water is treated to the standard level for municipal domestic consumption, and that brine disposal can be accomplished using an existing outfall line or similar method. It is not based on treating the water to a level needed for industrial uses requiring very high quality process water, such as Genentech and/or similar entities may provide with their own private treatment systems.

Brine disposal must be permitted by the Regional Water Quality Control Board under an NPDES discharge permit. It is assumed that brine disposal can be accomplished using an existing wastewater outfall line, such as at the existing wastewater treatment plant in South San Francisco, or a method that would be

similar in cost. Brine disposal has been a difficult issue for RO projects, and sometimes a fatal flaw. Potential disposal options include: discharging through an existing outfall such as a wastewater plant outfall, direct discharge to a waterway via a new discharge outfall, injection into deep saline wells if geologic conditions are appropriate, and other options such as selling the brine to a local salt company if a willing buyer can be identified.

Section 9
Plan Recommendations

This section presents an integrated summary of the water supply recommendations from Section 8 and the distribution system recommendations from Section 7. The plan provides capital costs for proposed facility improvements, and identifies the phasing for all recommendations.

9.1 Recommended Improvements and Phasing

The South San Francisco service area is close to buildout and the hydraulic capacity of the existing distribution system is adequate for buildout, so there are few capacity improvements needed. Many of the recommendations address improving the reliability of water supply to the service area, and the ability to move water from the southerly to northerly part of the system. The service area also contains many aging facilities that will need replacement over time.

SFPUC surface water will continue as the primary supply. Annual groundwater use is anticipated to remain similar to historic, at or below 1.5 mgd; and be accompanied by Cal Water participation in measures such as in-lieu recharge and recycled water use, that will support a higher level of future groundwater use. Depending on the availability and cost of surface water for in-lieu recharge and Cal Water's operating needs, the wells could be operated at lower rates when excess surface water is available to increase recharge, and at higher rates at other times. Cal Water will conduct a service areawide groundwater monitoring program to monitor the potential impacts of pumping on the groundwater basin. The recommendations also include measures to provide emergency well capacity to provide short-term emergency supply (i.e., emergency storage) in the event of a loss of SFPUC supply, in order to improve system reliability.

Table 9-1 summarizes the plan recommendations for both supply and distribution system, and the proposed system improvements with capital costs and phasing. Figure 9-1 shows the locations of proposed near-term improvements (to 2015) to provide additional capacity and/or reliability for the system. The basis of the capital cost estimates is described in Section 9.2. All costs in Table 9-1 are in 2006 dollars; costs for future years are not escalated for inflation.

Three timeframes were used to phase the recommendations:

- Near-term (2006 to 2010)
- Intermediate (2011 to 2015)
- Long-Term (2016 to 2030)

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Figure 9-1
Recommended Capacity Improvements

Table 9-1
Summary of Recommendations for South San Francisco System

Item	Description	Estimated Total Capital Cost June 2006 $)	Distribution of Capital Costs in June 2006 $ (per year for near-term and intermediate, per timeframe for long-term)										
			Near-Term					Intermediate					Long-Term
			2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016 - 2030
Distribution System Reliability (improve system reliability)													
Near-Term (2006-2010):													
Emergency Booster Pump Tie-ins for Northerly Area	Provide three emergency booster tie-ins to lift water from Zone 200 up to the following northerly zones are supplied solely from SFPUC turnouts: 260, 285, 330, 360 and 380. The only linkages between these zones are some PRVs or check valves from higher to lower zones in the cascade. These tie-ins will allow emergency booster pumps to lift water from the Zone 200 well field up to Zone 380 in the event of a loss of SFPUC supply. Each booster site could be sized to boost up to approximately 2000 gpm flow (about 3 mgd). The existing distribution system has adequate hydraulic capacity at the proposed locations (existing larger diameter transmission mains) to convey the recommended flow.	$240,000		$120,000	$120,000								
Station 1 GAC Treatment	Add granular activated carbon (GAC) treatment for trace organics at the Station 1 wellfield treatment facility.	$350,000	$350,000										
Emergency Storage for Zone 200 by means of additional well capacity instead of building new tanks	Construct up to 8 new wells (assuming average capacity of 150 gpm) in the vicinity of Station 1 with piping to connect them to the Station 1 treatment facility, in order to provide total firm capacity of 3 mgd at Station 1 well field with the existing and new wells, assuming one well out of service. Assumes 2 wells at Station 1 and 6 at new sites in vicinity of Station 1.	$9,450,000	$750,000	$1,050,000	$1,800,000	$2,650,000	$1,950,000	$1,250,000					
	Expand existing treatment facility at Station 1 from 1.6 to 3.2 mgd. Add another filter to provide 2,250 gpm (3.2 mgd) sustainable treatment capacity with allowance for backwashing (maximum instantaneous capacity of 2,500 gpm or 3.6 mgd). See Appendix I for detailed description of WTP improvements.	$1,500,000			$200,000	$650,000	$650,000						
	Telemetry and control system upgrades at Station 1: The booster pump station appears to have adequate firm pumping and electrical capacity for this initial expansion; and Station 1 pump station upgrade costs are included as a long-term measure. However, some telemetry and control improvements may be needed for the initial expansion to improve operational flexibility.	$350,000				$350,000							
Station 9 T1 (Reservoir 3) Upgrade	RES 3 (redwood tank) is seismically vulnerable and a high priority for replacement. Existing tank is 0.05 MG; storage capacity of 0.45 MG is required. Cost assumes replacement with a 0.5 MG tank.	$1,300,000			$100,000	$600,000	$600,000						
Pump Station 5 Upgrades	Pump C: Add Backup Pump and Replace Existing Pump. Add backup pump (40 HP) for Pump C supplying Zone 555. There is only one pump now supplying this zone. The other pumps at Station 5 serve other zones that have multiple feeds. Replace existing Pump C (40 HP) which is almost 40 years old as part of the station upgrade.	$200,000	$200,000										
	Pump A Replacement: When station upgrades are done, replace existing Pump A (20 HP) which is 50 years old, and was re-built in 2001. Cal Water to conduct efficiency test prior to replacement to confirm appropriate timing.	$70,000				$70,000							
Storage in Zone 265 for Emergency and Fire Reserve	Provide additional 1.0 MG storage at or in vicinity of RES 4 site. Due to the age of the existing small 0.25 MG tanks, cost assumes that the existing tanks are replaced with two new 0.75 MG tanks to both replace the existing tanks and provide the required additional storage (dual tanks will provide flexibility in operations to help maintain turnover and water quality). Other options that could be considered during predesign include building one tank instead of two, and/or keeping the existing tanks in service.	$3,600,000			$200,000	$1,700,000	$1,700,000						
Storage in 330 Zone for Emergency and Fire Reserve	Provide 3 MG storage at or in vicinity of RES 7 site. Due to the age of the existing tanks, cost assumes that the existing tanks are replaced with two new 1.5 MG tanks (dual tanks are costed to provide operational flexibility to manage turnover and water quality). During predesign, keeping one or more of the existing tanks in service could be considered. Since difference between existing and buildout requirement is very small, it is more cost effective to construct all the storage at once.	$6,800,000				$1,360,000	$2,720,000	$2,720,000					
	In addition, two emergency connections will feed water from surplus storage of 0.5 MG in Zone 430 through Zone 390 into Zone 330. The emergency interconnections should require minimal pipe improvements, since pipes of adequate hydraulic capacity are close to the potential zone connections. An estimated cost for up to 1,000 LF of 12-inch pipe is included for the two connections.	$220,000					$220,000						
Intermediate (2011-2015)													
New Well Field in Zone 380 for emergency supply in north part of system	Construct 6 new wells (assuming average capacity of 200 gpm) in a northerly area well field to provide up to 1.5 mgd supply capacity. These wells will provide emergency supply in the northerly area in the event of loss of SFPUC supply, and provide emergency storage rather than building a reservoir. Costs assume this northerly well field could be constructed, owned and operated by Cal Water. Another option for implementation would be to consider a joint agreement with SFPUC for this well field to be constructed by SFPUC as part of the SFPUC regional conjunctive use program. All would be at new sites.	$9,300,000						$1,860,000	$1,860,000	$1,860,000	$1,860,000	$1,860,000	
	Construct centralized 1.5 mgd treatment facility with clearwell and pump station for the northerly well field. Note: Another option that could be considered during predesign would be to construct a 1.5 MG tank and 2000 gpm pump station in Zone 380, instead of the well field and treatment facility. . This would provide one average day of emergency storage, but would not have the same multiple benefits for emergency/drought supply.	$7,500,000						$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	
Emergency Storage in Zone 360	Provide additional 0.5 MG storage at or in vicinity of RES 11 site. The cost assumes that the existing 1 MG tank is replaced with two new 0.75 MG tanks (due to age of facility when the project is implemented in the long-term). Other options to investigate during predesign include building a new 0.5 MG tank and keeping the existing 1 MG tank, or replacing the existing tank with one 1.5 MG tank.	$3,600,000						$720,000	$720,000	$720,000	$720,000	$720,000	
Long-Term (2016-2030)													
Emergency Storage for Zone 200 by means of additional well capacity to provide short-term emergency and critical drought supply	Increase well capacity in vicinity of Station 1 by an additional 2 mgd to a total of 5 mgd. Construct 9 new wells assuming average capacity of 150 gpm.	$11,925,000											$11,925,000
	Expand and upgrade existing treatment facility at Station 1 from 3 mgd to ultimate capacity of 5 mgd. Conduct pilot and predesign studies to determine if higher capacity could be achieved with higher filter loading rates; in addition, alternative process options could also be considered. Due to age of existing clearwell, cost assumes replacement of the existing 0.5 MG clearwell when the plant is upgraded. Note: The cost estimate is based on providing well capacity for emergency storage and emergency supply (multiple reliability benefits). Another option that could be considered during predesign studies to provide the emergency storage would be to construct new reservoirs. Both existing Zone 200 reservoirs (RES 1 and RES 2) are very old. If they were replaced with new larger tanks, it could provide the required additional storage. A total of 5 MG would be needed at the two sites to replace the existing 3 MG at the existing tanks and to provide the additional 2 MG. The appropriate split of storage would depend on the site constraints.	$7,500,000											$7,500,000
Station 1 Booster Pump Station	Replace the existing pumps and electrical/instrumentation to provide a total of 5 mgd firm pumping capacity (assuming there is 5 mgd of well capacity including the emergency storage for Zone 200).	$1,200,000											$1,200,000

Table 9-1
Summary of Recommendations for South San Francisco System

Item	Description	Estimated Total Capital Cost June 2006 $)	Distribution of Capital Costs in June 2006 $ (per year for near-term and intermediate, per timeframe for long-term)										
			Near-Term					Intermediate					Long-Term
			2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016 - 2030
Local Supply Measures (enhance supply capacity, improve supply reliability, maintain long-term groundwater basin sustainability)													
Water conservation measures													
Long term permanent conservation savings	Continue implementation of planned long-term conservation measures per Urban Water Management Plan. Evaluate implementation and effectiveness of planned conservation measures; modify as needed as part of Urban Water Management Plan update process.	Costs for these measures are not facility capital costs.	Conservation program implementation costs as determined in Urban Water Management Plan.					Conservation program implementation costs as determined in Urban Water Management Plan.					Conservation program implementation costs as determined in Urban Water Management Plan.
Temporary demand reductions	Implement temporary demand reductions during emergencies and droughts as outlined in Urban Water Management Plan (Water Shortage Contingency Plan), as needed to address temporary reductions in total supply.												
Groundwater monitoring	Design and implement a service area wide groundwater monitoring program to monitor impacts of potential in-lieu recharge program and groundwater pumping. Periodically evaluate data collected with respect to overall basin trends. Annual cost includes: developing and managing the program, installing monitoring wells, quarterly water levels (transducers), semi-annual water quality sampling and analysis, and semi-annual data analysis and reporting. Cost assumes 8 existing wells in network for first year (select Cal Water wells and private wells) gradually increasing to 18 wells by the 5th year.	Annual cost estimates for monitoring program are shown.	$150,000	$250,000	$250,000	$250,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	Assume continue at $150,000 per year. Re-assess long-term cost based on monitoring findings.
Groundwater recharge	*Near-Term:* Implement local in-lieu recharge within the service area, assuming an agreement can be reached to purchase in-lieu water at or less than the cost of SFPUC supply.	Annual costs for program-related studies.	$100,000	$100,000	$100,000	$100,000	$100,000	$150,000	$150,000	$150,000	$150,000	$150,000	Re-assess long-term costs in future master plan updates.
	Intermediate: Continue local in-lieu recharge within the service area. Re-evaluate status of regional in-lieu recharge program relative to Cal Water participation. Consider investigating potential benefits of surface percolation for aquifer storage and recovery, e.g., Colma Creek.												
	Long-Term: Continue local in-lieu recharge within the service area. Re-evaluate status of regional in-lieu recharge program relative to Cal Water participation. Evaluate potential for aquifer storage and recovery with injection/extraction wells.												
Regional recycled water program	*Near-Term:* Continue to participate in planning for future recycled water project(s) with South San Francisco, San Bruno, and SFPUC. Consider initiating a joint feasibility study with Daly City to investigate supplying recycled water to Colma cemeteries.	Annual costs included for near-term and intermediate program-related studies. Long-term cost range shown for regional recycled water project under consideration. Cal Water would share cost of regional project..	$100,000	$100,000	$100,000	$100,000	$100,000	$150,000	$150,000	$150,000	$150,000	$150,000	Total cost for regional recycled water project would range from $14,000,000 to $42,000,000 or more depending on level of implementation. Low end is limited implementation; high end is full implementation.
	Intermediate: Continue to participate in planning for future recycled water project(s) within service area: 1) With South San Francisco, San Bruno, and SFPUC; 2) With Daly City. Re-evaluate status and appropriate participation in recycled water projects based on new information that becomes available over time.												
	Long-Term: Determine appropriate participation in regional recycled water project if feasible project is identified. A range of capital costs is shown for the alternatives under consideration. Cal Water would share in these costs with other participants, with the cost share to be determined in future negotiations.												
Desalination	*Near-Term:* As part of regional supply planning for all three Peninsula Districts, scope and conduct a conceptual feasibility study to explore siting, technology, and potential partnering options.	Annual costs for program-related studies in near-term and intermediate timeframe. Long-term cost range shown for implementation of a 2 mgd RO project.	$100,000	$100,000	$100,000	$100,000	$100,000	$150,000	$150,000	$150,000	$150,000	$150,000	$12,000,000
	Intermediate: If feasible options are identified in the near-term feasibility study, evaluate implementing a pilot study as part of regional supply planning for all the Peninsula districts.												
	Long-Term: If confirmed by previous studies and if future conditions indicate it is cost competitive, an RO treatment facility of either 1 mgd or 2 mgd could be constructed in Zone 200 in lieu of some or all of the additional 2 mgd groundwater capacity. Capital costs are included for a 2 mgd facility assumed to be located near the Bay and adjacent to major transmission lines.												
Replacement/Rehabilitation Projects													
Reservoir Replacement	RES 101 replacement or major rehabilitation when hydropneumatic pump station is rehabilitated. Cost assumes replacement.	$750,000						$750,000					
Pump Station Replacement (listed in priority order)	Station 101 replacement of pumps, motors and hydropneumatic tank. A larger hydropneumatic tank should be considered to limit cycling time to 4 to 6 cycles per hour.	$500,000							$500,000				
	Pump Station 2 replacement of pump and motors, and associated electrical and telemetry upgrades. When upgraded, fewer and smaller pumps could be installed. Two pumps approximately equal in size to Pump 5-A (20 hp) would meet the performance criteria, in conjunction with Pump 5-A that also serves the same zone.	$300,000								$300,000			
	Pump Station 4 replacement of pumps and motors, and associated electrical and telemetry upgrades. When upgraded, fewer and smaller pumps could be installed. One pump would meet the performance criteria, in conjunction with Pump 5-B (30 hp) that also serves the same zone.	$250,000									$250,000		
Well Replacement	Major rehabilitation or replacement of the existing wells at Station 1. Cost assumes replacement of 7 wells at average 150 gpm each (no land cost since assumed to be replaced on existing site).	$5,250,000											$5,250,000
Pipeline Replacement	Cal Water has an ongoing program for pipeline replacement. Specific budget amounts for replacement are determined each year based on leak history and system needs. An estimated amount is shown assuming replacement of 1,900 LF per year of small diameter (less than 6-inch) pipe with 6-inch pipe (minimum diameter). This would replace all small diameter pipe over a 50-year period (assumes starting in 2006).	$5,225,000	$209,000	$209,000	$209,000	$209,000	$209,000	$209,000	$209,000	$209,000	$209,000	$209,000	$3,135,000
SCADA Replacement	Cal Water has an ongoing program for SCADA replacement.												
TOTALS			$1,959,000	$1,929,000	$3,179,000	$8,139,000	$8,499,000	$9,609,000	$5,389,000	$5,189,000	$5,139,000	$4,889,000	To be re-assessed in future master plan updates.

Within each timeframe, the projects are listed in priority order according to the following types of improvements (listed in highest to lowest priority):

- Enhancement of local supply sources to improve supply reliability in the event of short-term reductions in SFPUC surface supply during emergencies or critical droughts. This includes wells with backup power, treatment and other related facilities.
- Additional storage capacity to meet the performance criteria established for emergency storage and fire reserve. The emergency storage capacity would be met by a combination of additional well capacity and new tank storage.
- Additional pumping capacity to provide a standby pump for all zones.
- Long-term implementation of supply measures, such as recycled water and desalination, to help maintain long-term groundwater basin sustainability and enhance local supply.
- Replacement of other aging facilities over time including small diameter (less than 6-inch) pipelines, pump stations, reservoirs, wells, and SCADA facilities. An initial prioritization is provided in Table 9-1 for consideration by Cal Water for their replacement program. Specific priorities for implementation would be set by Cal Water based on both facility condition and compatibility with other projects.

More detailed information is provided on costs and phasing for recommendations over the next 5 to 10 years. These near-term and intermediate actions focus on improving the reliability of the existing water supply as discussed in the Section 8 water supply strategy, and providing required capacity in the distribution system to meet the performance criteria as defined in Section 5.

The recommended plan provides flexibility for implementation of various long-term steps depending on the outcome of near-term actions. Over the next 5 to 10 years, some uncertainties regarding local supply components, such as in-lieu recharge, recycled water and desalination, should be resolved that will help better identify long-term implementation steps. Then, based on actual conditions in the future, the appropriate long-term pieces can be implemented.

9.2 Basis for Capital Cost Estimates

Conceptual planning-level capital cost estimates were developed for facility improvements. All costs are in current dollars and are indexed to the Engineering New Records Construction Cost Index for San Francisco (ENR CCI of 8500 as of June 2006).

The estimated capital costs include:

- Construction Cost: Calculated using unit construction costs based on cost data from other CDM projects in the San Francisco Bay area. The unit costs assume a normal (average) construction environment, and do not include such things as significant rock excavation or dewatering, unusual working hours, or exotic construction methods.

- Construction Contingency: Markup of 30 percent of the construction cost, which is intended to account for additional work that may be identified during final design, uncertainties in the bidding climate, and change orders during construction.

- Project Implementation Allowance: Allowance of 40 percent of the total construction cost (construction cost plus construction contingency) to cover the following items:
  - Feasibility and siting studies (4%),
  - Preliminary and final design engineering, preparation of construction plans and specifications (12%),
  - Environmental documentation and permitting (4%),
  - Construction services including construction management, construction inspection, engineering support during construction, construction surveying, start-up services, and as-built drawings (10%),
  - Project administration, legal support (2%) and Cal Water overhead (8%).

- Land costs are included for new well sites. Replacement and/or improvement of existing facilities is assumed to be accommodated at the existing Cal Water sites.

Table 9-2 summarizes unit capital costs for water system improvements. These unit capital costs are based on the construction cost times a total markup of 1.82 for construction contingency and project implementation (markups are compounded).

Table 9-2
Unit Capital Costs for Water System Improvements
(June 2006 $) (1)

RESERVOIRS (2)

Capacity (MG)	Concrete		Steel	
	Unit Capital Cost ($ per gallon)	Total Capital Cost ($ per Reservoir)	Unit Capital Cost ($ per gallon)	Total Capital Cost ($ per Reservoir)
0.5	2.40	1,200,000	1.90	950,000
1	2.40	2,400,000	1.90	1,900,000
1.5	2.27	3,400,000	1.80	2,700,000
2	2.20	4,400,000	1.75	3,500,000
2.5	2.16	5,400,000	1.72	4,300,000
3	2.10	6,300,000	1.67	5,000,000
3.5	2.06	7,200,000	1.63	5,700,000
4	2.00	8,000,000	1.60	6,400,000
5	1.92	9,600,000	1.54	7,700,000

PORTABLE PUMP CONNECTIONS (3)

Size (inches)	Capital Cost ($ per Connection Location)
12	$80,000

PUMP STATIONS (4)

Total HP	Unit Capital Cost ($ per HP)	Total Capital Cost ($ per Station)	Cost Percentages for Replacement Projects
20	15,500	310,000	Replacement costs estimated as a percentage of the total capital cost for a new pump station: Pumps & motors – 20% Electrical/instrumentation – 30% Pipes, fittings, valves – 20% Building, site work – 30%
40	12,500	500,000	
60	11,000	660,000	
80	10,250	820,000	
100	9,300	930,000	
150	8,400	1,260,000	
200	7,500	1,500,000	
300	6,550	1,965,000	
400	6,200	2,480,000	
500	5,800	2,900,000	
600	5,500	3,300,000	
700	5,100	3,570,000	
800	4,750	3,800,000	

PIPELINES (5)

Diameter (inches)	Unit Capital Cost Within Existing Paved Right of Way ($ per foot)
6	110
8	145
10	180
12	220
16	290
18	330
20	365
24	440

WELLS (6)

Capacity	Total Capital Cost per Well at Existing Site	Total Capital Cost per Well at New Site
150 gpm per well in Station 1 area	$750,000	$1,325,000
200 gpm per well in north area	$975,000	$1,550,000

Table 9-2 Unit Capital Costs for Water System Improvements (June 2006 $) (1)		
TREATMENT FACILITY IMPROVEMENTS (groundwater) (7)		
Type	***Unit Capital Cost ($ per gallon)***	***Total Capital Cost***
Minor Expansion of Existing Station 1 Facility from 1.6 mgd to 3.2 mgd	2.50	1,500,000
Major Expansion of Existing Station 1 Facility from 3 mgd to 5 mgd	3.75	7,500,000
New 1.5 mgd Treatment Facility for North Area (includes clearwell and pumps)	5.00	7,500,000

(1) Unit capital costs include construction costs times 1.82 total markup for contingencies (30% of construction cost) and project implementation (40% of total construction cost with contingencies). Unit costs are in June 2006 dollars, ENR CCI of 8500 for San Francisco.
(2) Reservoir construction costs assume above ground structures and include average site work, valve vault, telemetry, piping and appurtenances. Steel reservoirs have a lower initial capital cost than steel reservoirs, however, steel reservoirs incur higher life cycle maintenance costs due to the need for periodic re-coating and cathodic protection. Cost estimates are based on concrete reservoirs.
(3) Cost of portable pump connections is for 2 hydrants with valves off the transmission pipeline at each connection point (one hydrant and normally closed valve on either side of the zone separation), as well as up to 100 LF piping. Connections are assumed to occur within existing right-of-way. Cost of portable pump and generator is not included.
(4) Pump station construction costs are based on an aboveground structure with standby pump, backup power capability, and telemetry.
(5) Pipeline unit construction costs include valves and appurtenances, pavement removal and replacement, traffic control, and an average allowance for correction of utility interferences.
(6) Well construction costs include well drilling, well equipping, and standby power. For new sites, the costs also include discharge piping from the well to treatment facility, and land purchase (at $350,000 per well site).
(7) Treatment construction costs assume water quality and processes similar to the existing Station 1 well field.

For the potential long-term water supply options of recycled water and desalination, placeholder costs are included based on the currently available information. These placeholder costs should be re-evaluated in future master updates, as more information becomes available to refine specific future supply recommendations. The placeholder costs are:

- Desalination with reverse osmosis – Capital costs are based on modular increments (skid-mounted units) assuming total ultimate supply of 1 or 2 mgd. Capital costs for self-contained RO units are approximately $3 per gallon, and are available in 0.5 and 1.0 MGD increments. The total capital cost for a complete package treatment unit would be about $6 million per million gallon per day capacity ($6 per gallon), including engineering and implementation costs. This cost assumes that advance filtration will be required before the RO process and that post-treatment would include pH and alkalinity recovery and disinfection. The cost does not include any raw water conveyance or distribution system improvements.

- Recycled water – Capital costs are shown for implementation of the alternatives under consideration based on the information from the joint feasibility study with City of South San Francisco and San Bruno. A recycled water project would be a regional project that would include participation by other agencies. Cal Water would share the costs of a recycled water project with the other participants. Cost sharing arrangements would be negotiated among the parties when the recycled water project is better defined.

Appendix A

Sensitivity Analyses of Service and Demand Projections

APPENDIX A-1
SENSITIVITY ANALYSES OF PROJECTED SERVICES

USING 10-YEAR AVERAGE GROWTH RATES:

Year	Customer Type						Total Services
	Single Family Residential Services	Multi-Family Residential Services	Commercial Services	Industrial Services	Government Services	Other Services	
2003	13,754	151	1,881	68	220	110	16,184
2005	13,989	154	1,921	68	222	110	16,465
2010	14,594	158	2,026	68	228	110	17,184
2015	15,224	163	2,137	68	234	110	17,937
2020	15,883	168	2,254	68	241	110	18,723
2025	16,569	172	2,377	68	247	110	19,544
2030	17,285	178	2,507	68	254	110	20,402

USING 5-YEAR AVERAGE GROWTH RATES:

Year	Customer Type						Total Services
	Single Family Residential Services	Multi-Family Residential Services	Commercial Services	Industrial Services	Government Services	Other Services	
2003	13,754	151	1,881	68	220	110	16,184
2005	14,036	153	1,929	68	224	110	16,520
2010	14,767	155	2,055	68	233	110	17,388
2015	15,535	157	2,189	68	243	110	18,302
2020	16,344	160	2,331	68	254	110	19,267
2025	17,195	162	2,483	68	264	110	20,282
2030	18,090	164	2,645	68	276	110	21,352

USING HIGHEST AVERAGE GROWTH RATES FROM TABLE 8:

Year	Customer Type						Total Services
	Single Family Residential Services	Multi-Family Residential Services	Commercial Services	Industrial Services	Government Services	Other Services	
2003	13,754	151	1,881	68	220	110	16,184
2005	14,036	155	1,929	68	225	110	16,523
2010	14,767	162	2,055	68	239	110	17,400
2015	15,535	169	2,189	68	253	110	18,324
2020	16,344	177	2,331	68	268	110	19,298
2025	17,195	185	2,483	68	284	110	20,325
2030	18,090	194	2,645	68	301	110	21,407

APPENDIX A-2
SENSITIVITY ANALYSES OF DEMAND PROJECTIONS

SCENARIO A: **10-Year Average Growth Rate**
10-Year Average Unit Demands per Service

Year	Average Day Demands (gallons per day)								
	Customer Type						Subtotal Customer Demand	Unaccounted-for Water (5%)	Total Demand
	Single Family Residential	Multi-Family Residential	Commercial	Industrial	Government	Other			
2003	3,232,190	396,979	3,220,272	665,040	433,400	90,420	8,038,301	401,915	8,440,216
2005	3,287,371	404,866	3,289,555	665,040	438,006	90,420	8,175,257	408,763	8,584,020
2010	3,429,479	415,382	3,469,352	665,040	449,737	90,420	8,519,411	425,971	8,945,382
2015	3,577,731	428,527	3,658,978	665,040	461,782	90,420	8,882,478	444,124	9,326,602
2020	3,732,392	441,672	3,858,967	665,040	474,150	90,420	9,262,641	463,132	9,725,773
2025	3,893,738	452,188	4,069,887	665,040	486,849	90,420	9,658,122	482,906	10,141,028
2030	4,062,059	467,962	4,292,336	665,040	499,888	90,420	10,077,705	503,885	10,581,590

SCENARIO B: **10-Year Average Growth Rate**
5-Year Average Unit Demands per Service

Year	Average Day Demands (gallons per day)								
	Customer Type						Subtotal Customer Demand	Unaccounted-for Water (5%)	Total Demand
	Single Family Residential	Multi-Family Residential	Commercial	Industrial	Government	Other			
2003	3,287,206	381,124	3,440,349	662,456	455,840	90,420	8,317,395	415,870	8,733,265
2005	3,343,326	388,696	3,514,366	662,456	460,685	90,420	8,459,949	422,997	8,882,946
2010	3,487,854	398,792	3,706,452	662,456	473,023	90,420	8,818,996	440,950	9,259,946
2015	3,638,629	411,412	3,909,036	662,456	485,692	90,420	9,197,645	459,882	9,657,527
2020	3,795,922	424,032	4,122,693	662,456	498,700	90,420	9,594,223	479,711	10,073,934
2025	3,960,015	434,128	4,348,028	662,456	512,056	90,420	10,007,103	500,355	10,507,458
2030	4,131,201	449,272	4,585,679	662,456	525,770	90,420	10,444,798	522,240	10,967,038

SCENARIO C: **5-Year Average Growth Rate**
10-Year Average Unit Demands per Service

Year	Average Day Demands (gallons per day)								
	Customer Type						Subtotal Customer Demand	Unaccounted-for Water (5%)	Total Demand
	Single Family Residential	Multi-Family Residential	Commercial	Industrial	Government	Other			
2003	3,232,190	396,979	3,220,272	665,040	433,400	90,420	8,038,301	401,915	8,440,216
2005	3,298,463	402,237	3,302,586	665,040	440,712	90,420	8,199,458	409,973	8,609,431
2010	3,470,151	407,495	3,517,695	665,040	459,535	90,420	8,610,337	430,517	9,040,854
2015	3,650,777	412,753	3,746,815	665,040	479,163	90,420	9,044,967	452,248	9,497,215
2020	3,840,803	420,640	3,990,858	665,040	499,628	90,420	9,507,390	475,370	9,982,760
2025	4,040,721	425,898	4,250,797	665,040	520,968	90,420	9,993,845	499,692	10,493,537
2030	4,251,045	431,156	4,527,666	665,040	543,220	90,420	10,508,547	525,427	11,033,974

APPENDIX A-2
SENSITIVITY ANALYSES OF DEMAND PROJECTIONS

SCENARIO D: **5-Year Average Growth Rate**
5-Year Average Unit Demands per Service

Year	Average Day Demands (gallons per day)								
	Customer Type						Subtotal Customer Demand	Unaccounted-for Water (5%)	Total Demand
	Single Family Residential	Multi-Family Residential	Commercial	Industrial	Government	Other			
2003	3,287,206	381,124	3,440,349	662,456	455,840	90,420	8,317,395	415,870	8,733,265
2005	3,354,607	386,172	3,528,289	662,456	463,530	90,420	8,485,474	424,274	8,909,748
2010	3,529,218	391,220	3,758,099	662,456	483,328	90,420	8,914,741	445,737	9,360,478
2015	3,712,917	396,268	4,002,877	662,456	503,972	90,420	9,368,910	468,446	9,837,356
2020	3,906,179	403,840	4,263,598	662,456	525,498	90,420	9,851,990	492,600	10,344,590
2025	4,109,500	408,888	4,541,301	662,456	547,942	90,420	10,360,507	518,025	10,878,532
2030	4,323,403	413,936	4,837,092	662,456	571,346	90,420	10,898,653	544,933	11,443,586

SCENARIO E: **Highest Growth Rate from Table 8**
5-Year Average Unit Demands per Service

Year	Average Day Demands (gallons per day)								
	Customer Type						Subtotal Customer Demand	Unaccounted-for Water (5%)	Total Demand
	Single Family Residential	Multi-Family Residential	Commercial	Industrial	Government	Other			
2003	3,287,206	381,124	3,440,349	662,456	455,840	90,420	8,317,395	415,870	8,733,265
2005	3,354,607	391,220	3,528,289	662,456	466,569	90,420	8,493,561	424,678	8,918,239
2010	3,529,218	408,888	3,758,099	662,456	494,510	90,420	8,943,590	447,180	9,390,770
2015	3,712,917	426,556	4,002,877	662,456	524,123	90,420	9,419,349	470,967	9,890,316
2020	3,906,179	446,748	4,263,598	662,456	555,510	90,420	9,924,911	496,246	10,421,157
2025	4,109,500	466,940	4,541,301	662,456	588,777	90,420	10,459,394	522,970	10,982,364
2030	4,323,403	489,656	4,837,092	662,456	624,036	90,420	11,027,064	551,353	11,578,417

Appendix B

Existing Facility Assessments (Site Visits)

Appendix B
Existing Facility Assessments (Site Visits) South San Francisco Water Supply & Facilities Master Plan

Purpose

This appendix presents the findings of the site visits conducted for the South San Francisco Water Supply and Facilities Master Plan as it pertains to the general condition of the existing pumping, storage and treatment facilities. The existing SCADA system is described in Appendix C.

Section 4 of the master plan report contains a description of the existing facilities, as well as figures showing the pressure zones (Figure 4-1), profile schematic (Figure 4-2), and distribution system facilities (Figure 4-3). The Section 4 description and figures should be consulted as references for this appendix.

The following topics are addressed in this appendix:

- Purpose
- Summary of Key Findings
- Overview of Field Investigation
- Station 1
- Pump Stations
- Reservoirs
- Station 101 - Broadmoor
- Pressure Reducing Valve (PRV) Stations

Summary of Key Findings

The evaluation was limited to visual observations, discussion with the operations staff, and review of the system map, system profile, and facilities data provided by Cal Water. General findings from the assessment are discussed below.

Treatment System at Existing Well Field

The groundwater treatment system at the existing well field has the basic infrastructure to reduce raw water iron and manganese concentrations to acceptable levels. However, it does not have any significant operational flexibility or redundancy, which makes operating various well combinations difficult, and if equipment malfunctions.

Pump Stations

Overall, based on discussions with operations staff, the pump stations are able to supply water to the various service areas with minimal apparent problems. The relatively small size of most of the pumps and the availability to feed all but one of the zones from SFPUC turnouts reduces the potential problems during normal operation. This is primarily a concern when operating the pump stations during peak demand periods, emergency conditions and when utilizing the well supply. The goal is the ability to easily adjust the operation of the pumps in response to changes in water supply or water system demands, which may translate into excessive starting and stopping of the pumps, inefficient operation (high energy costs), undesirable reservoir tank levels and higher labor costs for field visits.

In some cases, hydraulic issues affect facility operations. For example, Pump Station 3 does not operate effectively, which may be due to how the pump station is isolated/connected within the overall system.

Reservoirs

Based on discussion with Cal Water operations staff, Reservoirs 1, 10 and 101 have experienced poor turnover/circulation affecting water quality. A small circulating pump was recently added at Reservoir 10 in order to improve turnover.

As water sits in the tanks and ages, the chloramines residual diminishes and the potential for nitrification increases. High water ages are commonly found in reservoirs that have no pump station forcing turnover and/or that contain a large fire reserve for a small zone with low domestic demand. Some ways to address poor turnover in existing facilities include: adding a small pump at the tank to force turnover, changing set points to operate within a smaller volume range during low demand periods, having separate inlet and outlet lines on opposite sides of tank, installing a bypass valve to a lower zone that could be opened to increase the demand on the tank. When new reservoirs are constructed, the design should specifically address water quality and mixing issues.

Most of the tanks are not seismically anchored, and rely on friction between the tank and the pad to prevent horizontal movement during a large seismic event. Due to their large diameter relative to height, the tanks are not generally prone to overturning. The primary concern during a seismic event is overall flexing of the tank wall due to sloshing of the water in the tank and some potential movement of the tank. The flexible pipe connections already on most tanks are intended to reduce the potential for failure of the tank connections.

However, Reservoir 3, the old redwood tank, may be severely damaged during an earthquake, e.g., may fall over. Changes to the controls for Pump Station 4 that feeds Reservoir 3 should be considered in the event of loss of Reservoir 3.

Other than slight displacements and distortions during seismic events, the main areas of concern are the single inlet/outlet on the tanks which reduce tank circulation. This

along with coating failures would be the primary factors contributing to degradation of water quality in the reservoirs.

PRV Stations and Flow Meters

The vaults used to house many of the PRVs and flow meters are below grade, which make them prone to collecting water. The standing water or saturated floor materials increases the humidity and rates of corrosion for the mechanical and electrical equipment. Overall access is another general concern associated with ingress and egress, confined space issues, adequate space in front of electrical equipment and ability to work efficiently around the equipment. These concerns do not prevent effective operation of the PRVs, but often increase the time required to maintain or adjust the facilities.

Electrical

The electrical equipment at all facilities was very well maintained. Electrical components were visually clean as well as the space surrounding the components. All conduits were in good condition and none appeared to be damaged.

The well-maintained condition of the electrical equipment should facilitate continued operation with minimal failures, other than components failing because of life expectancy. However, many of the electrical components are outdated and finding replacement parts will be difficult unless the maintenance staff already has the component in their inventory. If a failure should occur on one of the old components, returning to normal operation may require a long lead time.

Electrical connections were not checked during the field visits. CDM recommends that an infrared study of the electrical equipment be conducted to check for any loose connections and/or failing components, as a preventive maintenance measure to detect and allow time for repair/replacement.

Cal Water is taking a proactive approach with their maintenance and is replacing their electrical equipment before any failures can occur. Cal Water recently replaced some equipment that had been installed in 1945. Electrical upgrades consist of full electrical replacement including the service transformer, switchgear, meter, and controllers. Station 4 has recently been upgraded. Upgrade at Station 5 is in progress. Station 1 is planned for upgrade within the next four years. Station 2 upgrades are currently being designed. Station 6 upgrades are being designed as part of a Genentech project. Projects are designed in-house and bid out to an electrical contractor for construction.

Overview of Field Investigation

Field investigations were conducted at the following facilities:

- Station 1 (wells, treatment facility, clearwell, pumps)
- Pump Stations 2, 3, 4, 5, 6, and 7

- Reservoirs 1, 2, 3, 4, 7, 9, 10, 11 and 12
- Station 101 - Broadmoor (reservoir and booster station)
- PRV Station (typical installation)

The facility assessment evaluation was limited to visual observations, discussion with the operations staff, and review of the system schematic, system map, and facilities data provided by Cal Water. Site visits were conducted on November 2 and 16, 2004, accompanied by key District staff.

The typical field assessment considered the following items.

- Inlet piping configuration
- Relative age of the equipment
- Housekeeping and environmental considerations
- Accessibility
- Condition of electrical supply equipment

The treatment system, wells and many pump stations were not currently being operated, so it was not possible to assess operating parameters such as vibration, noise, and leaks.

Photos from the site visits are included at the end of this appendix.

Station 1 (Wells, Treatment Facility, Clearwell, Pumps)

At Station 1, water can be pumped from series of wells to an iron and manganese treatment system that consists of chlorine oxidation, followed by filtration. The treatment system also has sodium bisulphite chemical facilities to reduce the chlorine concentration from 5 mg/l to 1 mg/l, and a backwash reclamation system to separate precipitated iron hydroxide and manganese dioxide before returning the backwash water back to the head of the treatment plant.

There are seven production wells around the Station 1 that can supply water to the iron and manganese treatment system. A couple of the wells have high nitrate concentration, which means they can only be operated when other wells or a supply of water from the San Francisco Public Utilities Commission (SFPUC) is available for blending. Some of the wells are located in small sheet metal enclosures to provide some weather protection and security at the well head. Most of the wells have been converted to submersible pumps, and there is no motor or shaft lubrication system at the top of the well. One of the operators noted that there appeared to be a layer of oil on top of the water in some of the wells. This is apparently residual oil from when oil lubricated line-shaft pumps were used.

To operate the treatment system, the operators manually start from one to seven of the wells around the Station 1 and pump water to the treatment plant where sodium hypochlorite is metered into the flow. The number of wells and the flow rate cannot

be controlled at the treatment plant site. Based on the flow rate from the wells the speed and stroke of the hypochlorite metering pump is manually adjusted to achieve the 4 to 6 mg/l chlorine residual needed to oxidize the iron and manganese in the raw water. The hypochlorite is stored in a 1,640-gallon double contained tank located under a canopy. The tank provides enough hypochlorite to treat 32 mg of water at a chlorine dose of 6 mg/l. The metering pump automatically starts when the well pumps are started. Information from the operators indicates that the system operates reliably, but requires operator oversight since it is not flow paced. The system needs a backflow preventer on the potable water connection for system flush water.

The chlorinated water flows through the first pressure vessel, which provides the contact time for oxidizing the iron and manganese. Sodium bisulphite is added between the first and second pressure vessels to reduce the chlorine to an acceptable concentration for discharge to the distribution system. A 100 gallon bisulphite storage tank and a small metering are located in the operations building storage room. Equipment access and ventilation are poor, and there is only enough sodium bisulfite to "neutralize" 1 mg/l of free chlorine for a total of 14 mg of flow.

After the sodium bisulphite reaction tank, the water flows to a pressure filter to remove precipitated iron and manganese. The pressure filter is a typical design, but it was not possible to inspect the condition of the filter media, underdrains or internal piping. The operators did not identify problems with turbidity breakthrough or backwashing associated with the filters, although it had been a couple of years since the filters were operated. The filters operated approximately 12 hours before needing to be backwashed. The main operational problem identified by the operators was associated with the backwash reclamation system, which resulted in significant changes in filter flow rate when the system started and stopped.

After the water leaves the filter aqua ammonia is injected into the discharge pipe to convert the free chlorine to chloramines, so make the water compatible with the San Francisco surface water supply. The aqua ammonia system is a new system, and it has not been operated as an on-line facility. The aqua ammonia is stored in a pressurized tank to reduce ammonia vapor emissions. The metering pump is flow paced, but the dosage has to be manually adjusted depending on the initial hypochlorite feed rate and the final chlorine residual after adding sodium bisulphite.

The backwash water from the filters is discharged to the reclamation tank to allow the iron and manganese sludge to settle before returning the decant water to the inlet of the first reaction vessel. The backwash return pump was designed to operate at 100 gpm, which would return the typical 6,000 gallons of backwash water to the head of the plant in 60 minutes and then stop. The change in flow rate required adjustment of the sodium hypochlorite pump feed rate to maintain the same chlorine dose, which in turn required an operator be present when the backwash reclamation pump was operating. The operations staff was in the process of installing a new low capacity backwash reclamation pump to allow backwash water to be return on a more continuous basis.

After leaving the pressure filters, the treated water flows by under pressure to the 500,000 gallon on-site clearwell (HGL 31-55). The treated water is pumped to Reservoir 2 (HGL 186-201) using centrifugal pumps in Station 1. All three pumps are 100 hp, but pumps A and B are older with limited capacity. Pump D is a newer pump used as the primary supply pump, but the operators noted that it experiences cavitation problems. The inlet piping to the pump uses concentric reducers, which can trap air. As the air is scoured out of the fitting, it can cause the pump to cavitate.

In the past, when the wells were operating, well water would typically be found in areas served by Pump Station 2 and Pump Station 5, and the industrial area.

The electrical distribution switchboard at the Treatment Facility is in excellent condition. There are some items placed in front of and on top of the switchboard which should be removed. The equipment pad has provisions for future expansion as well as conduit stub-ups. The lighting panel within the switchboard has plenty of spare breakers for future loads.

All exterior conduits and panels are in good condition. There is one lighting fixture in the chemical area that has water inside of it. This fixture needs to be cleaned out and sealed to prevent any more water seepage.

The electrical distribution equipment at the Station 1 Pump Station is in good condition, but is out dated and needs to be upgraded. Some of the circuit breakers have been tagged out but not locked out. If the equipment is truly out of service then a lockout procedure should be used.

Pump Stations

A discussion of the field observations at each station, except Station 101, follows. The Station 101 (Broadmoor) pump station is discussed in a later section.

Pump Station 2

Pump Station 2 can be used to supplement Zone 265 and Reservoir 4 if the wells are off-line. The pumps are horizontal centrifugal pumps of varying capacities. The pumps are older models, which makes it difficult to find repair parts. One of the pumps is a horizontal split case pump with the inlet and outlet connections on the same side. This type of pump casing is not commonly used anymore, and could make installation of a replacement pump more complicated.

The electrical equipment is in good condition but is out dated. These should be replaced with a switchboard lineup similar to the newer equipment in Pump Station 5 and the Treatment Facility. Conduits are in good condition. The pump directly in front of the electrical equipment is an NEC clearance violation. Also, there is one motor starter that cannot be reset unless the cover is removed from the enclosure. The enclosure for this starter must be replaced to allow the resetting of the starter without having to remove the cover.

All electrical exterior conduits and panels at this site are in good condition.

Pump Station 3

Pump Station 3 is one of the older pump stations and consists of one duty and one stand-by pump are located in a small building along with the electrical equipment. It is rarely used. Its purpose is to transfer water from Reservoir 2 to Reservoir 1 in the same 200 pressure zone when the SFPUC connections are unable to supply the necessary flow. The pumps are connected to the 18 inch diameter main transmission line for the 200 zone, but there are apparently also some distribution connections around the station.

The operators indicated that the pump station was not very effective in transferring water from Reservoir 2 to Reservoir 1, and think there may be problems with how the station is isolated within the system, e.g., how and where it draws water from the system.

The pump station does appear to be part of the west to east flow path as evidenced by the spinning of the pump impellers even when the pumps motors are off. There are no check valves on the pump discharge lines, so only one pump can be operated at any given time, which further limits its overall pumping capacity.

The pump motors are old 30 hp, 1200 rpm 220 volt motors with large open areas around the rotor assemblies. This results in a hazard during operation, and could allow rodents access to the insulation. The inlet pipe to Pump A consists of a mitered elbow connected directly to the suction flange of the pump, which results in turbulent flow at the intake to the impeller. The suction inlet to Pump B was a smooth straight inlet, which will minimize turbulence entering the pump. The seal box drain on Pump B was plugged resulting in water flowing across the floor of the pump station.

The electrical distribution equipment at the Pump Station 3 is in good condition but out dated and needs to be upgraded. Some of the circuit breakers have been tagged out but not locked out. If the equipment is truly out of service then a lockout procedure must be used. The limited space inside this pump station must be taken into account when specifying and designing a new distribution switchboard.

Pump Station 4

Pump Station 4 has constant speed pumps controlled by the water level in Reservoir 3. The pumps are located in small cement block enclosures with wood covers to provide weather protection. There was a concentric reducer on the inlet to Pump B, but the pump operated smoothly without any apparent vibration or cavitation. The pump on/off operating sequence was reasonable, and kept the motors starts per hour below the maximum recommended by the motor manufacturers.

The electrical equipment is in good condition and is located outdoors. Conduits and panels are in good condition.

Pump Station 5

Pump Station 5 pumps water from Reservoir 2 (HGL 186-201) to three different pressure zones as described below:

1. Pump A – Zone 265 and Reservoir 4. Horizontal centrifugal pump located in a small exterior enclosure

2. Pump B – Zone 390 and Reservoir 3. 30 hp vertical turbine can pump

3. Pump C – Zone 555 and Reservoir 9. 50 hp vertical turbine can pump rated at 400 gpm @ 165 psi

There is a 125 kW emergency generator that can operate Pump C which is the only supply for Zone 555 and Reservoir 9. All the other zones can be feed from Zone 555 in an emergency. There is a recirculation valve on the pump discharge for Pump C that allows operation of the pump if Reservoir 9 is on-line for maintenance or repairs. When Reservoir 9 is off-line Zone 555 is operated as a pump pressurized zone instead of a gravity feed zone.

There is a small 264-gallon hydromatic bladder tank for Pump B and Zone 390. Reservoir 3 is a small 50,000 gallon tank that serves Zone 390 and the hydromatic tank helps control pressures and surges when pumping to the zone. The tank was off-line during the site visit, so the maintenance staff could replace the tank bladder.

The electrical distribution switchboard is in excellent condition. The switchboard has a few spaces for future loads. The emergency generator is in good condition. There are some items placed around and on top of the generator which should be removed. All conduits and panels are in good condition.

Pump Station 6

Pump Station 6 boosts water pressure from HGL 191 to HGL 280 to serve buildings at higher elevations in the Genentech area. Genentech is also planning to build high rise buildings and would rather get water at a high enough pressure from the system without the need for in-building booster pumps. If the area is fed directly off the 200 zone, the pressures would be about 30 psi, which is too low. Genentech prefers higher pressures in the 70 psi range.

Pump Station 6 is a newer pump station built in 1978. The two 10-hp pumps are rated at 240 gpm at 100 ft TDH, and pump into a 3,000-gallon hydro-pneumatic tank. The pumps start when the pressure drops to 50 psi and stops when the pressure reaches 70 psi, which results in a working volume in the hydro-pneumatic tank of approximately 500 gallons.

The hydro-pneumatic tank has seismic anchors on the supports to prevent overturning and sliding during a seismic event. The air volume in the tank is controlled automatically using a level controller and a small on-site compressor.

The piping for the pumps is typical for modern pump stations and includes inlet and outlet isolation valves and check valves on the discharge of the pumps. There are flange coupling adaptors to provide some piping flexibility and reduce the potential for pipe stresses being transferred to the pump bodies. The inlet eccentric reducer to Pump B is station upside down, which traps air and creates turbulence.

The electrical distribution equipment at the Pump Station 6 is in good condition. The switchboard is old, although newer than the ones found in Pump Station 3 and Pump Station 1.

A portable emergency booster is stored at the site. The portable booster can be moved to appropriate spots in the distribution system when needed.

Pump Station 7

Pump Station 7 is the system's newest pump station that transfers water directly from San Francisco's Bayshore connection to the Terrabay tank, Reservoir 12. The station is about 12 years old.

The pump station has two 30-hp, 550-gpm vertical turbine can pumps rated at 170 ft TDH. The suction pressure is 95 to 100 psi and the discharge pressure is 160 to 168 psi. The pumps are controlled by the level in the Reservoir 12 and, during the low demand period, the pumps operate every 4 to 5 days for approximately 13 hours. The pumps start filling at a water level of 16 feet, and turn off at a maximum level of 29 feet.

The pumps have standard above grade discharge piping with Mercoid pressure switches for high pressure protection of the pumps. The suction piping is connected to the suction cans below the concrete slab. There are hydro-pneumatic tanks on the suction and discharge pipes to control pressure surges.

The electrical equipment is in good condition. Conduits and panels are also in good condition.

Reservoirs

A discussion of the field observations at each reservoir follows the table. The Station 101 (Broadmoor) reservoir is discussed in a later section.

Reservoir 1

Reservoir 1 is an excavated earthen reservoir with sloped walls and a wood framed roof supported by steel web joists. The roof is supported by an approximately 8-foot high concrete support wall around the perimeter of the reservoir. The space between the top of the support and the roof is wood frames and contains screened vents. The interior was lined in 1998 with 8 mils of sprayed-on asphalt based liner manufactured by Liquid Boot Co. The liner is NSF61 approved for drinking water.

The reservoir is supplied by an 18-inch diameter feed pipe with an altitude valve. There is a separate outlet that connects to Pump Station 6. The maximum water surface in the reservoir is 191 feet, which is 10 feet below the maximum HGL for Reservoir 2. As a result, during the low demand periods, Reservoir 1 is normally filled to 191 feet, and the only turnover is that withdrawn by Pump Station 6. This low turnover can create nitrification problems, and the tank was drained for cleaning at the time of the site visit due to a build-up of nitrate.

Due to the low demand (Pump Station 6 for higher elevation Genentech area), the operators are thinking about SCADA controls for the San Francisco connection that fills the reservoir. The controls would automatically shut down the connection, so that demand would be drawn from only the reservoir and increase the amount of turnover.

Reservoir 2

Reservoir 2 is a 1.5-mg reinforced concrete reservoir with a wood frame roof. The tank has experienced extensive weeping from numerous hairline cracks in the past. It was coated with 100 mils of polyurea to control the weeping. Most of the weeping had stopped; however, some of the cracks had reflected through the coating. There was minor weeping where this occurred. The continuous air vents around the circumference of the reservoir looked in good shape. The operators noted that treated water from Station 1 was blended with any additional supplies from SFPUC connections at Orange & Commercial, Elm Court, Farm & Market and Bay Shore Freeway. The only SFPUC water that can be blended directly with the well water, however, is from the SFPUC Orange & Commercial connection.

All electrical exterior conduits and panels at this site are in good condition.

Reservoir 3

Reservoir 3 is a 24-foot tall, 50,000-gallon redwood hoop tank with a fiberglass liner. The exterior of the tank is coated with a polyurea coating. The coating is approximately two years old, and there are localized areas where the paint is not adhered to the wood. The exterior coating is primarily for aesthetics and the paint problems are generally cosmetic. There is some evidence of water seeping from the tank wall, but it is not known if this is associated with a hole in the interior lining or exterior source of water that migrates along the wood joints.

The water level is controlled using a level sensor at the bottom of the tank to start and stop the pumps at Pump Station 4. Pumping typically starts when the water level is at 11 to 12 feet (about 45 to 50% full). The level sensor is a two wire pressure sensor mounted at the bottom of the tank, but can only be calibrated in the field by a manually measuring the water level in the tank. The small size of the tank makes it prone to overflow if the start and stop levels are not properly set.

The vent screen on the tank and overflow piping are in good condition. There is only a single inlet and outlet pipe to the tank, but mixing in the tank is apparently

adequate. The small size of the tank and relatively low operating level promote mixing. The tank floor is supported by wood framing on concrete supports, but there were no anchor bolts along the wall to resist sliding or overturning during to seismic events. There is some erosion at the edge of the site associated with tank overflows and storm water runoff.

Reservoir 4

Reservoir 4 consists of two 250,000-gallon steel tanks at the site that are operated in parallel. The tanks were recoated with an exterior hi-build epoxy coating in 2002, and the exterior coating is in good condition. The tanks rest directly on asphalt pads, and there are no seismic anchors or foundation rings along the tank walls. The ladders are secured and the vent screens on the tank and overflow pipe appear to be in good condition.

Reservoir 4 is filled from Pump Station 2. The normal low water level in the tanks is 15 ft and the high water level is 20 ft. There are no check valves on the Reservoir 4/ Tank 4 inlet and outlet to promote circulation in the tank, and mixing in both tanks is probably minimal. Reservoir 4/Tank 4 has separate inlet outlet pipes, but Reservoir 4/Tank 3 has a combined inlet and outlet pipe. There are stainless steel bellows on the connections to the tank to provide flexibility during a seismic event, so that the pipe does not shear. The operators, however, have not experienced any water quality problems, and indicated that there is good movement in the water level. The tanks are monitored weekly for ammonia and nitrite that would indicate extensive biological activity.

Reservoir 7

Reservoir 7 consists of a 250,000 -gallon tank and a 500,000-gallon tank at the site with separate connections to the main transmission piping for the 330 Pressure Zone. The tanks sit directly on asphalt pads without a concrete support ring or anchor bolts. There are stainless steel bellows pipes at the reservoir connections to provide flexibility during seismic events. There are separate altitude valves for each tank. The operators noted some problems filling the tanks, although they attributed it to pressure problems.

The exterior coating for both tanks was installed in September 2002, and is an epoxy urethane coating. The exterior coating is in good condition with not extensive areas of deterioration. There is a suppressed current cathodic protection system for each tank. The system is monitored and maintained annually by GMC Corrosion/Electrical Ontario California.

The tanks are filled from San Francisco's Buri-Buri connection that also serves the 330 Zone.

Reservoir 9

Reservoir 9 is a 500,000-gallon steel reservoir sitting on an asphalt pad with out any anchor bolts. There is an 8-inch diameter EBBA Iron articulated joint flexible

connection for seismic events. There is a single pipe for the inlet and outlet to the tank. The tank is equipped with a suppressed current cathodic protection system. The interior coating is a pliable mastic material.

The normal water level in the tank is from 18 feet to 26 feet. The tank can only be filled using Pump C at Pump Station 5. The pump is controlled by water level in the tank. There is also an altitude valve on the tank inlet.

Currently, the typical water levels for the system reservoirs fluctuate between about 60 to 90 percent full. Operations staff recently adjusted the typical operating levels in order to get better turnover after SFPUC switched to chloramines.

Reservoir 10 – Brentwood

Reservoir 10 is a 500,000-gallon steel tank filled by the SFPUC Brentwood connection on Wildwood Drive. The tank sits directly on an asphalt pad, and does not have a concrete foundation ring or anchor bolts. The exterior of the tank was coated in September 2001 with an epoxy urethane that appears in good condition. The tank has a 12-inch diameter stainless steel bellows on the connection to provide flexibility during a seismic event.

The tank sits at the west end of 285 Pressure Zone which is fed on the east side by a SFPUC turnout. As a result of the constant supply from SFPUC, water was historically withdrawn only when there was a fire or the connection to the SFPUC were closed. The primary purpose of Reservoir 10 is fire reserve.

To provide some turn over of the water in the reservoir, a small circulating pump was installed on the tank inlet and outlet pipe to periodically pump water from the tank into the distribution system. The small pump acts to raise pressures in the system and partially shut down the Brentwood connection, so that demand can be drawn from the tank.

The small pump is operated to lower the water level in the tank from 25 to 15 feet. The pump operates once a week for approximately 21 hours (150 gpm), and then the tank refills in approximately 9 hours. Operation of the pump is controlled by timers. Solenoids on the altitude valves are used to prevent the tank from refilling while the pump is operating. If pressures drop due to fire flows, the altitude valve should open to feed from the tank, as well as from the SFPUC connection.

Reservoir 11

A site visit was not made to Reservoir 11 however it was discussed in the field. It is a 1-mg reservoir similar to Reservoir 9. It sits on an oiled pad on the ground, and has a single inlet/outlet line. It is filled at system pressures from SFPUC's Duvall connection.

Reservoir 12 - Terrabay

Reservoir 12 serves the Terrabay development, and is filled from Pump Station 7. It is a 1-million gallon steel reservoir erected in 1991 by Trusco, and was constructed in accordance with AWA D100 using A36 steel. The reservoir is 27 feet 6 inches high and 75 feet in diameter, and is anchored to a concrete foundation ring around the perimeter of the tank. The ladder has a cover to prevent unauthorized use, and is equipped with a safety climber. There are guard rails at the top of the tank around the hatch and ladder landing. The site has chain link fencing around the perimeter of the site for security. The overflows on the tank are screened

The tank is equipped with suppressed current cathodic protection corrosion protection system. The interior is coated with an epoxy coating, which the operators indicate is in good condition compared to the Broadmoor Tank.

The tank has a single pipe for the inlet and outlet, and is equipped with a 12-inch diameter stainless steel bellows flexible pipe for seismic isolation.

Station 101 – Broadmoor

The Broadmoor area is in the far northwestern part of the system. It is an unincorporated island in Daly City that has historically been served by Cal Water. Cal Water's Station 101 is located in the Broadmoor area. Station 101 consists of a 250,000-gallon steel reservoir and booster station. The pump station is needed to lift water from the reservoir into the system.

The tank sits directly on an asphalt pad, and does not have a concrete support foundation ring or anchor bolts. There are separate inlet and outlet connections for the tank, but there are no flexible joints at the connections. The maximum water level in the tank is HGL 350, so the altitude valve is normally closed.

The tank level varies from 23 feet to 25 feet, and is filled by gravity from the 380 Pressure Zone (from SFPUC's D & Hill connection at system pressures). Operations staff indicated that there is little turnover in the tank since it is constantly being refilled from the SFPUC connection. The only turnover in the tank is associated with the water withdrawn by the booster pumps. The exterior of the tank was coated in September 2004 with an acrylic coating, and the coating appeared in good condition.

There are two pumps at the site in separate concrete block enclosures with wood covers. The pumps are 20 hp and pump into a 3,000-gallon hydro-pneumatic tank for Pressure Zone 520. The pumps boost the pressure from 10 to 15 psi from the tank to 78 psi. The pumps cycle frequently and operate for 30 to 60 seconds. One pump is designated the duty pump and the other is off-line. The duty pump starts 6 to 7 times per hour. The water level in the hydro-pneumatic tank varies 4 inches (24 to 28 inches), which corresponds to a working volume of approximately 400 gallons. Operations staff indicated that there are plans to replace existing hydropneumatic tank with another of the same size. Typically pump cycling of 4 to 6 times per hour is

desirable, which indicates that the hydropneumatic tank should be larger that the existing one.

The pumps had concentric reducers on the pump inlet, but there was no cavitation noise when the pumps were operating. The bottom of the enclosure for Pump A was full of water due to a plugged drain.

The air compressor used to fill the hydro-pneumatic tank is in the Pump A enclosure, but the compressor noise is still noticeable by the adjacent homeowners.

All the electrical equipment is outdoors and in good condition. Conduits and panels are also in good condition.

PRV Stations

A typical PRV station installation was visited in the field. The specific location visited was the PRV Station at Orange Avenue.

When the treatment plant is not operating, water is supplied to Reservoir 2 and the 200 HGL pressure zone through an 8-inch PRV connection to the SFPUC at Orange Avenue next to Station 1. The PRV station uses a single 8-inch diameter diaphragm globe valve to maintain the desired flow rate. The PRV is located in a buried vault, and is subject to flooding.

The configuration of this PRV station is typical of those in the South San Francisco system, which are buried vaults. Field visits were not made to the other PRV locations.

Field Assessments – South San Francisco Facility Photos from Site Visits

Station 1

Treatment Facility

Reservoir valving

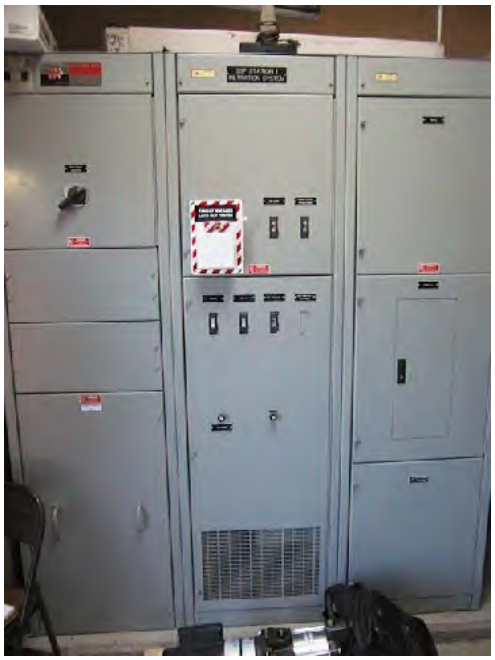
Pump D

500,000-gallon tank

Station 1

Typical well

Well pump equipment



Treatment Facility Switchboard

Pump Station Switchboard

Pump Stations

Pump Station 2

Pump A

Pump and piping

Electrical Equipment

Pump Station 3

Pump B

Switchboard

Pump Station 4

Switchboard

Pump equipment

Pump Station 4

Switchboard

Pump Station 5

Switchboard

Pump Station 6

Hydropneumatic tank

Pump B

Switchboard

Pump Station 7

Pumps A and B

Hydropneumatic tank

Switchboard

Station 101

Electrical Equipment

Reservoir and hydropneumatic tank

Pump B

Reservoirs

Reservoir 1

Outside of Reservoir 1

Reservoir 3

Reservoir 3

Reservoir 4

Reservoir 4

Reservoir 7

Electrical Equipment

Reservoir 9

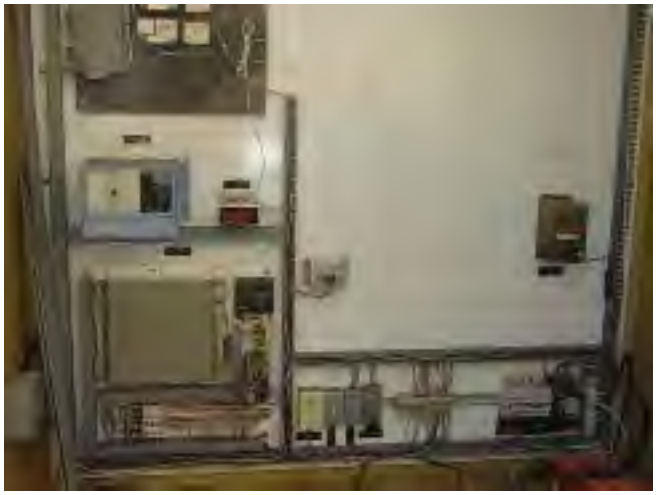
Reservoir 9

Reservoir piping

Reservoir 10

Electrical Equipment

Reservoir 12



Instrumentation Panels

Appendix C

Existing SCADA System Evaluation

Appendix C
SCADA System Evaluation
South San Francisco Water Supply & Facilities Master Plan

Purpose

This appendix presents the findings of the evaluation of the existing Supervisory Control and Data Acquisition (SCADA) system for the South San Francisco system. The purpose of the SCADA evaluation was to review Cal Water's existing SCADA system as well as planned upgrades and expansions, and to provide feedback and recommended improvements that can be implemented along with facility recommendations.

The following topics are addressed in this appendix:

- Purpose
- Summary
- Cal Water SCADA Background
- South San Francisco SCADA System Overview
- SCADA System Evaluation
- Recommendations for SCADA System Improvements for South San Francisco Service Area

Summary

The South San Francisco SCADA system consists of a central computer located at the operations center in San Mateo, telephone and radio communication to 15 remote sites, and sensors, switches and RTUs at each site.

The South San Francisco SCADA system is collecting and disseminating data and assisting with automatic control of booster pumps and valves. The system is capable of expansion and additional automation without replacing the main computer, current remote terminal units (RTUs) or communication infrastructure. Cal Water staff is adequately trained and support mechanisms are in place to ensure long term SCADA use and the ability to expand and make changes as needed.

Cal Water operations staff uses the SCADA system on a regular basis, and has recommended enhancements that will allow them to rely even more on the system to improve operations. These enhancements are discussed in this addendum.

The SCADA evaluation was limited to visual observations, discussions with headquarters and local operations staff, and review of the system map, system profile, and information provided by Cal Water. Site visits were made only to the main control systems at headquarters and District offices, not made to any RTU locations at the water system facilities.

Cal Water SCADA Background

Cal Water operates through 28 Customer and Operation Centers throughout California, many of which have similar SCADA systems. A test system in Cal Water's San Jose headquarters is used for programming and testing these systems, and can be used for remote monitoring and control of the various SCADA systems via Virtual Private Network, including the system for the South San Francisco service area.

On December 2, 2004, CDM met with Cal Water's electrical engineering manager (Jan Kooy) and SCADA manager (Clyde McMorrow) to learn about the overall SCADA platform, implementation background, current capabilities and future needs. The meeting was held at the headquarters office in the SCADA development room, and included a demonstration of South San Francisco process graphics, alarm information and report data. A copy of the South San Francisco overview SCADA graphic is included as Figure 1 (at the end of this appendix).

After conducting surveys of several water agencies, Cal Water selected a SCADA platform that consisted of RTUs, workstations and software by Hewlett-Packard. H-P has since discontinued their RTU product line, and sold their software to Verano who actively supports and develops it. As a result of the RTU discontinuation, Cal Water established performance criteria for replacement RTUs and now uses RTUs by Control Microsystems.

SCADA systems have progressively moved away from proprietary (i.e. developed and supported only by the manufacturer itself) hardware and software, in an effort to lower the cost of components and make them interoperable without customization. One side effect of this shift is that "open" technology progresses fairly rapidly and some SCADA components will become obsolete every 5-10 years. Cal Water understands this and is prepared to meet the challenge without disrupting operations.

SCADA implementation, upgrade and expansion projects are performed from headquarters using the same personnel, so the same general approach and "look and feel" is implemented. Upgrades are prioritized by operational need. General priorities are 1) Need for added control; 2) Need for data acquisition and alarms; and 3) Included with other site upgrades.

SCADA implementation and upgrade projects are in progress for Los Altos, Stockton and Visalia. SCADA site upgrades include replacement of the entire SCADA panel consisting of the RTU, power supply, batteries and relays. Projects are designed at

headquarters and installed by contractors. Programming is done by Cal Water. A long term goal is to implement standardized approaches in all operation centers to prepare for an eventual transition to a newer operator interface platform.

South San Francisco SCADA System Overview

A table of South San Francisco SCADA sites is included as Table 1 (at the end of this appendix). Table 1 lists the SCADA sites, the type of RTU at each site, and general comments regarding the site.

In general, the RTUs gather process data and equipment statuses and pass them to the central computer. The central computer performs data logging, alarm paging and control logic. Commands from the central computer pass back through the RTU to pumps and valves.

At some of the sites, backup controls exist in the form of relays and/or loop controllers to allow local operation in the event of a loss of SCADA communication between the central computer and the RTU. Some sites require a manual switch to backup relay or loop controller operation, and others operate in parallel with the control trip points set outside the SCADA system trip points.

Central Computer

The central computer in the operations center in San Mateo is a 400 MHz Hewlett-Packard Visualize™ B2000 workstation with dual hard drives and a 21" CRT monitor. This type of computer was first released in February 2000. The workstation operating system is Hewlett-Packard's HP-UX 11i (Unix).

The operator interface software running on the central computer is Verano's Real Time Applications Platform (RTAP) version 8.2, which headquarters reported is the latest available. RTAP is a database and graphics engine which can be expanded by the purchase of additional software licenses. It is a very powerful platform for real-time process monitoring and control, and is in use at Genentech's biotech production facility in Vacaville, CA (customized and re-sold by Siemens Energy & Automation as Process Supervisor™). Software drivers are available for connection to various programmable controllers and RTUs.

Add-on software modules have been developed for Cal Water, including a configurable alarm paging system that dials Nextel cell phones to notify lists of people when problems occur.

For data recording and archiving, daily files are generated by the central computer. Files are archived to tape daily, and periodically burned onto CDs. Data files can be accessed via the internet using the central computer's web server capabilities. Daily reports are generated at the operations center showing levels, minimum/maximum pressures and communication failures.

Data Communications

Communications between the operations center and the SCADA sites and between SCADA sites themselves consist of 900 MHz spread spectrum radio, 932/941 MHz Multiple Address Systems (MAS) radio and Bell 202 analog leased phone lines, depending on the site and equipment installed.

Remote Site Equipment

Sites that communicate with the central computer consist of pump stations, reservoirs, SFPUC connections, and sites with pumps and reservoirs -- "Station 1" and "Station 101 – Broadmoor". Each site has an RTU and some optional equipment as listed below:

- RTUs by Control Microsystems: SCADAPack
- RTUs by Hewlett-Packard: 48000 series (48040 and 48060)
- RTUs by Transdyn – SFPUC SCADA system only
- Circular Chart Recorders with communication capabilities, called "telemeters", by the Bristol Company: Model 20500-14 for pressure, and Model 1M1M500-238A for level.

H-P RTUs are currently being replaced with SCADAPack RTUs, but Cal Water is open to other RTUs that meet their main criteria-- standard communication using an industry standard or de facto protocol (i.e. Modbus), multiple serial ports to allow functionality as a master and a slave, and ease of programming.

Operations

At a typical reservoir site, the SCADA system monitors tank level(s) from level transmitter(s) with alarms generated from the analog signal(s).

At a typical pump station, the SCADA system starts and stops pumps and monitors run statuses; monitors pump suction pressure from a pressure transmitter, monitors pump discharge pressure from a pressure transmitter; and monitors flow from a flow transmitter. SCADA system logic allows pumps to automatically operate based on level (with time of day constraints), pressure (with time of day constraints), or based on time of day. Cal Water operators expressed a preference for level control for the South San Francisco service area.

At a typical SFPUC connection, the SCADA system monitors upstream pressure, downstream pressure, valve status, flow rate, and setpoints.

No monitoring points are required by outside regulatory agencies. Pressures and flows are critical to Cal Water. Chlorine residual will become critical. There is a

general trend toward more water quality monitors (analyzers). Cal Water is also experimenting with power monitoring.

SCADA System Evaluation

Based on available information, CDM evaluated the existing SCADA System and future plans, focusing on four key areas – reliability, flexibility, expandability and support.

Reliability

The selected hardware and software, both at the RTU level and at the operator interface level, are reliable when properly installed, used and maintained. Even the older Hewlett-Packard RTUs are remarkably robust.

CDM investigated the need for a backup central computer and determined that it is not necessary due to the availability of laptop PCs for basic monitoring and the ability to monitor and control from headquarters if needed. If the central computer does fail, it can be replaced and reconfigured fairly quickly.

Some of the communication links appear to be troublesome (e.g. SFPUC connections, Reservoir 3, Reservoir 4, Station 1 to Pump Station 5) based on communication failure errors. These need to be evaluated by Cal Water to determine the severity, frequency and root causes of failures.

Flexibility

The selected SCADA system is extremely flexible. The central computer can be programmed to display information and perform logic to meet almost any conceivable operations need. The SCADAPack RTUs can accommodate different combinations of status and control signals, different methods of communication, and flexible programming languages. The RTAP operator interface software can be highly customized as needed.

Expandability

The South San Francisco SCADA system can be expanded to more than double its current size without purchasing any additional central computer hardware or software. Cal Water's current South San Francisco RTAP license is for 1000 objects, and only about 250 are currently in use. Licenses can be expanded to 64K objects per database.

Support

Cal Water personnel have adequate training to configure, start up, operate and modify the SCADA system. In addition, Cal Water has support agreements with Verano for RTAP software, with TesserNet Systems for RTAP add-on tools, and with

Hewlett-Packard for workstations. No agreement is in place for RTUs, but this is probably not required.

Recommendations for SCADA System Improvements for South San Francisco Service Area

As discussed earlier in this appendix, the overall Cal Water SCADA system is well thought out with a proactive company-wide plan for the future. Based on discussion with local operations staff, specific needs for the South San Francisco service area have been identified, and improvements recommended for consideration as part of this master plan effort. These improvement recommendations were considered as part of the evaluation and formulation of facility improvements.

In general, the existing SCADA system in the South San Francisco service area should be expanded and enhanced to: A) add new controls; B) add new instruments and monitoring points; and/or C) enhance existing controls. Specific recommendations:

- Identify a local SCADA "owner" at the operations center serving the South San Francisco area to be a liaison with headquarters, point person for issues resolution, and primary contact regarding SCADA matters. The operations center currently does not have a Electrical-Mechanical Technician (EMT) to follow up on maintenance requests, and operators are too busy to dedicate significant time to improving the system. Consider contracting out a technician or local systems integrator until an EMT can be hired.

- Develop a system issues log or "punch list" of items that are not working or could be improved. Establish priorities and assign action items to specific people with deadlines. Follow up with regularly scheduled conference calls or net conferences.

- Standardize backup control schemes for automatic switchover upon failure, transfer of operating setpoints, and notification to the SCADA system that backup controls are in effect. Prioritize backup control for critical operation and/or locations where radio communications are problematic. Replace the Bristol telemeters with electronic recorders and RTU logic within five years due to obsolescence and lack of spare parts. Operators need local indication and history, but paper and pens require excessive maintenance. This might require a change in SOPs to eliminate the paper records.

- At Station 1, add remote monitoring of wells and remote shutdown capability. This site is normally unmanned, and current SCADA connections do not allow for efficient operation. Add level alarms to the pager system. Add sodium bisulfite and ammonia tank level monitoring to the SCADA system. Add control of the booster pumps.

- Replace the remaining Hewlett-Packard RTUs with newer RTUs as part of other upgrade or expansion projects. Plan to have all H-P RTUs replaced within five years.
- Consider a central historian server at headquarters with full-time connection to the operation centers. This could eliminate the need for operation center staff to archive data, change tapes, etc. and could facilitate central report generation, data analysis, etc.
- Add Pump Station 3 with two boosters to the SCADA system.
- At Pump Station 4, add local indication (real time and historical) of Reservoir 3 level.
- At Pump Station 5, add local indication (real time and historical) of Reservoir 9 level.
- At Pump Station 7, add local indication (real time and historical) of Reservoir 12 level.
- Reservoir 1 has no level control from Pump Station 6. Investigate a potential transducer failure. The backup telemeter at Station 3 is also not working.
- At Reservoir 2, repair the tank level transmitter or SCADA signal (currently frozen).
- At SFPUC Connection "Bayshore", add phone lines to get pressure signal to SCADA.
- At SFPUC Connection "Chestnut", repair the regulator with high and low pressure settings.

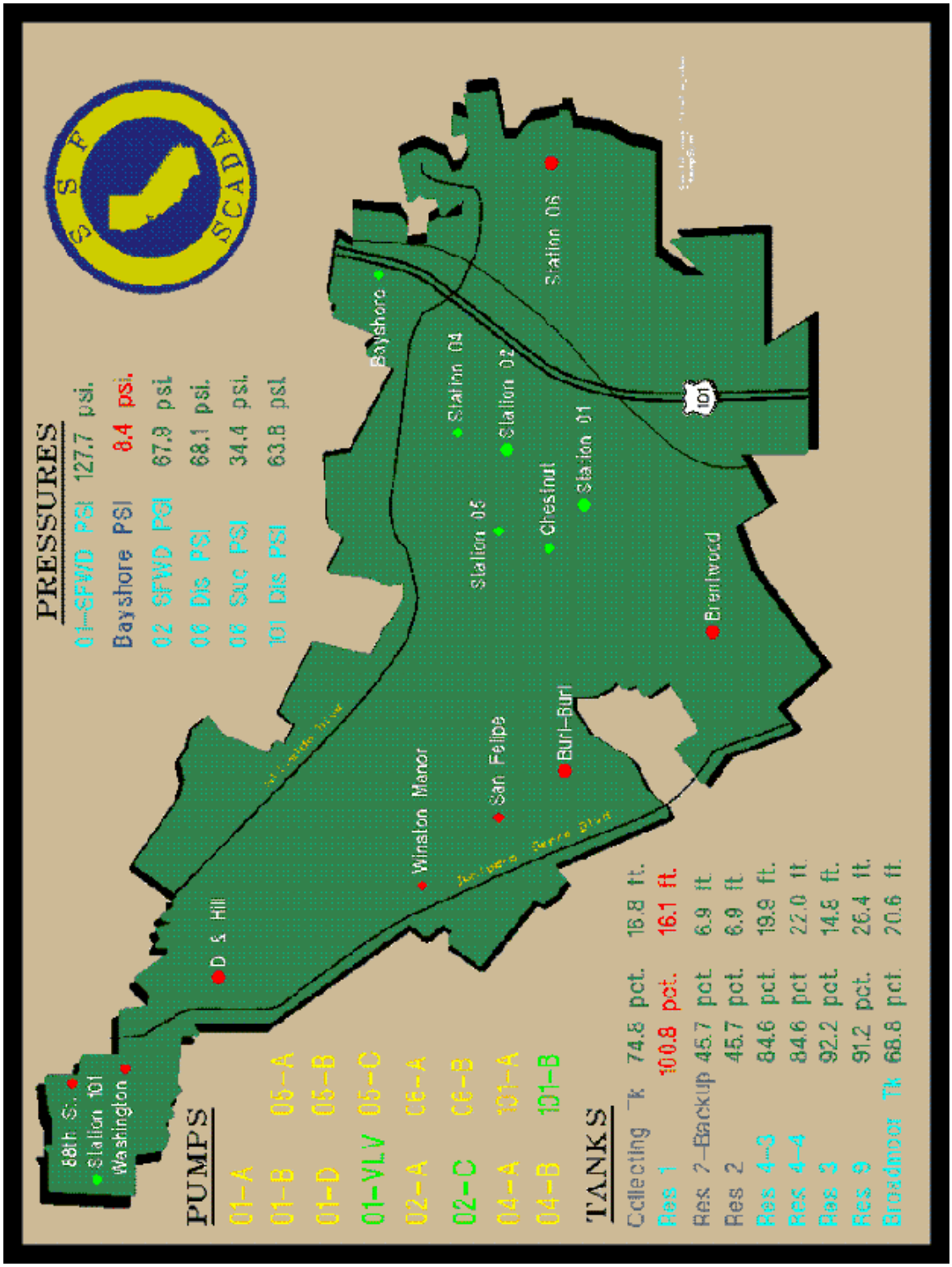


Figure 1
South San Francisco SCADA Overview Graphic

Table 1 ***SCADA Site Summary***			
SSF SCADA Site	***H-P RTU***	***SCADAPack RTU***	***Comment***
Station 1		X	Consider adding remote control (wells) and remote shutdown.
Pump Station 2		X	Includes SFWD Elm Ct. connection
Pump Station 4		X	
Pump Station 5		X	
Pump Station 6	X		Station Upgrade
Pump Station 7			H-P Out; Upgrade in Progress
Pump Station 11			H-P Out; Upgrade in Progress
Station 101	X		
SFPUC Connection 88th & Sullivan	X		SCADA not in operation – site might be abandoned
SFPUC Connection Bayshore Freeway		X	Upgrade in progress
SFPUC Connection Brentwood			H-P Out; Upgrade in Progress
SFPUC Connection Buri-Buri			H-P Out; Upgrade in Progress
SFPUC Connection Chestnut		X	Orange Ave. Connection. This is monitored out of station 1
SFPUC Connection D&Hill	X		Needs Repairs
SFPUC Connection San Felipe	X		SCADA not in operation
SFPUC Connection Washington & Sullivan	X		Needs Repairs/Minor Upgrade
SFPUC Connection Winston Manor			H-P Out; Upgrade in Progress

Appendix D

Surface Water Supply Reliability Analysis

Appendix D
SFPUC Surface Water Supply Reliability South San Francisco Water Supply and Facilities Master Plan

This appendix discusses the reliability of the San Francisco Public Utilities Commission (SFPUC) supply. The reliability assessment includes: an analysis of the ability to serve SFPUC regional system customers following natural disasters, such as seismic events, that cause supply disruptions; and potential supply cutbacks during drought periods, such as occurred during 1976 and 1977 and 1987 through 1992. The update includes a discussion of potential SFPUC projects that would mitigate potential supply reductions.

Information is based on SFPUC documents that address seismic and supply reliability issues. Several documents review reliability as it pertains to the existing system. In February 2005, SFPUC published a draft program description for the Water System Improvements Program (WSIP), the $4.3 billion capital improvement program currently underway to reinforce the SFPUC system. This draft program was subsequently updated and a revised draft issued in October 2005. The program description establishes level of service goals for seismic and delivery reliability to meet 2030 demands, and identifies the WSIP projects to meet these goals.

In addition, information was obtained from the Bay Area Water Supply & Conservation Agency (BAWSCA), which represents members who purchase SFPUC supplies, regarding their perspective on SFPUC supply reliability.

The following topics are discussed in this appendix:

- Summary of Key Findings
- Overview of SFPUC Supply System
- SFPUC Supply Vulnerability to Hazards
- SFPUC Supply Vulnerability to Droughts

All tables and figures are included at the end of this appendix.

Summary of Key Findings

Key findings are summarized below:

- In the SFPUC Emergency Response and Recovery Manual (2003), a number of potential emergency scenarios were identified and evaluated for the existing system. Several earthquake scenarios investigated in detail the impacts of a major earthquake on the San Andreas, Hayward or Calaveras Faults. The SFPUC findings indicate that it will take two days to initiate water service after a major earthquake, and 90 days to restore all facilities. Until all facilities are restored, the existing SFPUC supply system will be able to deliver 50% of the current average summer day demand, which is equivalent to 50% to the Year 2030 average day demand of 300 MGD.

- SFPUC's current Water System Improvements Program (WSIP) includes a number of projects to improve system reliability in the event of a major earthquake, or other disaster. WSIP goals include restoring minimum service (215 MGD) within 24 hours of an earthquake, and restore average daily demand (300 MGD) within 30 days. The WSIP includes a number of projects to seismically reinforce the system, to achieve these goals. The current schedule calls for completion of all the projects that would benefit the Cal Water system over the next 11 years (by the end of 2016).

- SFPUC's projected 2030 demand for normal hydrologic years is 300 MGD. SFPUC's current planning goals include drought cutbacks of up to 20%, based on 2030 level of demands. For planning purposes, SFPUC used an 8.5 year "design drought," similar to extended drought 1987 through 1992, followed by a critically dry conditions similar to 1976-1977. SFPUC's cutbacks would increase throughout the drought period, beginning with 3.3% reductions during the first 3 years, then 13.3% reductions in the next 3 years, and finally 20% reductions in the last 2.5 years. For the 8.5-year design drought, this equates to deliveries ranging from 240 MGD to 290 MGD, with an average delivery of 265 MGD during the drought, or average cutback of 12% during the drought. Improvements will be needed to the SFPUC supply system to meet these goals.

- SFPUC's firm yield of its existing supply system, the amount it can reliably supply in dry years, is 226 MGD. This yield is 75% of projected 2030 demand of 300 MGD, requiring an average 25% cutback in demands during dry years, when insufficient supply is available to meet demand. Since deliveries are typically higher in the early years of a drought, before long-term drought conditions are recognized, an average drought cutback of 25% would likely mean cutbacks of less than 25% in early drought years, and cutbacks of greater than 25% in later drought years.

- Because SFPUC has an existing firm yield that is less than projected dry-year deliveries, SFPUC is investigating potential supply projects to increase drought reliability. These include restoring the SFPUC's Calaveras Reservoir to 98,000 AF

capacity, desalination projects, groundwater conjunctive use projects, and recycled water projects. Projects are currently in the preliminary planning phase.

Overview of SFPUC Supply System

SFPUC supplies its regional system customers from the Hetch Hetchy system, the Sunol Valley Water Treatment Plant (SVWTP) and the Harry Tracy Water Treatment Plant (HTWTP). Figure 1 provides an overview of the SFPUC regional system facilities that are described in this section.

The Hetch Hetchy and SVWTP serve the Lower Gradient Pressure Zone of the regional system. The Hetch Hetchy and SVWTP supplies are blended and chloraminated in the Sunol Valley and served to regional system customers via the Bay Division Pipelines serving the South Bay, and the Pulgas and Crystal Springs Bypass Tunnel, and the Sunset and Crystal Springs Pipeline that convey water to Peninsula and San Francisco customers. The nominal operating gradient to Peninsula customers is elevation 302 feet, based on the overflow weir on Pulgas Tunnel that discharges water to the raw water Crystal Springs Reservoir. The gradient at Cal Water turnouts which are about 15 miles north of the tunnel would typically be lower, due to friction losses in the regional transmission pipelines.

Cal Water has three turnouts served from the Lower Gradient Pressure Zone, on the Crystal Springs Pipeline.

Turnout	***Zone Served***
Orange Avenue (SSF-03)	200
Elm Court (SSF-09)	200
Bayshore Blvd (SSF-02)	200

The HTWTP supplies the Upper Gradient Pressure Zone of the regional system. HTWTP treats water from the Crystal Springs and San Andreas reservoirs and serves water to the San Andreas 2 and 3 pipelines that serve customers in the northern Peninsula and San Francisco. The nominal gradient for the pressure zone is 465 feet, based on the overflow elevation of the treated water reservoir at the HTWTP.

Cal Water has eight turnouts in the Upper Gradient Pressure Zone, on the San Andreas pipelines.

Turnout	***Zone Served***
Brentwood (SSF-05)	285
Buri Buri (SSF-01)	330
San Felipe Drive (SSF-07)	360
Winston Manor (SSF-06)	360
Serramonte (SSF-12)	360
“D” & Hill (SSF-15)	380
Washington & Sullivan (SSF-14)	380
88 & Sullivan (SSF-13)	380

During supply disruptions in the Lower Gradient Pressure Zone, SFPUC can increase the HTWTP production rate and use the Capuchino Regulating Station in San Bruno to supply the Lower Gradient Pressure Zone from the Upper Gradient Pressure Zone. During HTWTP disruptions, SFPUC can use the Baden Pump Station in South San Francisco to supply the Upper Gradient Pressure Zone from the Lower Gradient Pressure Zone.

SFPUC Supply Vulnerability to Hazards

The SFPUC has evaluated the existing system to identify supply vulnerability to hazards. Based on this assessment, SFPUC identified several improvements that have been incorporated into its Water System Improvements Program to reduce supply vulnerability. This section discusses both the review of the existing system and the proposed improvement projects.

Existing System Vulnerability Assessment

The SFPUC Emergency Response and Recovery Manual (Pirnie-Williams, 2003) identifies the types of hazards that could cause supply disruptions to the regional water system. Hazards that could result in supply disruptions include: earthquakes; dam failures; fires; contamination of water supplies; hazardous spills or leaks; severe storms or floods; landslides; aqueduct, pipeline, reservoir, tank and/or building failure; civil unrest, disturbance or terrorist action; national security emergency; widespread power outage; process/treatment plant failure; and, facility failures.

Each event is discussed qualitatively in the report. The report also includes a quantitative analysis of several earthquake scenarios, including which facilities would likely fail during specific events, how long it would take to restore service, and what level of demand could be met while facilities are being restored. The other scenarios are only discussed qualitatively.

Table 1 includes a summary of the potential earthquake scenarios that could affect service to Cal Water. The table includes the following information, developed from the SFPUC Report:

- Failure scenario;
- Anticipated facilities out of service for scenario;
- Qualitative assessment of likelihood of event;
- Anticipated outage duration; and
- Anticipated level of service during outage.

For earthquake scenarios, where the SFPUC has provided quantitative analysis, the SFPUC report used the following assumptions in determining recovery time estimates:

- Major pipeline breaks can be repaired within 20 days;
- All pipeline leaks can be repaired within 34 days;
- Water treatment plants can be repaired within 3 weeks;
- Tunnels can be repaired within 3 months; and
- A combined force of 100 SFPUC staff and contractors is available for repair work.

The top portion of Table 1 (Scenarios 1 through 8) summarizes earthquake scenarios that could disrupt or limit service to Cal Water. Several scenarios would serve about 50% of the current average summer demand (150 to 160 MGD system demand which is 50% of the Year 2030 average day demand of 300 MGD) for a part or all of the outage. For three of the scenarios, breaks are predicted in the Crystal Springs No. 2 pipeline that would isolate Cal Water turnouts on these pipelines. The Task 5 distribution system analysis will investigate alternative options to serve these zones if the turnouts are off-line.

The bottom portion of Table 1 (Scenarios 9 through 12) summarizes other natural hazards that would potentially impact service to Cal Water identified in the SFPUC Emergency Response and Recovery Manual but not evaluated in detail. Information in this portion of the table was developed by CDM, based on its knowledge of the SFPUC system and qualitative information in the Emergency Response & Recovery Manual.

Of these non-earthquake scenarios, it is CDM's opinion that only a contamination event in the Crystal Springs watershed could likely impact service to Cal Water. Under this scenario, if Harry Tracy WTP is unable to adequately treat water and cannot be used, Baden PS would be used to supply the Upper Gradient Zone. The pump station has a capacity of about 45 MGD. Although average summer demands or higher could potentially be met through the pump station, it is uncertain whether there is sufficient capacity in the Lower Gradient Zone transmission piping to meet both Upper Gradient Zone and Lower Gradient Zone demands.

Water Supply Improvement Program Projects to Reduce Vulnerability

For seismic reliability, SFPUC has established the following service goals, based on meeting certain threshold Year 2030 demands for the system:

- Deliver minimum system demand (215 MGD) within 24 hours after a major earthquake;

- Restore facilities to meet average daily demand (300 MGD) within 30 days after a major earthquake;

The 300 MGD level of demand is equivalent to average daily demand for 2030 demand conditions and is equivalent to average summer demand at current demand levels.

Table 2 summarizes the planned Water System Improvement Program (WSIP) projects to meet the level of service goals. Figure 2 shows the locations of planned projects. The current SFPUC schedule for their CIP calls for completion of all the projects that would benefit the Cal Water system by the end of 2014.

All of the projects listed in Table 2 will improve the seismic reliability of the regional system and thereby benefit Cal Water to some degree. Of the projects listed in the table, the following provide the most seismic reliability benefit for the Cal Water South San Francisco system:

- Crystal Springs Pipeline No. 2 Replacement. This project will reinforce sections of the Crystal Springs Pipeline that, without reinforcement, are predicted to fail during certain seismic events and isolate Cal Water's Orange Avenue, Elm Court and Bayshore Boulevard turnouts from the SFPUC regional system.

- Harry Tracy WTP Short-term and Long-term Improvements, Capuchino Valve Lot Capacity Improvements and Crystal Springs-San Andreas Transmission Upgrade projects. These projects will reinforce the Harry Tracy WTP and associated facilities, to improve reliability of the Harry Tracy WTP during emergencies.

- Irvington Tunnel No. 2/Alameda Siphons. Failure of the Irvington Tunnel would sever the regional system from the Hetch Hetchy and Sunol Valley WTP supplies, which would mean that SFPUC supply would be available only from Harry Tracy WTP. This project would provide redundant, seismically reinforced facilities that would enable continued delivery of Hetch Hetchy and/or Sunol Valley WTP supplies during an emergency.

- Standby Power, Various Locations. This project includes standby power improvements at Harry Tracy WTP and San Pedro Valve Lot, both of which could improve SFPUC's ability to serve Cal Water during emergencies.

In late February 2005, the Bay Area Water Supply & Conservation Agency (BAWSCA) sent a letter to the SFPUC expressing concern about SFPUC's ability to implement the Water Supply Improvement Program. BAWSCA sees significant challenges to implementation, including institutional barriers, delays and escalating costs. BAWSCA is continuing to track WSIP progress and work with SFPUC to facilitate program implementation.

SFPUC Supply Vulnerability to Drought

For water supply, SFPUC anticipates being able to meet an average daily system demand of 300 MGD in normal and wet hydrologic years, which is the existing average summer day demand. It is also the Year 2030 average day demand, which was developed based on purchase projections provided by BAWSCA members who purchase SFPUC supplies.

During drought, SFPUC has established a service goal of providing up to 20% cutback during a design drought of 8.5 years. The target delivery reduction would be time-phased. During the first three years, the average reduction is anticipated at 3.3%. During the second three years, the average reduction is anticipated at 13.3%. During the last 2.5 years, the average reduction is anticipated at 20%. For the 8.5-year design drought at 2030 demand levels, this equates to deliveries ranging from 240 MGD to 290 MGD, with an average delivery of 265 MGD during the drought, or an average cutback of 12% during the drought.

The existing firm yield of the SFPUC system is estimated to be 226 MGD with existing supplies.[1] The firm yield represents the amount that could be delivered during drought years. During normal and wet hydrologic years, adequate water would be available to meet a system demand of 300 MGD, which is the existing average summer day demand and the Year 2030 average day demand. During dry years, the existing supply is not adequate to meet this system demand.

With the current yield, SFPUC could meet 75% of Year 2030 demand, based on the firm yield. Since deliveries are typically higher in the early years of a drought, before long-term drought conditions are recognized, an average drought cutback of 25% would likely mean cutbacks of less than 25% in early drought years, and cutbacks of greater than 25% in later drought years. SFPUC planning documents do not state the assumptions for the existing yield (existing supply amount); however, CDM's estimate is noted below for Year 2030 based on proportional cutback similar to SFPUC's target service goals.

Design Drought Years	***Year 2030 Reductions With Future Additional Supply to Increase Firm Yield to 254 mgd (Target Service Levels)***	***Year 2030 Reductions With Existing Supply at Firm Yield of 226 mgd (reductions estimated by CDM at twice the target service level)***
First 3 years	3.3%	7%
Second 3 years	13.3%	27%
Last 2.5 years	20%	40%
Average over entire 8.5 years	12%	25% (average is about twice the target service level)

[1] The firm yield estimate includes Calaveras Reservoir at 98,000 AF. The reservoir is currently restricted by California Department of Water Resources, Division of Safety of Dams to approximately 38,000 AF.

To meet SFPUC drought goals of a 20% maximum reduction during any year of the drought, an additional 39 MGD of supply would be needed to meet the Year 2030 average day demand. SFPUC has identified the following potential supplies that could make up the shortfall:

- Groundwater. Groundwater projects include three coupled projects: 1) restore Lake Merced water levels; 2) develop new local groundwater wells with 4 mgd total capacity within the City and County of San Francisco that can serve as emergency and regular supply in the Sunset District and along the Great Highway; and 3) the regional groundwater conjunctive use program in San Mateo County to provide supplemental dry year supply (10 new wells are estimated to provide 7 mgd of supply).. The Water System Improvements Program description of the regional conjunctive use program anticipates that SFPUC surface water would be used in lieu of pumping groundwater in normal and wet years. Water would then be stored in the groundwater basin to pump during dry years or an extended drought.

- Recycled Water. SFPUC is completing a Recycled Water Master Plan. Two specific projects included in the Water System Improvements Program include: 1) recycled water on the west side of San Francisco (Westside Baseline) treated with centralized advanced treatment to deliver water to irrigation users, primarily parks; and, 2) highly advanced treatment of recycled water for Harding Park irrigation and Lake Merced recharge. SFPUC is also partnering with the North Coast County Water District on a recycled water project to irrigate areas of Pacifica and Sharp Park Golf Course, and with Daly City on recycled water for golf courses in the Lake Merced area.

- Desalination. SFPUC is participating in a joint venture study being conducted by four Bay Area utilities to investigate whether a joint venture desalination facility is feasible. The regional desalination facility would treat ocean or Bay water using reverse osmosis (RO) treatment technology. The purpose of the desalination facility would be to increase the reliability of the agencies' water supplies by providing a new source that is not dependent on any of their existing sources.

The Water System Improvements Program includes funding for the groundwater projects and recycled water projects, and a contribution of up to $10 million to continue funding its participation in the regional desalination concept. In some cases, funding covers planning, but does not cover construction. In all instances, planning is at a relatively early stage and yield estimates are not provided in current planning documents. Therefore, implementation and future supply amounts from these projects is uncertain.

It is not anticipated that SFPUC surface water supply from its local watershed reservoirs will increase in the future. Currently, there are restrictions on the operation of Calaveras Reservoir, which is a key component of the local surface water supply.

Due to safety concerns, the Division of Safety of Dams has restricted the operating volume of Calaveras Reservoir to about a third of its maximum capacity. The SFPUC's current CIP includes a project for reconstruction of Calaveras Reservoir to restore the reservoir to its original capacity. Expansion of the reservoir beyond its original capacity would require participation of regional partners and additional funding beyond that designated in the current CIP. Therefore, the project is expected only to restore existing local yield to the system, not provide additional yield, unless regional partners are identified.

The current direction from the SFPUC is that it is committed to meeting projected 2030 purchases in normal and wet hydrologic years, and to meeting drought supply reliability goals. BAWSCA has expressed concern that only preliminary technical work has been completed to date, and that there is still considerable uncertainty about whether issues may be identified in the CEQA process that could affect overall implementation schedules and feasibility of programs.

BAWSCA sees its role with its member agencies as helping them to increase their overall supply reliability, given many agencies dependence on surface water supply from the SFPUC. To date, BAWSCA's efforts have focused on conservation and reclamation.

With respect to conservation, BAWSCA currently has a subscription-based program available to member agencies, where member agencies can pay for BAWSCA to administer specific conservation programs for them. BAWSCA currently has three conservation programs that they are administering. These three programs are the: Residential Washing Machine Rebate Program, Large Landscape Audit Program, "Out Water" 4th grade school education program. Cal Water has participated in the washing machine program and the school program.

BAWSCA is considering adding five new conservation programs: Commercial, Industrial and Institutional Audit Program, Multi-Family and Commercial Washing Machine Rebates, Commercial Toilet Rebate Program, and increased public outreach and education on the regional level addressing outdoor/landscape water use. Decisions on which programs to include will be made as part of their budget adoption process.

On the reclamation side, BAWSCA is providing support for the North Coast County Water District (City of Pacifica) Recycling Project, the Redwood City Recycling Project and the Palo Alto/Mountain View Recycling Project. To date, BAWSCA support has been on the regional level. This has involved pushing these projects forward for grant funding consideration through regional programs BAWSCA is participating in, such as the Bay Area Water Quality and Supply Reliability Program, the Integrated Regional Water Master Plan, and other CALFED programs.

Individual BAWSCA board members have expressed interest in considering taking the lead on procurement of other non-SFPUC supplies for member agencies. However, to date, the BAWSCA board has taken no formal action or provided policy direction regarding possibly taking on this role.

Table 1
SFPUC Existing System Supply Vulnerability - Natural Hazards

Hazard Scenario	***Facilities Out of Service that Affect Deliveries to Cal Water***	***Likelihood of Event***	***Duration of Outage***	***Level of Service During Outage, Impact to Cal Water*** *(Existing Average Summer Demand = Year 2030 Average Day Demand)*
Earthquake Scenarios				
1. San Andreas Fault M7.9, without Pulgas Tunnel damage	Crystal Springs-San Andreas PL Pulgas PS Crystal Springs PS BDPL No. 1, 2, 4 - one break each Sunset Supply Line south of HTWTP one break San Andreas PL3 @ HTWTP - one break	Significant threat	2 days to initiate water service. 90 days to restore all facilities	All customers receive existing average summer demand (299 MGD) during outage. Cal Water served from HTWTP.
2. San Andreas Fault M7.9, with collapse of Pulgas and Crystal Springs Bypass Tunnels	Pulgas Tunnel Crystal Springs Bypass Tunnel Pulgas PS Crystal Springs PS BDPL No. 1, 2, 4 - one break each Crystal Springs No. 2 - one break in South San Francisco San Andreas PL No. 2 - one break between Baden PS (South San Francisco) and San Pedro Valve Lot (Daly City)	Significant threat	2 days to initiate water service. 90 days to restore all facilities	Cal Water service connections at Orange Ave. and Elm Court are out of service; supply could be possibly be augmented from Cal Water system. San Andreas Pipeline 2 out of service in area of Cal Water turnouts, but San Andreas Pipeline 3 in service. All customers receive existing average summer day demand (299 MGD) during outage, except turnouts isolated by breaks.
3. San Andreas Fault M7.9, without Pulgas Tunnel damage, with HTWTP out of service	HTWTP Pulgas PS Crystal Springs PS BDPL No. 1, 2, 4 - one break each Sunset Supply Line south of HTWTP one break San Andreas PL3 @ HTWTP - one break	Significant threat	2 days to initiate water service 15 days to meet existing average summer demand (300 MGD) 34 days to restore all facilities	54% of existing average summer demand (160 MGD) during first 15 days if only potable water is served to the system. Cal Water would receive treated Hetch Hetchy supply. 94-99% of existing average summer demand (280 to 297 MGD) if raw water is served to the system from Lake Merced and/or San Andreas Reservoir. Cal Water would
4. Hayward Fault M.7.1, with SVWTP out of service	SVWTP San Antonio PP BDPL No. 1, 4 - two breaks each BDPL No. 2, 3 - one break each Sunset Supply Line south of HTWTP one break San Andreas PL3 @ HTWTP - one break	Significant threat	2 days to initiate water service. 16 days to provide 217 MGD 34 days to provide existing average summer demand (300 MGD) 90 days to restore all facilities	52-54% of existing average summer demand (156 to 160 MGD) if only potable water is served to the system. Cal Water would be served from HTWTP. 59% of existing average summer demand (177 MGD) if raw water is served from Lake Merced. Cal Water would be served from HTWTP.

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Table 1
SFPUC Existing System Supply Vulnerability - Natural Hazards

Hazard Scenario	***Facilities Out of Service that Affect Deliveries to Cal Water***	***Likelihood of Event***	***Duration of Outage***	***Level of Service During Outage, Impact to Cal Water*** *(Existing Average Summer Demand = Year 2030 Average Day Demand)*
5. Hayward Fault M.7.1, with SVWTP and Crystal Springs No. 2 out of service	SVWTP San Antonio PP BDPL No. 1, 4 - two breaks each BDPL No. 2, 3 - one break each Crystal Springs No. 2 - one break San Andreas PL No. 2 - one break between Baden PS (South San Francisco) and San Pedro Valve Lot (Daly City)	Significant	2 days to initiate water service. 16 days to provide 216 MGD 34 days to provide existing average summer demand (300 MGD) 90 days to restore all facilities	52-54% of existing average summer demand (154 to 160 MGD) during first 15 days if only potable water is served to the system. Cal Water would be served from HTWTP. 59% of existing average summer demand (177 MGD) if raw water is served from Lake Merced. Cal Water would be served from HTWTP. Cal Water service connections at Orange Ave. and Elm Court are out of service; supply could possibly be augmented by Cal Water system. San Andreas Pipeline 2 out of service in area of Cal Water turnouts, but San Andreas Pipeline 3 in service.
6. Hayward Fault, with collapse of Irvington Tunnel, with SVWTP out of service	SVWTP San Antonio PP Irvington Tunnel BDPL No. 1, 4 - two breaks each BDPL No. 2, 3 - one break each Sunset Supply Line - one break San Andreas PL No. 3 - one break at HTWTP	Least likely of all scenarios	Provide 153 to 177 MGD for duration of outage 90 days to restore all facilities	51-54% of existing average summer demand (153 to 160 MGD) for duration of outage if only potable water is served to the system. Cal Water would be served from HTWTP. 59% of existing average summer demand (177 MGD) for duration of outage if raw water is served from Lake Merced. Cal Water would be served from HTWTP.
7. Calaveras Fault M6.8, with SVWTP out of service	SVWTP Alameda Siphons San Antonio PP BDPL No. 1, 2, 4 - one break each Sunset Supply Line - one break	Significant threat	2 days to initiate water service 16 days to provide 240 MGD 90 days to restore all facilities	54% of existing average summer demand if only potable water is served to the system. Cal Water would be served from HTWTP. 59% of existing average summer demand if raw water is served from Lake Merced. Cal Water would be served from HTWTP.
8. Calaveras Fault M6.8, with SVWTP and Crystal Springs No. 2 out of service	SVWTP San Antonio PP BDPL No. 1, 2, 4 - one break each Crystal Springs No. 2 north of HTWTP - one break	Significant threat	2 days to initiate water service 90 days to restore all facilities	95% of existing average summer demand (285 MGD). Cal Water would be served from HTWTP. Cal Water service connections at Orange Ave. and Elm Court could be out of service depending on location of Crystal Springs No. 2 pipe break; supply could possibly be augmented by Cal Water system.

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Table 1
SFPUC Existing System Supply Vulnerability - Natural Hazards

Hazard Scenario	***Facilities Out of Service that Affect Deliveries to Cal Water***	***Likelihood of Event***	***Duration of Outage***	***Level of Service During Outage, Impact to Cal Water*** *(Existing Average Summer Demand = Year 2030 Average Day Demand)*
Scenarios Not Evaluated in Detail in SFPUC Report. Information developed by CDM.				
9. Rainfall Induced Reservoir Turbidity Events in Hetch Hetchy System	Hetch Hetchy Aqueduct.	Limited. (1)	None.	Events occur during winter months when SFPUC has sufficient capacity to switch to local sources of supply. 100% level of service anticipated.
10. Rainfall Induced Reservoir Turbidity Events in Peninsula Reservoirs	Hetch Hetchy Aqueduct.	--	None.	Events occur during winter months when SFPUC has sufficient capacity to use Hetch Hetchy/SVWTP supplies, along with Baden PS to supply High Zone.
11. Landslide Damaging Crystal Springs Bypass Tunnel	Crystal Springs Bypass Tunnel	Limited (2)	90 days, if same criterion used as for repair following seismic events.	Events occur during winter months when SFPUC has sufficient capacity at HTWTP to meet Peninsula demands. 100% level of service anticipated.
12. Crystal Springs Watershed Contamination	Harry Tracy WTP	Unknown	Unknown.	Potentially up to average summer demand (approx 40 mgd for Peninsula/western SF) through Baden PS.

(1) SFPUC experienced high turbidities in 1995, 1997 and 1997 due to heavy rainfall in the Hetch Hetchy watershed. Completion of the Priest Bypass in late 2003 is expected to significantly reduce the number of watershed events that affect SFPUC's ability to serve Hetch Hetchy supply.

(2) Occurred in 1998.

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Table 2
SFPUC Capital Improvement Programs that Mitigate Natural Hazards

Project	**Project Description**	**Estimated Project Completion**	**Potential Mitigation for:**										
			1. San Andreas EQ	2. San Andreas EQ, Pulgas/ CS Bypass Tunnel Out of Service	3. San Andreas EQ, HTWTP Out of Service	4. Hayward EQ, SVWTP Out of Service	5. Hayward EQ, SVWTP and CS 2 PL Out of Service	6. Hayward EQ, SVWTP and Irvington Tunnel Out of Service	7. Calaveras EQ, SVWTP Out of Service	8. Calaveras EQ, SVWTP and CS 2 PL Out of Service	9. Turbidity Event, Hetch Hetchy or Peninsula Reservoirs	10. Landslide Damaging Crystal Springs Bypass Tunnel	11. Crystal Springs Watershed Contamination
1. Calaveras Dam Replacement	Reconstruct dam to restore capacity of 98,000 AF	Q2 2012			✓						✓		✓
2. Irvington Tunnel # 2/Alameda Siphons	Provide redundant facilities for Irvington Tunnel and Alameda siphons.	Q3 2013						✓					✓
3. Bay Division Pipelines Seismic Reinforcement at Hayward Fault	Seismically reinforce the Bay Division 3 & 4 Pipelines.	Q4 2012				✓	✓	✓					
4. Bay Division Pipeline 4 Slipline PCCP Sections	Reinforce pre-stressed concrete cyclinder pipeline sections of Bay Division PL 4	Q2 2007	✓	✓	✓	✓	✓	✓	✓	✓			
5. Bay Division Pipeline Hydraulic Capacity Upgrade	Provide new Pipeline 5 to replace Pipelines 1 & 2	Q1 2014	✓	✓	✓	✓	✓	✓	✓	✓			✓
6. BDPL No. 3 and 4 Crossover/Isolation Valves	Provides additional shutoff and crossover facilities on each side of the Hayward Fault	Q4 2008				✓	✓	✓					
7. BDPL No. 3 and 4 Crossovers	Additional valve stations to facilitate maintenance or repairs	Q3 2012				✓	✓	✓					
8. New Crystal Springs Bypass Tunnel	New redundant facility for Crystal Springs Tunnel	Q4 2010		✓								✓	
9. Crystal Springs-San Andreas Transmission Upgrade	Improve raw water transfer capability to Harry Tracy WTP	Q2 2014	✓	✓									
10. HTWTP Short-term Improvements	Filter improvements and seismic reinforcement.	Q3 2010			✓	✓	✓	✓	✓	✓	✓		
11. HTWTP Long-term Improvements	Seismic retrofit and rehabilitation to provide sustainable plant capacity of 140 MGD	Q4 2014			✓	✓	✓	✓	✓	✓	✓		
12. Capuchino Valve Lot Capacity Improvements	New pressure reducing station to improve delivery capability from Harry Tracy WTP to Low Zone.	Q3 2009				✓	✓	✓	✓	✓	✓	✓	

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Table 2
SFPUC Capital Improvement Programs that Mitigate Natural Hazards

Project	**Project Description**	**Estimated Project Completion**	**Potential Mitigation for:**										
			1. San Andreas EQ	2. San Andreas EQ, Pulgas/ CS Bypass Tunnel Out of Service	3. San Andreas EQ, HTWTP Out of Service	4. Hayward EQ, SVWTP Out of Service	5. Hayward EQ, SVWTP and CS 2 PL Out of Service	6. Hayward EQ, SVWTP and Irvington Tunnel Out of Service	7. Calaveras EQ, SVWTP Out of Service	8. Calaveras EQ, SVWTP and CS 2 PL Out of Service	9. Turbidity Event, Hetch Hetchy or Peninsula Reservoirs	10. Landslide Damaging Crystal Springs Bypass Tunnel	11. Crystal Springs Watershed Contamination
13. Baden and San Pedro Valve Lot Improvements	Seismic reinforcement to increase delivery reliability during emergencies.	Q4 2011		✓			✓						
14. Crystal Springs PL 2 Replacement	Repair and replacement of portions of the pipeline on the Peninsula and in SF.	Q1 2012		✓			✓						
15. Standby Power Facilities, various locations	Provide standby power at facilities, including San Pedro Valve Lot; Capuchino Valve Lot; Harry Tracy WTP and Calaveras Reservoir	Q4 2010	✓	✓	✓	✓	✓	✓	✓	✓			

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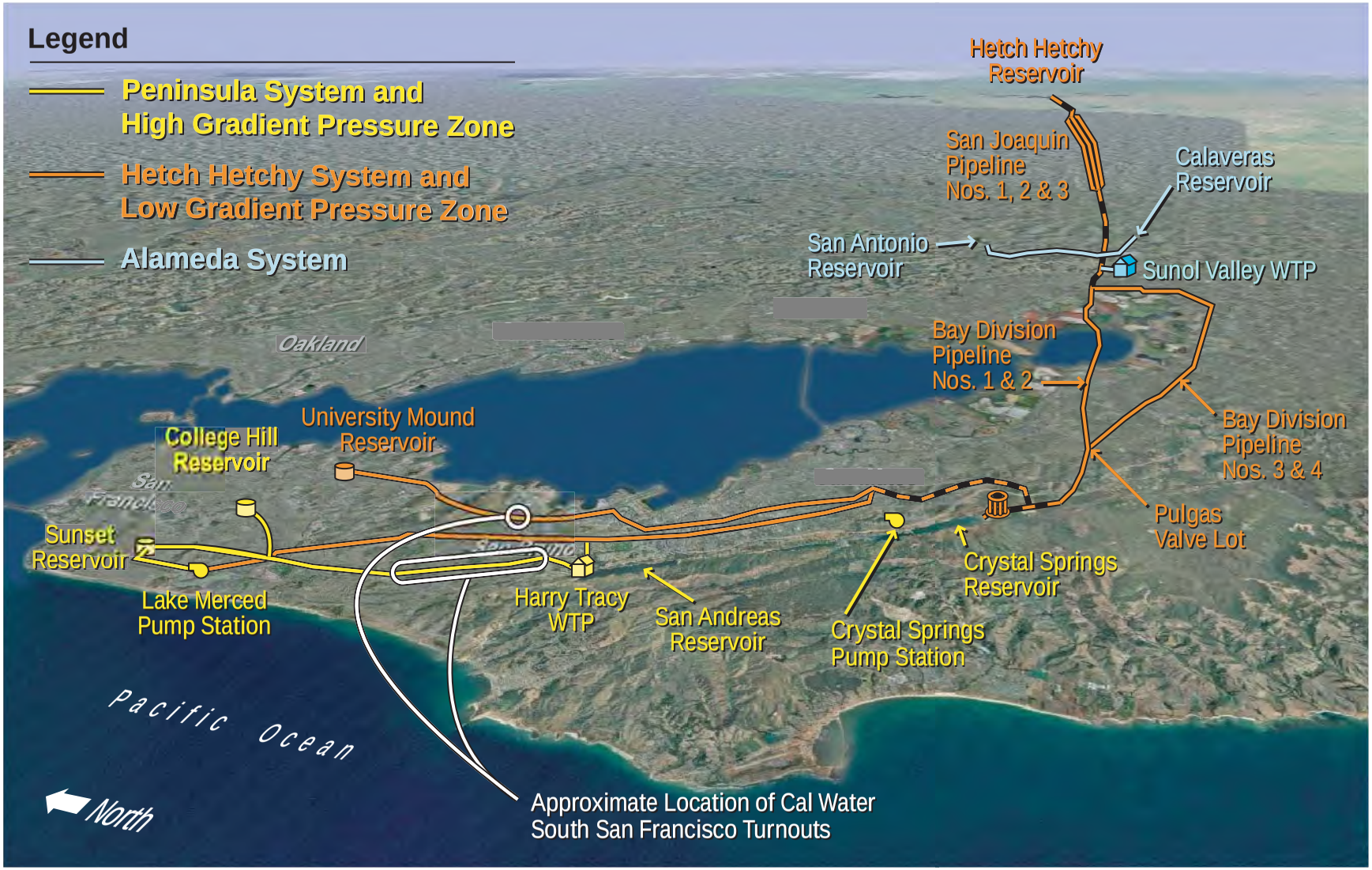

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Figure 1
SFPUC Regional Water System Overview

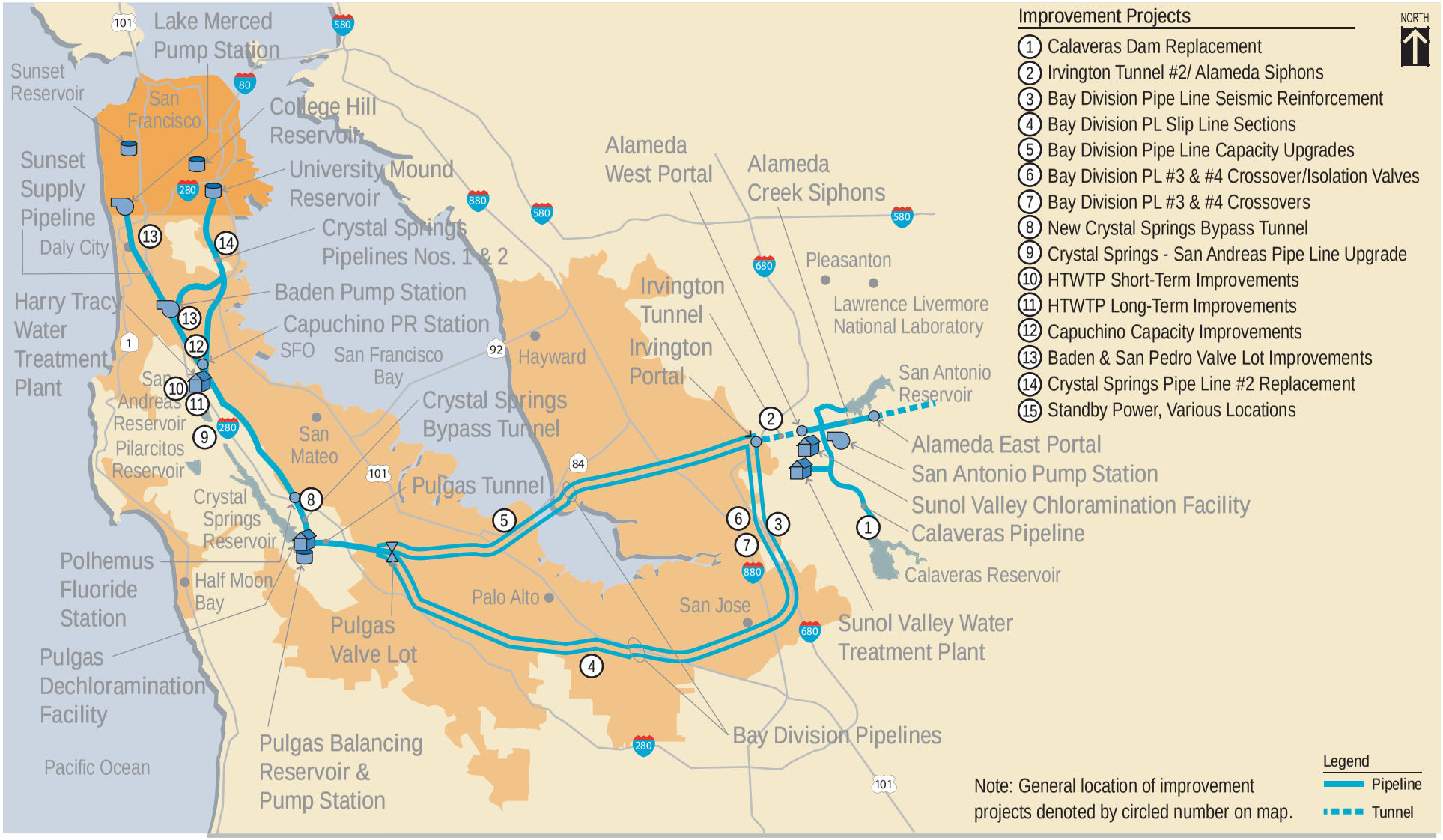

Figure 2
SFPUC Water Supply Improvement Projects to Reduce Vulnerability

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Appendix E

Groundwater Supply Analysis

Public Version

Technical Memorandum
Groundwater Supply
South San Francisco Water Supply & Facilities Master Plan

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HydroFocus Technical Memorandum
Groundwater Supply
South San Francisco Water Supply & Facilities Master Plan

This technical memorandum presents the results from the groundwater supply analysis for the South San Francisco Water Supply & Facilities Master Plan that was conducted by HydroFocus Inc, as a subconsultant to CDM.

The following items are discussed in this technical memorandum:

- Summary of key findings
- Hydrogeologic assessment and existing well field performance
- Background on basin-wide groundwater model
- Analysis approach
- Historical simulation results
- Model assumptions for all scenarios
- Description of scenarios simulated
- Simulation results for all scenarios
- Interferences between existing and alternative well field locations
- Water quality and supply considerations for new wells

All figures are included at the end of the technical memorandum.

SUMMARY OF KEY FINDINGS

Key findings are summarized below, followed by a detailed discussion of the analysis and the results.

Detailed data review and site specific modeling results for Cal Water's existing well field located in South San Francisco indicates:

- Existing Cal Water production wells extract water primarily from semi-confined (leaky) aquifers.

- Static water level and pumping data indicate water levels beneath the present-day well field are sensitive to regional groundwater extraction rates. Average annual extraction rates, and accordingly annual groundwater levels,

have been fairly stable since 1960. Increased local and/or regional extraction rates may lower present-day water levels beneath Cal Water's well field.

- Future well locations should be selected to maximize distances from existing wells. A maximum distance of about 2,500 feet can be achieved between existing wells and potential alternative wells sited at the land parcels being considered. A minimum distance of 500 feet between new and existing wells is recommended; the distances between present-day Cal Water wells ranges from 200 to 2,500 feet.

- Field studies designed to control well extraction rates and measure actual drawdown in nearby non-pumping wells can confirm the relationships identified above, and improve well location and design recommendations for future Cal Water wells.

- We are not aware of conflicts between existing land uses and the alternative well locations considered. For example, the nearest private production well is at the California Golf and County Club, and is located more than 2,400 feet from the nearest present-day Cal Water Service well (SSF 1-18).

Basin-wide data review and groundwater-flow modeling results indicate:

- Storage volumes decrease within the Cal Water Service Area under the No-Action Scenario, indicating that under current water use conditions groundwater storage decreases -470 acre-feet per year.

- Negative changes in groundwater storage correspond to declining groundwater levels. The lowering of groundwater levels can create greater pumping lifts for municipal and private wells. It also increases the potential for saltwater intrusion from South San Francisco Bay, but intrusion may be limited by shallow bedrock areas located between the Bay and California Water Service Area pumping wells.

- If groundwater extraction is increased, the additional water comes primarily from groundwater storage and increases the annual decline in water levels.

- Declining groundwater levels and storage can be curtailed by increasing recharge or decreasing pumping, thereby improving the long-term sustainability of the resource.

    - An In-Lieu conjunctive use project substantially curtailed annual declines in groundwater storage from -470 acre-feet per year (No Action) to -40 acre-feet per year. Hence, the In-Lieu project curtailed the annual storage decline by +430 acre-feet per year relative to the No Action Scenario.

- A Recycled Water project, which switches irrigators from groundwater to recycled water, can substantially decrease extraction rates and curtail annual groundwater storage declines. For example, a 50-percent reduction in irrigation pumpage curtailed the annual decline from -470 acre-feet per year (No Action) to -60 acre-feet per year. Hence, the 50-percent recycled water use level curtailed the annual storage decline by +410 acre-feet per year relative to the No Action Scenario. Increasing recycled water use from 50- to 100-percent reversed the annual decline from -470 acre-feet per year (No Action) to +350 acre-feet per year. Increasing recycled water use to 100-percent provided a net benefit of +820 acre-feet per year, which is a significant improvement over the No Action Scenario. If fully realized, average annual Cal Water pumpage could increase under the 100-percent recycled water use level to 1,570 acre-feet per year (13-percent of their projected 2030 demand).

- If both In-Lieu and Recycled Water (50-percent) projects were implemented, groundwater storage in the Cal Water Service area increases during the simulation period. If fully utilized, Cal Water could increase their average annual extraction rate to 2,410 acre-feet per year (20-percent of the projected 2030 demand). Increasing recycled water use from 50- to 100-percent could add additional 410 acre-feet per year.

- Injecting 3,200 acre-feet of surface water during Above Normal and Wet runoff years (a total of 73,600 acre-feet during the 45-year simulation period) provided a net benefit of 1,370 acre-feet per year. If fully utilized, annual average Cal Water Service pumping rates could increase to 2,940 acre-feet per year, or 24-percent of the projected 2030 demand.

- For the conditions analyzed in this study, model results indicate the net change in groundwater storage and related drawdown in water levels are similar employing either a new distributed well network or the existing well field. The water supply benefit to Cal Water from distributed wells therefore appears negligible.

- Potential locations for a new distributed well network are discussed in this report. Our analysis of water quality data, summarized in the separate Task 2-2 Technical Memorandum, suggests negligible water quality improvements from new wells.

  - TDS, hardness, iron and manganese problems are characteristic for the Westside Basin, and we expect similar problems in new wells located within the Cal Water Service Area.

  - Nitrate concentrations are probably the result of historical fertilizer use, and therefore high NO3 concentrations most likely also occur at other

locations within the Cal Water Service Area. For example, the NO3 concentration measured in an April 2000 sample from the Home of Peace Cemetery well was 85 mg/L, which exceeds the Federal EPA Maximum Contaminant Level.

- Organic compounds, which are present in the water produced by some Cal Water wells, may be less likely up-gradient to the industrialized zone.

HYDROGEOLOGIC CONDITIONS

Local Geology and Water Transmitting Properties

Beneath Cal Water's well field (South San Francisco Station 1), previous studies and well driller reports indicate the average depth to bedrock is about 650 feet below land surface. The water-bearing deposits between land surface and bedrock can be conceptualized as alternating layers of predominantly fine-textured silt and clay and coarse-textured sand and gravel (aquifers); the fine- and coarse-textured beds in the vicinity of the well field can be approximated as horizontally layered sediments[1].

Cal Water production wells extract water primarily from semi-confined[2] aquifers. Well screen intervals are variable, and the perforations begin from less than 100 feet below land surface to as deep as 380 feet below land surface. Hence, the water extracted is derived from various depths and most likely multiple aquifers.

We utilized observed water-level recovery rates and employed the *Cooper-Jacob Recovery Method*[3] to estimate the transmissivity[4] of aquifer materials beneath the well field[5]. We conducted our analysis on wells having data from the April

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[1] Erdmann H. Rogge, 2003, "Dimensions of the Westside Groundwater Basin San Francisco and San Mateo Counties, California", Masters Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, San Francisco State University.

[2] Semi-confined aquifers, or leaky aquifers, are partially confined by low permeability silt and clay beds through which recharge and discharge can still occur.

[3] H.H. Cooper and C.E. Jacob,1946: "A Generalized Graphical Method for Evaluation Formation Constants and Summarizing Well Field History", American Geophysical Union Transactions, v. 27, pp. 526-534.

[4] Transmissivity is a property of water-bearing materials, and is the rate at which water is transmitted through a unit width of the water bearing material under unit gradient, and is equal to the hydraulic conductivity multiplied by the thickness of the water-bearing material. The units for transmissivity are L^2/T.

[5] In April 2000, water level changes in wells were measured during a voluntary 24-hour basin-wide production-well shutdown. Pumping wells were shut down at 10:00 AM on April 27th 2000 until 10:00 AM on April 28th. Well water levels were measured with electronic sounders and pressure transducers. The test protocols, data and results were reported by San Mateo County in "Results of the April 2000 Westside Basin Twenty-Four Hour Well-Water Level Response Test". Prior to this test, one or more Cal Water wells were active and therefore the well field in general operated continuously from April 1997 until the well shut-down in April 2000 (although not

2000 basin-wide production-well shutdown (See Figure 1 for our graphical analysis of the water level recovery data), and our results are summarized below in Table 1[6]. Estimated transmissivity ranges from 1,000 to 20,000 square feet per day (ft^2/day); the effective hydraulic conductivity, calculated as the transmissivity divided by the total screen length, ranges from 7 to 50 feet per day (ft/day). The hydraulic conductivity of the deepest aquifers (7 to 9 ft/day for sediments adjacent to wells 20 and 21 - the deepest of the eight Cal Water wells) is about half an order of magnitude lower than the overlying aquifers adjacent to wells 2, 15, 17, 18 and 19 (20 to 50 ft/day). The average hydraulic conductivity is 26 ft/day (the median conductivity is 30 ft/day).

Table 1. Estimated transmissivity from April, 2000 recovery test data.

Well Number	***Perforations (feet below land surface)***		***Transmissivity (ft^2/day)***	***Hydraulic Conductivity (ft/day)***
	Top	Bottom		
2	?	210	7,000	30
14	---	---	---	---
15	120	535	10,000	30
17	150	460	10,000	40
18	231	578	20,000	50
19	216	528	5,000	20
20	380	580	1,000	7
21	370	580	2,000	9
		Average	7,860	26
		Median	7,000	30

Water Level Trends

In Figure 2, historical water levels observed in well 18 and groundwater extraction rates from both Cal Water's well field and the entire basin indicate that water levels beneath the well field are sensitive to regional groundwater consumption. For example, Cal Water extraction rates were fairly constant during the period 1940 through 1960 (1.7 to 2.0 million gallons per day - MGD), yet observed static groundwater levels in well 18 declined about 60 feet. The declining water levels are attributed to the almost doubling in basin wide extraction rate (increase from less than 6 to about 11 MGD). Since 1960,

all wells operated the entire time). The average well-field pumping rate during this period was 729 GPM (1.0 MGD).

[6] For this analysis, we assumed the recovery observed in each well was in response to an extraction rate equal to the extraction rate for the entire well field. We assumed this approach was reasonable because the wells remove water from semi-confined aquifers, and the wells are located fairly close to each other. However, the well shutdown test was not explicitly designed and implemented for the purpose of conducting a controlled aquifer test. Conclusions based on the transmissivity values reported in Table 1 must therefore consider the limitations of the data and assumptions inherent to our calculations.

average Cal Water and basin-wide extraction rates have both remained fairly constant (about 2 and 11 MGD, respectively). Accordingly, groundwater levels in well 18 have also remained fairly stable. Similar water level changes and trends are observed in other Cal Water South San Francisco wells.

During the last thirty years, a direct relationship is generally observed between relatively short term groundwater extraction rates and depth to groundwater. Temporary increases in the annual extraction rate above the long-term average produce temporary increases in depth to groundwater (i.e., groundwater levels beneath the well field decline). Similarly, temporary decreases in annual extraction rate below the long-term average produced temporary decreases in depth to groundwater (i.e., groundwater levels beneath the well field rise). These short term water level changes (i.e., annual increases or decreases in groundwater levels) are influenced by changes in both basin-wide and local extraction rates.

Existing Well Field Performance

Well yield is the volume of water produced per unit of discharge time. The yield is influenced by the water transmitting and storage properties of the aquifer materials; well design, construction and condition; and long-term regional water level trends. On the average, Cal Water's Station 1 well field has produced at an average annual rate of about 125 gpm per well (1.08 MGD total extraction rate). Individual well yield tests reported by Cal Water indicate pumping rates as high as 500 gpm. However, it is uncertain how long these wells could sustain this pumping rate. For planning purposes, 150 gpm is a reasonable assumption for representative average annual yields for new wells located in the vicinity of Station 1[7]. Well construction and testing are necessary to confirm the assumed average annual yield.

Specific capacity is a measure of well performance, and is calculated as the well yield per unit of water level drawdown after a given time of continuous pumping. Specific capacity generally varies with discharge rate and pumping period, and can change over time as the physical condition of the well changes. For example, encrustation of well screens can increase friction losses as groundwater moves from the formation and through the well screen, resulting in a lower yield per unit of water level drawdown.

Within a semi-confined aquifer, yield is generally proportional to drawdown as long as the drawdown does not fall below the bottom of the overlying low

[7] In the northerly portions of Cal Water's service area, estimated and reported extraction rates for private and public wells ranges from 70 to about 550 gpm (average of about 220 gpm). For planning purposes, 200 gpm is a reasonable assumption for representative average annual yields for new wells located in northerly portions of Cal Water's service area. Well construction and testing are necessary to confirm the assumed average annual yield.

permeability silt and clay bed (the top of the aquifer). Well driller reports for existing Cal Water wells suggest that, based on clay bed and well screen intervals, the average depth to the top of the aquifer is about 175 feet below land surface. If the drawdown exceeds this depth (water levels fall below the top of the aquifer), portions of the water bearing zone can become unconfined. Under unconfined conditions, well interferences can have a potentially greater influence on well yield.

Reported water level drawdown and well yield (pumping rate) for Cal Water wells is plotted in Figure 3. In general, the relationships between reported drawdown and yield are linear indicating that the specific capacity is constant. This is consistent with wells extracting water from semi-confined aquifers. The lowest specific capacities are measured in wells 1-20 and 1-21; these two wells are preferentially perforated in the deepest aquifers, which have the lowest water transmitting properties beneath the well field (lowest estimated values for hydraulic conductivity).

BACKGROUND ON BASIN-WIDE GROUNDWATER MODEL

In 2001, the City of Daly City utilized a combination of local funds and a grant from the California Department of Water Resources' AB303 program to complete several tasks directed toward improving groundwater management in the Westside Groundwater Basin[8]. One task was to combine the best elements of previous groundwater-flow models into a unified and updated tool for ongoing use by basin stakeholders (herein referred to as "the model").

For the South San Francisco Water Supply and Facilities Master Plan, HydroFocus, Inc. employed this model[9] to assess the potential for groundwater to meet projected water demands in Cal Water's South San Francisco service area.

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[8] City of Daly City, 2002, "AB303 Grant Final Report".

[9] The groundwater-flow model reasonably matches observed groundwater levels and responds as expected to changes in recharge and pumpage. However, convergence criteria (the change in calculated groundwater levels between successive iterations), and the difference between simulated water inflows and outflows (error in the simulated volumetric water balance) do not meet commonly accepted guidelines (a simulated groundwater level change of 0.01 foot or less between successive iterations, and simulated inflows and outflows that agree within 1-percent or less). Currently, on a model-wide basis, the maximum simulated groundwater level changes between iterations are more than 1 foot; the error in the volumetric water balance ranges between about 1- to 3-percent. The City of Daly City jointly developed a work plan with technical consultants representing SFPUC and the City of San Bruno to collectively review and, where appropriate, revise model input. Once the input data sets have been reviewed and updated, the group is to re-calibrate the model and evaluate model uncertainty. The purpose for this collaboration is to develop consensus from basin stakeholders on model input and calibration. The updated model is scheduled for completion in spring 2006, and we recommend the groundwater modeling analysis for the South San Francisco Water Supply and Facilities Master Plan be updated when model revisions are completed and accepted.

The model simulates groundwater-flow in the Westside Basin. Figure 4 shows model boundaries and the general area represented by the model. The San Andreas Fault forms the southwestern model boundary, and the northeastern boundary is formed by the contact between the relatively young "alluvium" (Merced and Colma formations and younger Quaternary and Pleistocene age deposits) and old "bedrock" (Franciscan Assemblage). In the northwest and southeast, the Pacific Ocean and South San Francisco Bay are important hydraulic boundaries represented in model. The model employs a monthly time-step scheme, and simulates historical hydrologic conditions during the period October 1958 through September 2003 (Water Years 1959 through 2003).

ANALYSIS APPROACH

HydroFocus utilized the model to preliminarily assess hydrologic changes within California Water Service Company's South San Francisco service area (herein referred to as the "Cal Water Service Area"). Figure 5 shows the Cal Water Service Area relative to the model boundaries, and extraction well locations represented by the model. Note that minor northeastern portions of the Cal Water Service Area are not represented by the model. These areas are considered insignificant from the standpoint of the groundwater resource; the areas overlie shallow alluvial deposits or are effectively separated from the basin by bedrock outcrops.

The analysis employed a 45-year simulation period, which begins in October 2003 and extends to 2048. In general, we repeated the historical 1958-2003 monthly rainfall and evapotranspiration data and utilized the model to simulate groundwater level and storage changes that occur as a result of alternative proposed pumping levels from Cal Water wells.

A water budget approach was utilized to assess simulated changes in groundwater storage. A volumetric groundwater budget is a summary of subsurface inflows and outflows, as shown on Figure 6. Recharge, which is the net result of rainfall, water deliveries, and land and water use activities, is a key groundwater inflow:

$$R = I - ET + \Delta S_{soil}, \text{ where} \qquad (1)$$

R is monthly recharge, which is water that percolates to the saturated groundwater system, in units of acre-ft;
I is monthly infiltration of applied water, rainfall, and other sources like leaky water supply and sewer lines, in acre-ft;
ET is monthly consumptive water requirement by plants, in acre-ft; and,
ΔS_{soil} is the monthly change in soil moisture content.

The model employs Equation (1) and soil moisture accounting methods to calculate recharge rates. The accounting algorithm utilizes reported soil properties, water deliveries, evapotranspiration data, and water budget accounting equations to estimate monthly infiltration, runoff, pipe leaks, soil moisture changes and recharge[10].

In addition to recharge, inflow includes up-gradient groundwater that moves laterally into the Cal Water Service Area. Outflows include lateral water movement out of the Service Area, shallow groundwater discharge, and extraction by municipal and private pumping wells. The difference between summed inflows and outflows is the change in groundwater storage:

$$R + GW_{in} - GW_{out} - Wells = \Delta S_{GW}, \text{ where} \qquad (2)$$

GW_{in} is monthly volume of inflowing groundwater, in acre-ft;
GW_{out} is monthly volume of outflowing groundwater, in acre-ft;
Wells is the monthly pumping rate from municipal and private wells, in acre-ft; and,
ΔS_{GW} is the monthly change in groundwater storage, in acre-ft.

A positive change in groundwater storage represents an increase in the volume of water stored in the aquifer; groundwater storage increases result in rising water levels in wells. A negative change in groundwater storage represents a decrease in the volume of water stored in the aquifer; groundwater storage decreases result in declining water levels in wells. Decreases in groundwater storage and declining water levels can induce the inland movement of saltwater[11], which may degrade water quality within the Cal Water Service Area.

HISTORICAL SIMULATION RESULTS

A simulation was conducted to check how closely model results match historical data, which is an indicator of how reasonable the model reproduces groundwater-flow conditions in the Westside Basin. The historical simulation ends in September 2003, which is the starting point for all subsequent projection runs. Simulated and reported water levels were compared to see how closely they matched.

Figure 7 compares simulated and observed water levels in two[12] Cal Water wells (SSF-17 and SSF-19). The model reasonably reproduces reported static water

[10] Phillips, S.P., SN. Hamlin, and E.B. Yates, 1993: "Geohydrology, water quality, and estimation of groundwater-recharge in San Francisco, California, 1987-92", U. S. Geological Survey Water Resources Investigations Report 93-4019.
[11] Jacob Bear, 1979: "Hydraulics of Groundwater", McGraw-Hill.
[12] Cal Water wells fall within 6 model cells. Wells 2 and 15 are located in the same cell, wells 17 and 20 are located in a different cell, and the remaining wells are located in cells all by

levels, and both observed and reported water levels show a net decline in groundwater storage during the 1958-2003 period. Inserting simulated volumetric fluxes[13] into Equation (2), the average annual decline in groundwater storage was -750 acre-feet per year in the Cal Water Service Area:

$$1{,}980 + 3{,}590 - 1{,}780 - 4{,}540 = -750.$$

Figure 8 shows the simulated potentiometric surface[14] in September 2003, and represents hydraulic conditions near the pumped zone of the aquifer.

Inflow occurs from the north, and groundwater moves toward irrigation wells in the Colma area (cemetery wells). Inflow also occurs from the south, and groundwater moves from the San Bruno area toward the California Water Service well field. Some groundwater also moves inland from easterly areas beneath South San Francisco Bay; groundwater inflow from beneath the Bay is a potential source of saltwater intrusion.

Although landward gradients have existed for decades, well water quality data is inconclusive regarding degradation by intruding baywater[15]. Beneath the eastern portion of the Cal Water Service Area, sediment deposits between the Bay and pumping wells are relatively thin, and bedrock is encountered at shallow depths, as shown on Figure 9. This relative high point in the bedrock surface, or "bedrock high", appears to impede the inland movement of saltwater that probably exists in the shallow aquifers beneath the Bay.

MODEL ASSUMPTIONS FOR ALL SCENARIOS

The following modeling assumptions apply to all scenarios in this study.

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themselves. Results are reported for two of the cells as representative of model results for the entire well field. The well field is small in area relative to the scale of the model and Westside Groundwater Basin (see Figures 1 and 2).

[13] The simulated monthly volumetric budget error ranges from -1 to 5-percent, and averaged 1-percent.

[14] The potentiometric surface represents the hydrostatic head in a semi-confined aquifer system. It is analogous to a water table in an unconfined aquifer, and is obtained by connecting equilibrium water levels in wells penetrating the semi-confined portions of the aquifer.

[15] Daly City's 2002 AB303 Study utilized seawater indicators, groundwater age-dating results, and geochemical modeling to assess the probable sources of dissolved constituents measured in Westside Basin wells. Although 4 California Water Services wells (SSF-14, -17, -19, and -21) exhibited statistically significant chloride ion concentration increases (a possible indicator of saltwater intrusion), the analysis was inconclusive regarding saltwater intrusion. Several pieces of information (age-dating results, low chloride concentration levels, and the modest annual increase in chloride ion concentration) suggest a source other than South San Francisco Bay water may be responsible for the observed chloride ion trends.

- **Hydrology.** Use rainfall and ET for water years 1959-2003, which is the same as presently used in the model and includes three droughts (1959-1961, 1976-1977, and 1987-1992). The scenarios therefore represent a 45-year simulation period.

- **Initial groundwater levels.** Use simulated water levels in September 2003 from the calibration run of the Westside Basin Groundwater-Flow Model.

- **Lake Merced.** Use existing lake geometry and initial elevation equal to the September 2003 simulated elevation. Other lake assumptions include:
  - No Vista Grande diversions into Lake Merced during the projection period.
  - No SFPUC or other water additions during the projection period.
  - No direct withdrawals from the lake during the projection period.

- **Existing recycled-water use.** Existing recycled water projects include tertiary water delivered to the Olympic Golf Club, Lake Merced Golf and Country Club, and San Francisco Golf Club to meet 50-percent of their irrigation demand up to a maximum of 850 acre-feet per year. Assume no reclaimed water use at other golf courses, parks or cemeteries. Table 2 reports the historical average annual golf course pumpage; the No-Action Scenario assumes 50-percent of the pumpage in Table 2 is replaced with recycled water (356 acre-feet per year).

Table 2. Average Estimated Pumpage for Irrigators Receiving Daly City's Recycled Water (average annual pumpage for water years 1959-2003).

Name	***Area*** ***(acres)***	***Irrigated Area*** ***(acres)***	***Pumpage*** ***(acre-feet per year)***
Lake Merced Golf and Country Club	*136.3*	*91.3*	*163*
San Francisco Golf Club	*172.2*	*115.4*	*211*
Olympic Golf Club	*280.5*	*187.9*	*338*
		TOTAL	*712*

- **Recharge and pumping at active irrigation wells.** Annual recharge and pumping is the same as the 1959-2003-calibration simulation because consumptive use and application rates are the same.

- **Present-day municipal water demand.** Municipal demand assumed equal to average water use during the period 1998-2002 (existing development level, conservation level, and near-average rainfall). In 2003, municipal pumpers voluntarily reduced pumping rates as part of a conjunctive use pilot project. Therefore, the 2003 pumping data were excluded because it would bias average annual pumping rates. The estimated water demand and pumping rates are reported in Table 3.

Table 3. Five-Year (1998-2002) Average Municipal Water Use, in acre-feet per year

Municipality	*Total Water*[a]	*Groundwater*[a]
City of San Francisco[a]	18,550	0
City of Daly City	7,540	3,970
South San Francisco (Cal Water)	7,470	1,220
City of San Bruno	5,130	2,010

a: Does not include groundwater use by Golden Gate Park, San Francisco Zoo, other parks and schools.

- **Drought and conservation impacts.** In the 1959-2003 hydrologic record, droughts occurred during 1959-1961, 1976-1977, and 1987-1992. Municipal water supply data indicates an approximately 10- to 20-percent reduction in total water supply as a result of reduced surface water deliveries; groundwater pumpage remained relatively stable, as shown on Figure 10. We therefore assumed that reduced surface water supplies due to drought conditions are absorbed by conservation.

- **Recharge**. Potential future changes in land use patterns and changes in system losses (i.e., pipe leakage rates) are assumed to have a negligible effect on the quantity and distribution of groundwater recharge.

DESCRIPTION OF SCENARIOS SIMULATED

The following scenarios are described below, and the results of the simulations are presented in the next section.

- No Action Scenario
- Existing Well Field Scenarios
    - Increased Supply (three levels)
    - In Lieu Conjunctive Use
    - Recycled Water Project
- Distributed (New) Wells Scenarios
    - Increased Supply (three levels)
    - In Lieu Conjunctive Use
    - Recycled Water Project
    - Aquifer Storage and Recovery

No Action

The No-Action Scenario is a continuation of present-day water use with no new projects (i.e., no increases in pumpage, no in-lieu conjunctive use, no new recycled water use, no aquifer storage and recovery projects). The No-Action Scenario is the starting point for comparison with all other simulations. Specifically, the scenario repeats observed rainfall and ET records (water years

1959-2003) and projects future groundwater storage changes under "present-day" water use conditions (Table 3).

Existing Well Field

During the 1998-2002 averaging period, Cal Water employed six of their nine wells. The Existing Well Field Scenarios assume these wells have adequate capacity to meet simulated pumping increases; if increased capacity were required, we assumed additional wells could be activated or new wells added in the general vicinity of the existing well field. These new wells are not explicitly introduced into the model, but instead are implicitly added by increasing the pumping rates from model cells representing existing wells.

Existing Well Field – Increased Supply

Based on information in the 2003 Urban Water Management Plan, Cal Water's 1998-2002 average groundwater supply was 12.8 percent of the total water supply. The Existing Well Field – Increased Supply Scenario assesses Cal Water's continued use of their wells to meet the following demands:

i. Groundwater extraction to maintain 13-percent of future total average supply.
ii. Groundwater extraction equal to 20-percent of future total average supply.
iii. Groundwater extraction equal to 26-percent of future total average supply.

CDM's *South San Francisco Water Supply and Facilities Master Plan: Task 1 Draft Technical Memorandum Service and Water Demand Projections* (Table 1, "Summary of Planning-Level Demand Projections") was utilized to prescribe average annual water demand in 2030 at 12,280 acre-feet per year. This 2030 water demand does not include a future 10% reduction due to implementation of additional conservation measures. The allocation of this supply between surface water and groundwater resources is summarized in Table 4.

During 2004-2030, projected water demand will gradually increase. However, the gradual increase in demand was not simulated by the model. Model results are therefore considered conservative as they are based on the maximum projected demand for water[16]. Furthermore, groundwater extraction by other

[16] If instead of the maximum demand, a gradual rise in demand was simulated, the net effect would be to reduce the cumulative volume of water removed from the aquifer during the simulation period. Hence, the magnitude and rate of simulated groundwater level and storage volume changes would be less than simulated using the maximum demand. The decision to use maximum demand may therefore be overly conservative, as pumping rates can be more than double the No-Action pumping rate. However, the effect is somewhat counter-balanced by the assumption that other municipal pumpers do not increase their demands for groundwater. Increased pumping rates by these groundwater users, combined with continued pumping by Cal Water and private groundwater users, all can contribute to the lowering of simulated groundwater levels and storage in the basin.

municipal pumpers was not changed. Model results therefore isolate the hydrologic effects from Cal Water well pumping, and do not include potential cumulative impacts from pumping increases by other groundwater users.

Table 4. Water Supply Summary for Existing Well Field – Increased Supply Scenarios.

Scenario	***Water Supply (acre-feet per year)***		
	Total 2030 Demand	Groundwater	Surface Water
13% groundwater	12,280	1,600	10,680
20% groundwater	12,280	2,450	9,830
26% groundwater	12,280	3,180	9,100

Existing Well Field – In Lieu Conjunctive Use

The Existing Well Field – In Lieu Scenario is a continuation of the conjunctive use pilot project (or in-lieu recharge pilot project)[17]. Specifically, the scenario repeats observed rainfall and ET records (water years 1959-2003) and projects future groundwater storage changes under continued in-lieu project conditions. Relative to the No-Action Scenario, all other conditions remain the same except the following: during periods of supplemental surface water deliveries, groundwater extraction rates are voluntarily reduced; during periods of reduced surface water supply, groundwater extraction rates are increased. When groundwater extraction is reduced, natural groundwater recharge is retained, thereby storing it in the basin for future use.

The San Joaquin Valley water year Hydrologic Classification Index and the 45-year historical hydrologic record were used to construct an example In-Lieu Recharge Scenario. The San Joaquin Index was used to identify plausible years when supplemental surface water could be available. For example, it was assumed supplemental surface water would be available to replace 100-percent of the average groundwater use during water years classified as Wet or Above Normal. For Below Normal and Dry water years, it was assumed groundwater extraction rates are similar to average 1998-2002 conditions. In other words, for Below Normal and Dry water years, surface water deliveries and groundwater use are equal to No-Action levels. In Critical runoff years (corresponding with the 1959-61, 1976-77, and 1987-92 droughts), it was assumed that groundwater

[17] In-lieu recharge refers to a conjunctive use approach whereby additional surface water is delivered, when available, to replace groundwater extraction that otherwise would have occurred. The use of this supplemental surface water retains natural groundwater recharge that otherwise would have been extracted for use, thereby storing this recharge in the basin for future use during periods of reduced surface water supply.

extraction rates are voluntarily increased[18], and increased extraction rates replace voluntary cut-backs in surface water deliveries. Table 5 lists the water year types for each year of the 45-year simulation period.

Table 5. San Joaquin Valley Water Year Hydrologic Classification, 1959-2003.

Water Year	*Water Year Index*	*Action*
1959	Dry	---
1960	Critical	Take
1961	Critical	Take
1962	Below Normal	---
1963	Above Normal	Put
1964	Dry	---
1965	Wet	Put
1966	Below Normal	---
1967	Wet	Put
1968	Dry	---
1969	Wet	Put
1970	Above Normal	Put
1971	Below Normal	---
1972	Dry	Put
1973	Above Normal	Put
1974	Wet	Put
1975	Wet	Put
1976	Critical	Take
1977	Critical	Take
1978	Wet	Put
1979	Above Normal	Put
1980	Wet	Put
1981	Dry	---
1982	Wet	Put
1983	Wet	Put
1984	Above Normal	Put
1985	Dry	---
1986	Wet	Put
1987	Critical	Take
1988	Critical	Take
1989	Critical	Take
1990	Critical	Take
1991	Critical	Take
1992	Critical	Take
1993	Wet	Put
1994	Critical	Take
1995	Wet	Put
1996	Wet	Put
1997	Wet	Put

[18] We assumed simulated pumping rate increases during drought runoff years are feasible using existing wells. However in practice, additional wells are most likely required to provide the necessary capacity to extract the large volumes of groundwater needed to replace the voluntary reductions in surface water deliveries. The location and pumping rates of these additional wells can influence the simulated magnitude and rate of local water level declines. However, if the simulated total volume of water extracted is the same using existing wells, or a combination of new and existing wells, the magnitude and rate of decline in groundwater storage will be approximately the same.

Table 5. San Joaquin Valley Water Year Hydrologic Classification, 1959-2003.

Water Year	*Water Year Index*	*Action*
1998	Wet	Put
1999	Above Normal	Put
2000	Above Normal	Put
2001	Dry	---
2002	Dry	---
2003	Below Normal	---

"---" = no-action pumping rates.
"Take" = pumping rates are voluntarily increased.
"Put" = pumping rates are voluntarily curtailed.

In drought water years, it was assumed for this analysis that extraction rates are increased by participants such that 80-percent of their total demand for water is supplied by groundwater[19]. This is a conservative assumption as to the maximum groundwater use during a critical drought, and assumes most pumpers cannot use 100-percent groundwater due to water quality concerns, such as nitrates.

The assumed demands and corresponding groundwater extraction rates are summarized in Table 6. Note that over the 45-year simulation period, the average annual pumping rate from Cal Water wells increases from 1,220 to 1,570 acre-feet per year. This is a consequence of wells providing 80-percent of the total water supply during Critical water years. As noted, this a conservative assumption and will be considered in the overall development of the alternative water supply plans, in conjunction with information developed in Task 2-3 on potential cutbacks of SFPUC supply during droughts.

Table 6. Municipal Water Use and Water Year Types, in acre-feet per year.

Participant	***Total Water***[a] (Dry, Below Normal, Above Normal, and Wet Years)	***Groundwater***			
		No Action	*San Joaquin Valley Water Year Hydrologic Classification Index*		
			Critical (drought)	Below Normal and Dry	Above Normal and Wet
City of San Francisco	18,550	0	0	0	0
City of Daly City	7,540	3,780	5,130	3,970	380[b]
South San Francisco (Cal Water)	7,470	1,220	5,080	1,220	0
City of San Bruno	5,130	2,010	3,490	2,010	0

a: During drought water years, we assumed a 15-percent reduction in total water supply as a result of conservation. For example, annual total water demand supplied by Cal Water during non-drought years (Dry, Below Normal, Above Normal, and Wet runoff years) is 7,470 acre-feet. In drought water years (Critical runoff years), we assumed total water use in the Cal Water Service area decreases by 15-percent to 6,350 acre-feet (1,270 acre-feet surface water and 5,080 acre-feet groundwater).
b: We assumed Daly City continues to pump from their Vale well even during Normal and Wet runoff years.

[19] We assumed and 80:20 groundwater to surface water mixing ratio to dilute for nitrate or other inorganic constituents of concern in groundwater.

Existing Well Field – Recycled Water

The Existing Well Field – Recycled Water Scenario implements recycled water projects in the Cal Water Service area. It was assumed that turf irrigators utilize recycled water at either 50-percent or 100-percent of their consumptive use requirement. Table 7 lists the estimated consumptive use requirement for present-day areas irrigated with groundwater, and the expected reduction in pumpage for each recycled water use level.

Table 7. Simulated Future Recycled Water Use.

Groundwater User	*Estimated Irrigated Area (acres)*	*Average Consumptive Use (acre-feet per year)*	*Simulated Recycled Water Use (acre-feet per year)*	
			50-percent	100-percent
Cypress Lawn Cemetery	970	323	162	323
Eternal Home		85	42	85
Hills of Eternity Cemetery		108	54	108
Holy Cross Cemetery		252	126	252
Home of Peace Cemetery		90	45	90
Italian Cemetery		72	36	72
Olivet Cemetery		180	90	180
Woodlawn Memorial Cemetery		171	86	171
California Golf Club	188	250	125	250
Total	*1158*	*1531*	*765*	*1531*

Existing Well Field – Alternative Well Locations

We compared groundwater level drawdown as a result of pumping from existing extraction wells (SSF-2, -14, -15, -17, -18, -19, -20, and -21), and wells installed at potential alternative locations[20] (Figure 11). In general, the alternative well sites are located slightly south of the present-day well field.

In the aquifer adjacent to a pumping well, the groundwater-level drawdown is called the cone of depression (or cone of influence). As the pumping period increases, the water removed from aquifer storage is derived greater distances from the well. The rate of drawdown within the well and expansion of the radius of influence around the well decreases with time as an increasing volume of stored water is produced with each incremental expansion of the cone of depression. In a well field, several cones of depression can overlap thereby

[20] Cal Water provided the map used to develop the alternative well site locations shown in Figure 11. The map showed potential alternative well locations in the vicinity of South San Francisco Station 1. Our analysis considered eight new wells constructed at these general alternative locations.

increasing the net drawdown within each well. The magnitude of this interference depends largely on well construction, location, and pumping rates.

The Westside Basin groundwater-flow model is designed to simulate basin-wide hydrologic conditions, and is limited for conducting a detailed assessment of hydraulic interferences within Cal Water's well field. We therefore employed the computer software WinFlow[21], which utilizes analytical functions developed by Strack[22] to simulate detailed, two-dimensional, steady-state groundwater elevations within and adjacent to the Cal Water well field. The software utilizes the principle of superposition to evaluate the cumulative interference from multiple wells. We calculated the difference between the two simulated drawdown distributions and utilized the results as a quantitative measure of the relative impact of well field geometry and cumulative well interferences.

Our analysis utilized the following assumed well construction and aquifer conditions for the Cal Water well field:

Depth to Top of Aquifer: 175 feet below land surface and static regional groundwater levels.

Bottom elevation of Aquifer: 650 feet below land surface.

Effective Hydraulic Conductivity: 15 ft/day (corresponding to an average transmissivity of 7,860 ft^2/day). Hydraulic conductivity estimates ranged from 2 to 42 ft/ day, corresponding to the range in estimated transmissivity of 1,000 to 20,000 ft^2/day.

Depth to Top of Well Perforations: variable and based on well construction logs (ranges from 0 to 380 feet below land surface). New wells at alternative locations were assumed constructed uniformly with well perforations starting at a depth of 220 feet below land surface.

Length of Well Perforations: variable and based on well construction logs (ranges from 200 to 415 feet). New wells were assumed constructed uniformly with a perforation length of 300 feet.

Well Field Pumping Rate: 267,360 cubic feet per day (2.0 MGD), distributed evenly among eight extraction wells (33,420 cubic feet per day per well, which corresponds to a pumping rate of 0.25 MGD per well).

[21] Environmental Simulations, Inc., 2003, "Aquifer^{Win32} – WinFlow – WinTran Version 3".
[22] Otto D.L. Strack, 1988, "Groundwater Mechanics", Prentice Hall Englewood Cliffs.

Distributed (New) Wells

Potential Well Locations and Scenario Description

Representative sites for potential new wells were identified following a consideration of land availability (i.e., open and undeveloped land areas), mapped surficial geology and depth to bedrock, proximity to potential geologic barriers to groundwater movement (i.e., the Serra Fault), existing production wells, and reconnaissance level search for active soil and groundwater contamination sites[23]. Open and undeveloped land areas were initially identified using 2003 aerial photographs, and confirmed by a field reconnaissance conducted in November 2005. Based on the above criteria, our efforts identified 16 potential sites shown on Figure 12. These sites are considered a representative sampling of potential well sites; our search was not comprehensive, and additional suitable areas may exist within Cal Water's service area. Additionally, we did not confirm site accessibility by way of land purchases or easements.

Northerly Area

The representative potential new well sites in the northerly portion of Cal Water's service area are plotted on Figure 13. A detailed description of each site is provided below.

Site 1 is located along South Park Plaza Drive and includes about 10 acres of land at the Franklin and Garden Village Schools. At this location, surficial deposits consist of Pleistocene sand and gravel (Colma Formation) and bedrock is mapped at about 750 feet below land surface. The site is located about 1,000 feet east of the Daly City Westlake well, and less than 2,500 feet west of three additional existing Daly City production wells (DC-4, Vale, and Jefferson). In April 2000, water quality data from these Daly City wells indicated the TDS values ranged from 240 to 324 mg/L, nitrate concentrations ranged for 12 to 42 mg/L, and iron and manganese concentrations were non-detects (San Mateo County Health Services Agency, "Results of the 2000 Water Quality Analysis at Selected Wells in the Westside Groundwater Basin", April 2001). The Serra Fault, which impedes groundwater movement and reduces potential well productivity, is mapped about 750 feet southwest of Site 1.

Site 2 is located on Eastmoor Avenue and includes about 18 acres of land at the Brown School. Most, if not all, of the area appears to be located adjacent to but outside of the Cal Water service area. At this location, surficial deposits consist of mostly Pleistocene sand and gravel (Colma Formation) and a small area of

[23] Our soil and groundwater contamination site search is not considered exhaustive, and other sites may exist in Cal Water's Service Area.

Pliocene and/or Quaternary sandstone (Merced Formation). Bedrock is mapped at about 1,400 feet below land surface. The site is located less than 2,500 feet from three existing Daly City production wells (DC-4, Vale, and Jefferson), and maps show the Serra Fault is mapped beneath the western site boundary.

Site 3 is located on the south side of Colma Road and east of Junipero Serra Boulevard. The site is about 6 acres in size and south of a shopping center. Part of the site is currently being used as a flower/vegetable garden. A monument centrally located on the site suggests that at least part of the site is a former cemetery. At this location, surficial deposits consist of Pleistocene sand and gravel (Colma Formation), and bedrock is mapped approximately 1,200 feet below land surface. Irrigation wells for four cemeteries (Woodlawn Cemetery, Italian Cemetery, Eternal Home Cemetery, and Olivet Cemetery) are located about 1,200 to 1,800 feet to the northeast. The Serra Fault is mapped about 1,000 feet southwest of the site.

Site 4 is about 4 acres in size and located near the intersection of El Camino Real and F-Street. An access road passing through the site suggests that it may be owned by the Italian Cemetery. At this location, surficial deposits consist of Pleistocene sand and gravel (Colma Formation), and bedrock is mapped approximately 900 feet below land surface. Irrigation wells for four cemeteries (Woodlawn Cemetery, Italian Cemetery, Eternal Home Cemetery, and Olivet Cemetery) are located within 1,000 feet of the site. The Serra Fault is mapped about 3,000 feet southwest of the site.

Site 5 is about 3 acres in size and located on the west side of Hillsdale Boulevard near Olivet Parkway. The site is possibly owned by Salem Memorial Park. At this location, surficial deposits consist of Pleistocene sand and gravel (Colma Formation), and bedrock is mapped about 800 feet below land surface. The nearest existing production well is located about 800 feet to the south at the Home of Peace Cemetery. In April 2000, water quality data from the Home of Peace Cemetery well indicated the TDS concentrations were 522 mg/L, the nitrate concentration was 85 mg/L, the iron concentration was 0.06 mg/L, and the manganese concentration was non-detect (San Mateo County Health Services Agency, “Results of the 2000 Water Quality Analysis at Selected Wells in the Westside Groundwater Basin”, April 2001). The nitrate concentration exceeds the Federal EPA Maximum Contaminant Level. The Serra Fault is mapped over 4,500 feet southwest of the site. Bedrock beneath this site rises steeply to the east, which may affect potential well yield.

Southerly Area

The representative potential new well sites in the southerly portion of Cal Water’s service area are plotted on Figure 14. A detailed description of each site is provided below.

Site 6 is at El Camino High School. It is a 26-acre area located near Mission Road and Evergreen Road. At this location, surficial deposits consist of Pleistocene sand and gravel (Colma Formation), and bedrock is mapped at about 450 to 800 feet below land surface. The existing Cal Water well field is located about 3,500 feet to the southeast, and the existing well at Holy Cross Cemetery is located about 2,800 feet to the northwest. The Serra Fault is mapped about 4,700 feet to the southwest. Bedrock rises steeply to the east, which may affect potential well yield. The nearest active contamination site (as of October 2004) is a San Mateo County LOP site mapped about 1,400 feet to the west. The County data base does not identify the constituent(s) of concern. In April 2000, water quality data from the Holy Cross Cemetery well indicated TDS concentrations were 354 mg/L, the nitrate concentration was 41 mg/L, and the iron and manganese concentrations were non-detect (San Mateo County Health Services Agency, "Results of the 2000 Water Quality Analysis at Selected Wells in the Westside Groundwater Basin", April 2001).

Site 7 is about 0.7 acres for sale located at the corner of Mission Road and McClellan Drive. In November 2005, the site was used for temporary construction storage. At this location, surficial deposits consist of Pleistocene sand and gravel (Colma Formation) and bedrock is mapped about 800 feet below land surface. The existing Cal Water well field is located about 4,200 feet to the southeast. The Serra Fault is mapped 4,200 feet to the southwest. The nearest active contamination site (as of October 2004) is a San Mateo County LOP site mapped about 1,000 feet to the west. The County data base does not identify the constituent(s) of concern.

Site 8 is about 1.3 acres for sale located on the north side of Mission Road. The site appears to have been used previously to grow flowers and vegetables, but currently (November 2005) is unused. At this location, surficial deposits consist of Pleistocene sand and gravel (Colma Formation), and bedrock is mapped 800 feet below land surface. The existing Cal Water well field is located about 3,000 feet to the southeast. The Serra Fault is mapped about 5,000 feet to the southwest. The nearest active contamination site (as of October 2004) is a San Mateo County LOP site mapped about 1,600 feet to the southeast. The County data base does not identify the constituent(s) of concern.

Site 9 is about 0.7 acres of vacant land located at the corner of Mission Road and Sequoia Avenue. At this location, surficial deposits consist of Pleistocene sand and gravel (Colma Formation), and bedrock is mapped about 800 feet below land surface. The existing Cal Water well field is located about 2,200 feet to the southeast. The Serra Fault is mapped about 5,100 feet to the southwest. The nearest active contamination site (as of October 2004) is a San Mateo County LOP site mapped about 1,000 feet to the southeast. The County data base does not identify the constituent(s) of concern.

Site 10 is about 5 acres of undeveloped land located between Mission Boulevard and Colma Creek. At this location, surficial deposits consist of Holocene sand, gravel, silt, and mud; well boring information suggests a general thickening of fine-grained deposits. Bedrock is mapped about 750 feet below land surface. The existing Cal Water well field is located about 600 feet to the southeast, and the existing well at the California Golf and Country Club is located about 2,200 feet to the southwest. The Serra Fault is mapped about 5,000 feet to the southwest. San Mateo County LOP shows contamination at the site (as of October 2004), but does not identify the constituent(s) of concern.

Site 11 is at the Sunshine School. It is a 14-acre site located near the intersection of Miller and Holly Avenues. At this location, surficial deposits consist of Pleistocene sand and gravel (Colma Formation), and bedrock is mapped about 500 feet below land surface. The existing Cal Water well field is located about 4,000 feet to the south. The Serra Fault is mapped about 6,300 feet to the southwest. Bedrock rises steeply to the east, which may affect potential well yield. The nearest active contamination site (as of October 2004) is a San Mateo County LOP site mapped about 1,400 feet to the south. The County data base does not identify the constituent(s) of concern.

Site 12 is at the Alta Loma School. It is a 23-acre area located near El Camino Real and McClellan Drive. At this location, surficial deposits consist of Pleistocene sand and gravel (Colma Formation), and bedrock is mapped about 900 feet below land surface. The existing Cal Water well field is located about 4,000 feet to the southeast, and the existing well at Holy Cross Cemetery is located about 2,800 feet to the north. The Serra Fault is mapped about 2,200 feet to the southwest. The nearest active contamination site (as of October 2004) is a San Mateo County LOP site mapped about 500 feet to the north. The County data base does not identify the constituent(s) of concern.

Site 13 is at the Burl Burl School. It is about 9 acres located near the intersection of El Campo Drive and Del Monte Avenue. At this location, surficial deposits consist of Pleistocene sand and gravel (Colma Formation), and bedrock is mapped about 950 feet below land surface. The existing Cal Water well field is located about 3,000 feet to the east, and the existing California Golf and County Club well is located about 1,500 feet to the southeast. The Serra Fault is mapped 2,200 feet southwest of the site. There are 2 active (as of October 2004) San Mateo County LOP sites 3,000 feet east of the site. The County data base does not identify the constituents of concern.

Site 14 is Orange Memorial Park, which is located on Orange Avenue and is about 25 acres in size. At this location, surficial deposits consist of Holocene sand, gravel, silt, and mud; well boring information suggests a general thickening of fine-grained deposits. Bedrock is mapped about 550 to 650 feet below land

surface. The existing Cal Water well field is located about 600 feet to the northwest, and the existing well at the California Golf and Country Club is about 3,200 feet to the west. The Serra Fault is mapped over a mile to the southwest. There is an active (as of October 2004) MTBE contamination site adjacent to the north edge of the site. There are also additional active contamination sites near and west of the site. About 1,000 feet to the southwest, there are active (as of October 2004) San Mateo County LOP (oil) and MTBE sites.

Site 15 is about 9 acres located at the Ponderosa School near El Camino Real. At this location, surficial deposits consist of Pleistocene sand and gravel (Colma Formation); well boring information suggests a general thickening of fine-grained deposits. Bedrock is mapped about 700 feet below land surface. The existing Cal Water well field is about 3,000 feet to the north, and the existing well at the California Golf and Country Club is about 3,000 feet to the northwest. The Serra Fault is mapped 3,000 feet to the southwest. Within 1,500 feet to the northwest, there is active (as of October 2004) San Mateo County LOP (oil) and MTBE sites.

Site 16 is about 24 acres located at South San Francisco High School on El Camino Real. At this location, surficial deposits consist of Pleistocene sand and gravel (Colma Formation); well boring information suggests a general thickening of fine-grained deposits. Bedrock is mapped about 700 feet below land surface. The existing Cal Water well field is located about 3,000 feet to the north. The Serra Fault is mapped 4,700 feet to the southwest. Several active contamination sites exist within about 1,500 feet of the site. Within 1,300 feet to the north, there is active (as of October 2004) San Mateo County LOP (oil) and MTBE sites. Within 1,500 ft south of the site, there are three active (as of October 2004) San Mateo County LOP and MTBE sites. The substances of concern are gasoline and diesel.

Scenario Description

The Distributed Well Scenarios we analyzed utilized an example network of new wells distributed throughout the southerly portion of the Cal Water Service Area. The well network could conceivably replace Cal Water's existing South San Francisco well field. It was assumed the number, capacity, and use of extraction wells remains the same, and only the locations change. The locations were selected based on the following general criteria.

- New well locations selected to maximize the saturated thickness of the water-bearing zone (estimated from the simulated 2003 water table elevation and reported depth to bedrock).

- Located new wells in public and/or open spaces (i.e., schools, green belts, and parks).

- New wells were located east of the Serra Fault, and in areas underlain by surficial Colma Formation (or younger) alluvial deposits.

- Locations selected to minimize their proximity to shallow groundwater contamination site locations which are shown on Figure 15.

Figure 16 shows the assumed well locations employed in our Distributed Wells Scenarios. The example well network is comprised of nine wells corresponding to potential well sites 6, 8, 11, 12, 13, 14, 15 and 16. The new wells are underlain by at least 200 feet of saturated alluvial deposits, located in public open space land use areas, and up-gradient to the industrialized zone where most soil and groundwater contamination sites are located.

Distributed Wells – Present Day Use

During 1998-2002, the six Cal Water wells actively pumped at an average annual rate of about 200 acre-feet per well per year (203 acre-feet per well per year). Our Distributed Well – Present Day Use Scenario therefore utilized only six of the nine potential wells; all six wells operated at the same pumping rate (203 acre-feet per year, or about 125 gpm).

Distributed Wells – Increased Supply

The Distributed Wells – Increased Supply Scenario assesses Cal Water's potential use of new wells to meet the following demands:

i. Groundwater extraction to maintain 13-percent of future total average supply.
ii. Groundwater extraction equal to 20-percent of future total average supply.
iii. Groundwater extraction equal to 26-percent of future total average supply.

The Distributed Wells – Increased Supply Scenario is identical to the Existing Well Field – Increased Supply Scenario except it utilizes the new wells rather than Cal Water's existing well field. Hence, the allocation between surface water and groundwater is identical to Table 4.

To meet increased demands for groundwater, the new wells are used as needed until all nine wells operated. Further increases in groundwater pumping were simulated by uniformly increasing the individual pumping rate of each well.

Table 8 lists total groundwater use, number of active extraction wells, and per well annual extraction rate.

Table 8. Well Activity Assumptions for the Distributed Well Scenario.

Percentage of Year 2030 Total Demand	*Groundwater Use (acre-feet per year)*	*Number of Active Wells*	*Annual Per Well Extraction Rate (acre-feet per year)*
Current Conditions	1,220	6	203
13%	1,600	8	200
20%	2,460	9	273
26%	3,190	9	354

Table 9 shows the average monthly fraction of groundwater use simulated at each active well.

Table 9. Assumed Monthly Fraction of Annual Groundwater Use.

Month	*Fraction of Annual Water Use*
October	0.057
November	0.062
December	0.077
January	0.107
February	0.098
March	0.106
April	0.097
May	0.061
June	0.079
July	0.088
August	0.092
September	0.077

Distributed Wells – In Lieu Conjunctive Use

The Distributed Wells – In Lieu Conjunctive Use Scenario is a continuation of the conjunctive use pilot project (or in-lieu recharge pilot project), but utilizes the new distributed wells rather than Cal Waters' existing well field. Six new wells were used operating at average present-day pumping rates. The Distributed Wells – In Lieu Conjunctive Use Scenario is therefore identical to the Existing Well Field

– In Lieu Conjunctive Use Scenario except it utilizes the new wells rather than Cal Water's existing well field.

Distributed Wells – Recycled Water

The Distributed Wells – Recycled Water Scenario implements recycled water projects in the Cal Water Service Area. It was assumed irrigators utilize recycled water at 50-percent of their consumptive use requirement. The Distributed Wells – Recycled Water Scenario is identical to the Existing Well Field – Recycled Water Scenario except it utilizes six new wells rather than Cal Water's existing well field. This scenario distributes pumping equally between the six wells.

Distributed Wells – Aquifer Storage and Recovery

The Aquifer Storage and Recovery (ASR) Project Scenario simulates conditions where Cal Water utilizes dual injection and extraction wells. The project employs the network of new wells which are designed for injection and extraction operations[24]. In general, the ASR Project Scenario is a continuation of the In Lieu project, with the exception that Cal Water injects additional surface water into the aquifer during periods of supplemental surface water deliveries. Like the In Lieu Scenario, groundwater extraction rates are increased during periods of reduced surface water supply. Table 10 lists the assumptions for this scenario.

Table 10. Municipal Water Use and Water Year Types, in acre-feet per year.

Participant	***Total Water***[a] (Dry, Below Normal, Above Normal, and Wet Years)	***Groundwater***			
		No Action	*San Joaquin Valley Water Year Hydrologic Classification Index*		
			Critical (drought)	Below Normal and Dry	Above Normal and Wet
City of San Francisco	18,550	0	0	0	0
City of Daly City	7,540	3,780	5,130	3,970	380[b]
South San Francisco (Cal Water)	7,470	1,220	5,080	1,220	-3200[c]
City of San Bruno	5,130	2,010	3,490	2,010	0

a: During drought water years, we assumed a 15-percent reduction in total water supply as a result of conservation. For example, annual total water use by Daly City during non-drought years (Dry, Below Normal, Above Normal, and Wet runoff years) is 7,540 acre-feet. In drought water years (Critical runoff years), we assumed total water use in Daly City decreases to 6,410 acre-feet (1,280 acre-feet surface water and 5,130 acre-feet groundwater).
b: Due to constraints in their delivery system, Daly City cannot utilize 100-percent surface water, and must continue to pump from their Vale well even during Normal and Wet runoff years.

[24] We did not consider surface water supply lines when locating the example wells. Conceivably, injection/extraction wells are best located where surface water supplies are easily diverted under aquifer storage operations, and where groundwater produced during recovery operations is easily introduced into the water delivery system. Minor deviations in well locations that could occur as of result of these considerations should have a negligible effect on model results.

c: The negative sign indicates water is injected beneath the subsurface. We assumed this water is spatially distributed evenly between active wells, and temporally distributed evenly during the year. For example, a network of six wells would employ an annual injection rate of 533 acre-feet per year (1/6 of the total annual injection rate), distributed evenly throughout the year at a rate of 44.4 acre-feet per month (1/12 of the annual injection rate at each well).

SIMULATION RESULTS FOR ALL SCENARIOS

Table 11 shows each component of the simulated volumetric budgets[25]. The last column in Table 11 is the net change in groundwater storage. This net change in groundwater storage reflects potential impacts on groundwater levels, i.e., groundwater levels decrease with annual declines in groundwater storage (negative values) and water levels rise with annual groundwater storage increases (positive values).

Utilizing the existing well field, storage volumes decrease within the Cal Water Service Area under the No-Action and Increased Supply scenarios (Scenarios 2 through 5). Under the No Action Scenario (continuation of average 1998-2002 municipal water use conditions), Table 10 shows an average annual decrease in groundwater storage of -470 acre-feet per year. Larger annual declines in groundwater storage are simulated as the extraction rate increases, up to an annual decline of -1,720 acre-feet per year under Scenario 5 (Existing Well Field utilized to meet 26% of 2030 supply).

[25] The maximum simulated monthly volumetric budget errors in all simulations ranged from -4 to 8-percent, and averaged from 0- to 1-percent.

Table 11. Simulated Volumetric Groundwater Budget for Cal Water Service Area.

Scenario		***Water Budget Component*** **(in acre-feet per year)**				
		Recharge	**Net Groundwater Flow** (inflow – outflow)	**Wells**		**Annual Storage Change**
No.	Description			Cal Water	Others	
Existing Well Field						
1	*Historical*	+1,980	+1,810	-1,380	-3,160	-750
2	*No Action*	+1,950	+1,720	-1,220	-2,920	-470
	Increased Supply (2030) from Groundwater					
3	13%	+1,970	+1,870	-1,600	-2,920	-680
4	20%	+1,970	+2,150	-2,450	-2,920	-1,250
5	26%	+1,970	+2,420	-3,190	-2,920	-1,720
6	*In Lieu*	+1,950	+2,220	-1,570	-2,640	-40
	Recycled Water					
7	50%	+1,950	+1,370	-1,220	-2,160	-60
8	100%	+1,950	+1,010	-1,220	-1,390	+350
Distributed Network of New Wells						
9	*Present Day*	+1,950	+1,710	-1,220	-2,920	-480
	Increased Supply (2030) from Groundwater					
10	13%	+1,970	+1,860	-1,600	-2,920	-690
11	20%	+1,970	+2,180	-2,450	-2,920	-1,220
12	26%	+1,970	+2,450	-3,190	-2,920	-1,690
13	*In Lieu*	+1,950	+2,250	-1,570	-2,640	-10
	Recycled Water					
14	50%	+1,950	+1,370	-1,220	-2160	-60
	Aquifer Storage and Recovery					
15	Present Day	+3,510	+1,600	-1,570	-2,640	+900
16	26% Supply	+3,520	+2,160	-2,880	-2,640	+160

In the Cal Water Service Area, extraction increases are supplied primarily by groundwater storage. For example, in order to meet 13-percent of the 2030 water demand (Scenario 3), the annual extraction rate must increase 380 acre-feet per year relative to the No-Action Scenario. The simulated annual decline in groundwater storage increases from -470 acre-feet per year (Scenario 1) to -680 acre-feet per year (Scenario 3) – an additional decrease of -210 acre-feet per year, or 55-percent of the pumping increase. The remaining water extracted is derived mostly from increased groundwater inflow into the Cal Water Service area (a net increase in groundwater inflow of 150 acre-feet per year, or about 40-percent of the pumping increase), and increased recharge attributed to increased water use (20 acre-feet per year, or 5-percent of the pumping increase).

Negative changes in groundwater storage correspond to declining groundwater levels. Figure 17 shows simulated groundwater levels in wells 17 and 19, which decrease almost 100 feet under Scenario 1 (No-Action). Further declines in

groundwater levels continue under the increased supply scenarios - up to almost 200 feet under Scenario 5 (the highest simulated pumping rate).

The decline in groundwater storage creates a depression in simulated groundwater levels that increases in depth and area with increasing extraction rate. Figure 18 shows the depression expanding to the northwest and southeast as the pumping rate increases. The lowering of groundwater levels can create greater pumping lifts for municipal wells (Cal Water and Daly City) and private irrigation wells (cemeteries and golf courses). It also increases the potential for saltwater intrusion from South San Francisco Bay, but intrusion may be limited by shallow bedrock areas located between the Bay and inland Cal Water Service Area pumping wells.

Declining groundwater levels and storage can be curtailed by increasing recharge or decreasing pumping, thereby improving the long-term sustainability of the resource. For example, the in-lieu recharge program reduces the annual decline in groundwater storage from -470 acre-feet per year in the No Action Scenario to -40 acre-feet per year (a net storage benefit of +430 acre-feet per year). The in-lieu recharge program substantially curtailed the annual decline in groundwater storage and water levels, as shown on Figure 19.

Another option for improving long-term sustainability is replacing groundwater use with recycled water. The irrigation demand by large turf areas in cemeteries and golf courses is substantial, and represented 34-percent of historical groundwater extraction within the Cal Water Service Area. A recycled water program, which switches irrigators from groundwater to recycled water, can substantially decrease groundwater consumption. For example, Scenario 7 simulated a 50-percent reduction in irrigation pumpage by switching from groundwater to recycled water. The annual decline in groundwater storage decreases from -470 acre-feet per year (No Action) to -60 acre-feet per year in Scenario 7 (a net storage benefit of +410 acre-feet per year). Increasing recycled water use from 50- to 100-percent (Scenario 8) resulted in a net increase in groundwater storage, whereby the annual change in groundwater storage increased from -470 acre-feet per year (No Action) to + 350 acre-feet per year (a net storage benefit of 820 acre-feet per year). As a result, water levels in Cal Water Service wells increased about 20 feet during the 45-year simulation period, as shown on Figure 19.

The groundwater storage benefit from combined projects can be estimated using the results reported in Table 11. For example, the net benefit from the In-Lieu Scenario (Scenario 6) relative to the No-Action Scenario (Scenario 2) is a +430 acre-feet per year savings in groundwater storage. Similarly, the net benefit from the 50-percent Recycled Water Scenario (Scenario 7) relative to the No Action Scenario is a +410 acre-feet per year savings in groundwater storage. If both actions were implemented, model results suggest a net savings in groundwater

storage of +840 acre-feet per year. If fully realized, the combined In-Lieu and Recycled Water projects could feasibly provide for an increase in Cal Water pumpage from 1,220 to 2,410 acre-feet per year (20-percent of the projected 2030 demand).

Another option for improving long-term sustainability is to increase conjunctive use efforts with an aquifer storage and recovery project. Scenario 15 simulated increased recharge using a distributed network of groundwater extraction and injection wells. Injecting 3,200 acre-feet per year during Above Normal and Wet runoff years (a total of 73,600 acre-feet during the 45-year simulation period) resulted in a net accretion in groundwater storage[26]. The annual change in groundwater storage increases from -470 acre-feet per year (No Action) to +900 acre-feet per year (Scenario 15) – a net annual benefit of 1,370 acre-feet per year. If this water was fully utilized by Cal Water, their annual pumping rate could increase from 1,220 to 2,940 acre-feet per year (24-percent of the projected 2030 demand).

INTERFERENCES BETWEEN EXISTING AND ALTERNATIVE WELL FIELD LOCATIONS

Figure 20 shows the calculated difference in simulated long-term (steady-state) drawdown between the present-day well field and possible alternative well sites. In general, the cone of depression beneath the alternative wells deepens and moves slightly south from its present location beneath the existing well field. Additionally, the maximum simulated drawdown (not shown in Figure 5) increases from 20 feet beneath the existing well field to 30 feet beneath the alternative well sites (a net increase in maximum simulated drawdown of 10 feet). The net increase in maximum simulated drawdown (10 feet) indicates a greater cumulative well interference effect, but the impact is considered modest and represents only 2-percent of the assumed saturated thickness of the aquifer (475 feet).

Well driller reports and water-level recovery data indicate Cal Water's wells extract water from semi-confined aquifers. Under these hydrogeologic conditions, well depth, aquifer hydraulic conductivity, and well extraction rates

[26] The ASR scenarios assume surface water is supplied by the Hetch-Hetchy system, and therefore the timing and quantities of supplemental surface water deliveries must be confirmed with the San Francisco Public Utilities Commission (SFPUC). This confirmation step would be completed during the design and planning phases prior to implementation of an ASR project, which is beyond the scope of this study. Additional geotechnical data and analysis would also be required to confirm the assumed ASR well locations and injection rates.
The assumptions employed in Scenarios 15 and 16 are considered reasonable for this planning level analysis because (1) The pilot In-Lieu project demonstrates SFPUC's interest in developing Westside Basin conjunctive use projects, and (2) the 3,200 acre-feet per year of supplemental surface water assumed available for injection represents a modest 16-percent increase above the water potentially available to the on-going pilot In-Lieu conjunctive use project.

are potentially more important to consider for optimizing well yield than hydraulic interferences between neighboring wells. Indeed, the consideration of well interferences is often impractical in confined and semi-confined aquifers because the cones of depression can extend great distances relative to the distances between existing Cal Water wells. Implications for the selection of potential future alternative well field sites can be summarized as follows.

- The area considered, whether it pertains to existing wells or potential future alternative well locations, is fairly small relative to the expected cones of depression produced by pumping from the underlying semi-confined aquifers.

- Future well locations should be selected to maximize distances from existing wells. A maximum distance of about 2,500 feet can be achieved between existing wells and potential alternative sites at the land parcels being considered. A minimum distance of 500 feet between new and existing wells is recommended; the distances between present-day Cal Water wells ranges from 200 to 2,500 feet.

- We are not aware of conflicts between existing land uses and the alternative well locations considered. For example, the nearest private production well is at the California Golf and Country Club, and is located more than 2,400 feet from the nearest present-day Cal Water Service well (SSF 1-18).

- For the assumed aquifer hydraulic conductivity and well field pumping rates we considered, simulated water levels do not fall below the top of the aquifer. Transmissivity therefore does not change, and the relationship between well yield and drawdown should remain constant[27].

- Under unconfined conditions, greater drawdown would be required to maintain Cal Water's extraction rates, and well interferences may have a greater influence on yield.

- Field studies designed to control well rates and measure actual drawdown in nearby non-pumping wells can confirm the relationships identified above, and improve well location and design recommendations for future Cal Water wells.

WATER QUALITY AND SUPPLY CONSIDERATIONS FOR NEW WELLS

Our analysis of water quality data, summarized in Appendix F, suggest negligible water quality improvements from new wells, and the model results summarized

[27] The analysis assumes static regional water levels, and a regional water level decline superimposed on the well field simulation results could result in drawdown beneath the top of the aquifer and conversion to unconfined aquifer conditions. In an unconfined aquifer, the formation within the cone of depression is dewatered during pumping, and the well yield decreases with increased drawdown.

above in Table 11 suggest a negligible water supply benefit from a distributed network of new wells relative to continued use of Cal Water's existing well field.

- Water Quality (Inorganic Constituents): TDS, hardness, iron and manganese problems are characteristic for the Westside Basin, and we expect similar problems in new wells located within Cal Water's Service Area. Nitrate concentrations are probably the result of historical fertilizer use, and therefore high NO3 concentrations most likely occur at other locations within the Cal Water Service Area as well. For example, NO3 concentrations measured in an April 2000 sample from the Home of Peace Cemetery well was 85 mg/L, which exceeds the Federal EPA Maximum Contaminant Level.

- Water Quality (Organic Constituents): Organic compounds may be less likely in groundwater located up-gradient to the industrialized zone. One existing well (18) produces water that exceeds the Federal EPA's Maximum Contaminant Level for PCE. Two different wells (14 and 17) either already exceed the Maximum Contaminant Level for 1,2 DCPA, or are expected to exceed it within the next 5 to 6 years.

- Water Supply (Groundwater Storage): In terms of groundwater storage, model results indicate the net storage change is similar for either new wells or the existing well field. For example, employing a new network of distributed wells to produce 26-percent of the 2030 supply (Scenario 12) results in an annual average decrease in storage of -1,690 acre-feet per year. Pumping at the same rate from Cal Water's existing well field (Scenario 5) results in an annual average decrease in storage of -1,720 acre-feet per year, which is within 30 acre-feet of Scenario 12. The simulated storage changes in these two scenarios agree within 2-percent, which may be insignificant considering the average simulated volumetric budget error of the model results are 1-percent or less.

- Water Supply (Water Levels): The differences in simulated drawdown and expected pumping lifts are insignificant between scenarios that use new or existing wells. The average drawdown in the existing well field for Scenario 5 (63 feet) is only 7 feet deeper than simulated with the new distributed wells for Scenario 12 (70 feet).

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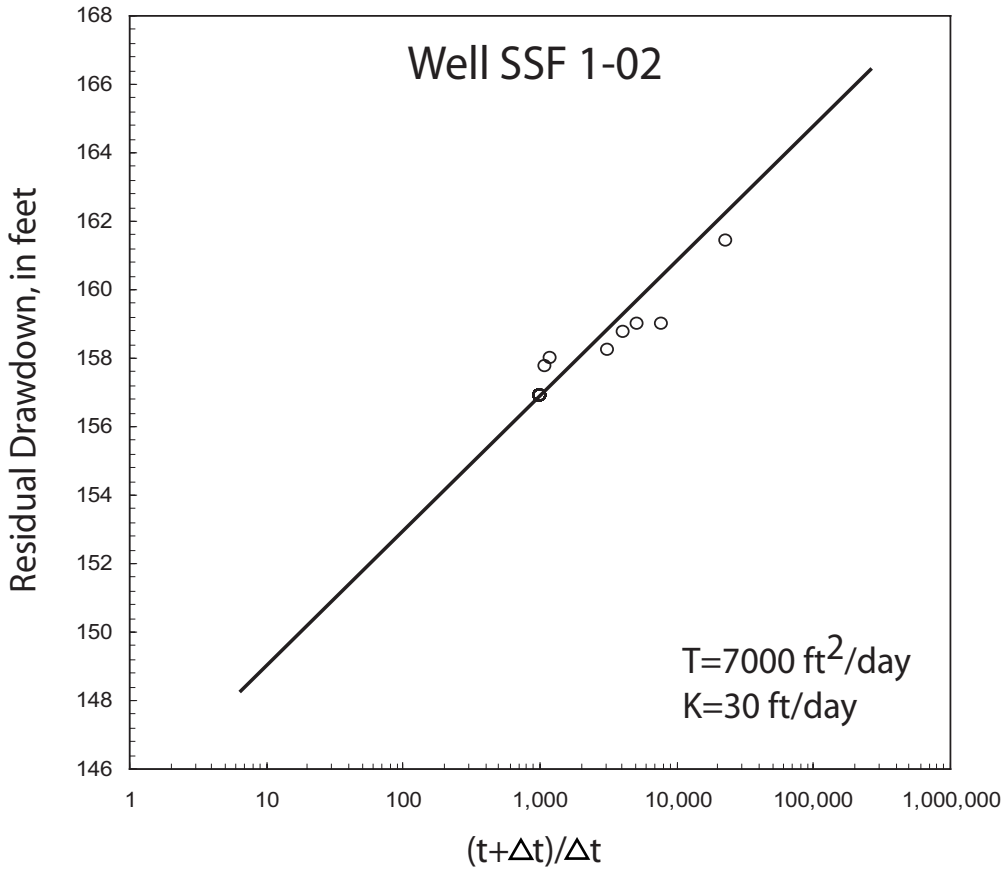

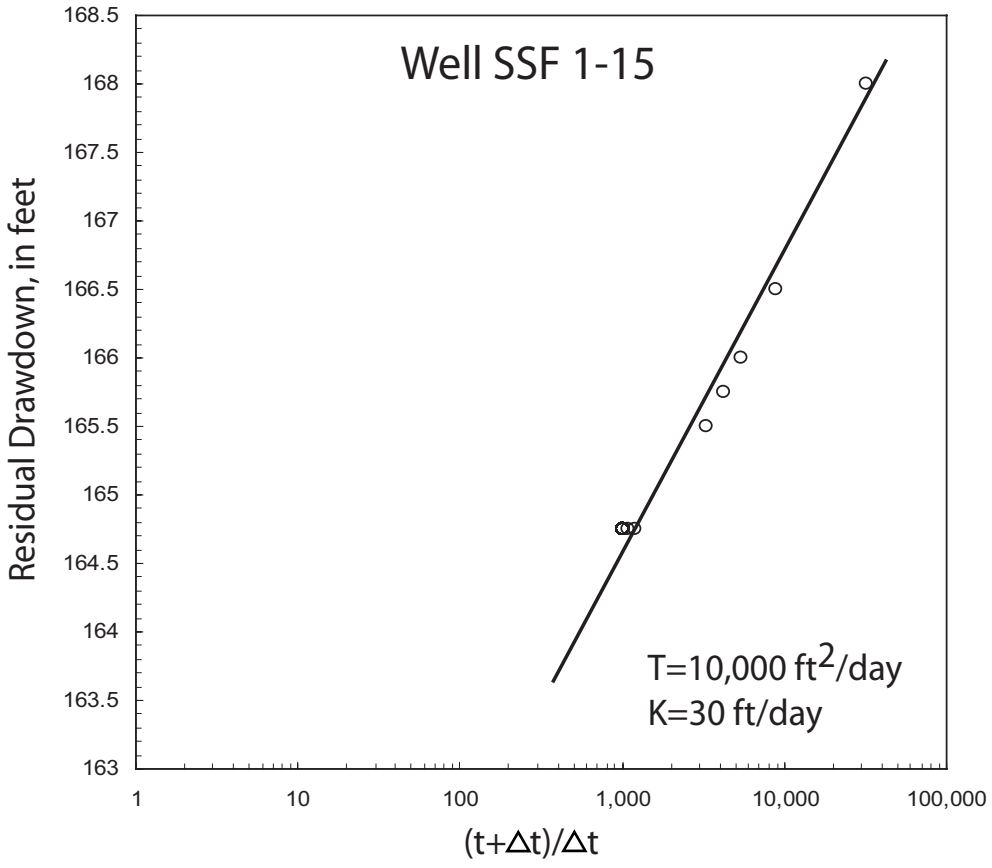

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Cooper-Jacob recovery analyses of single-well aquifer tests.

Figure 1(a)

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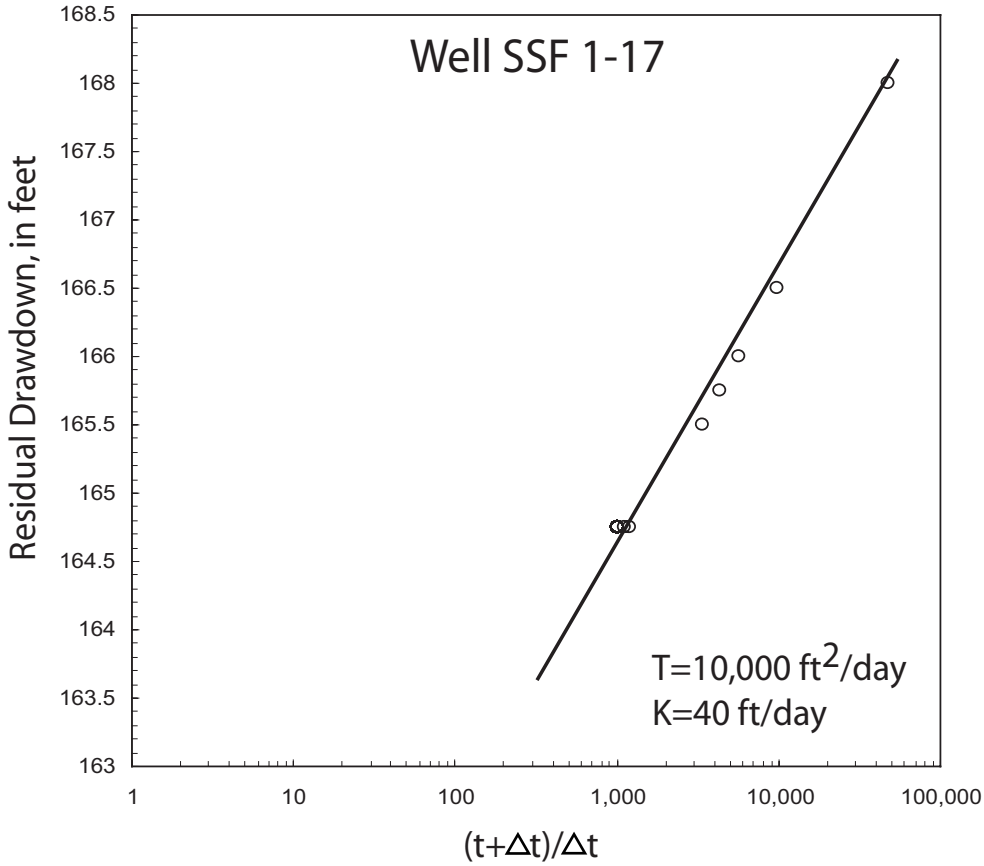

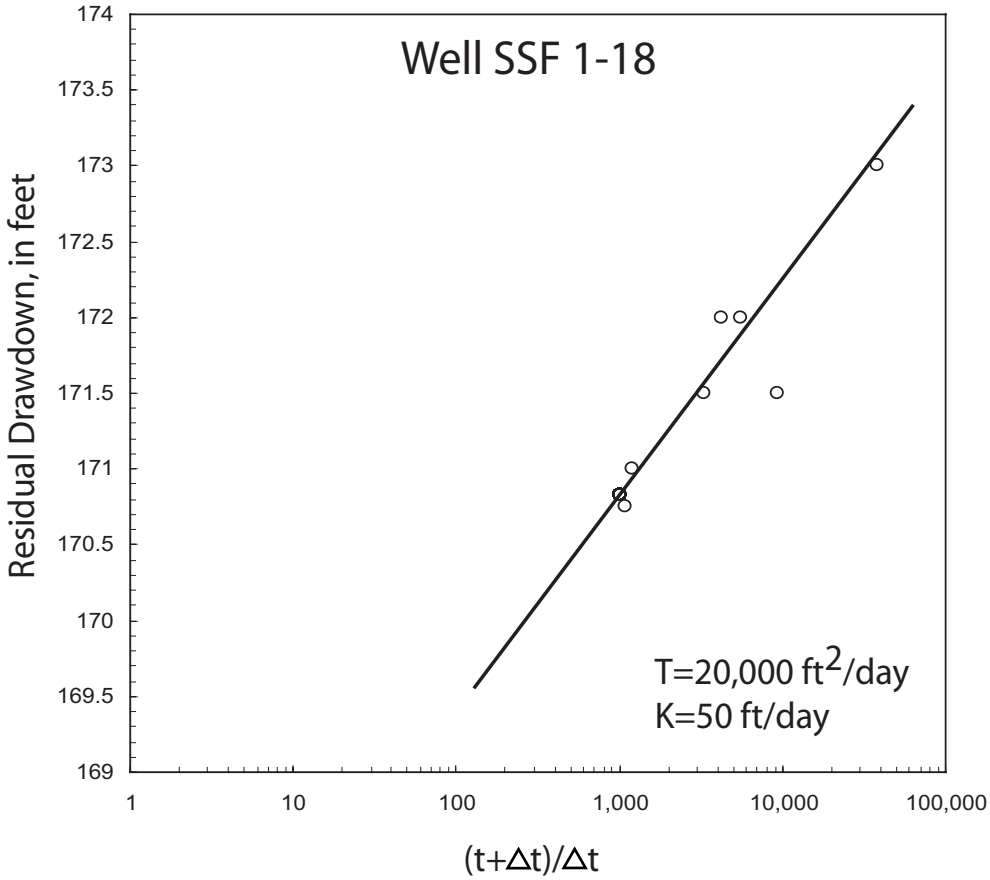

HYDROFOCUS INC.
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Cooper-Jacob recovery analyses of single-well aquifer tests.

Figure 1(b)

PROJECT: 5021

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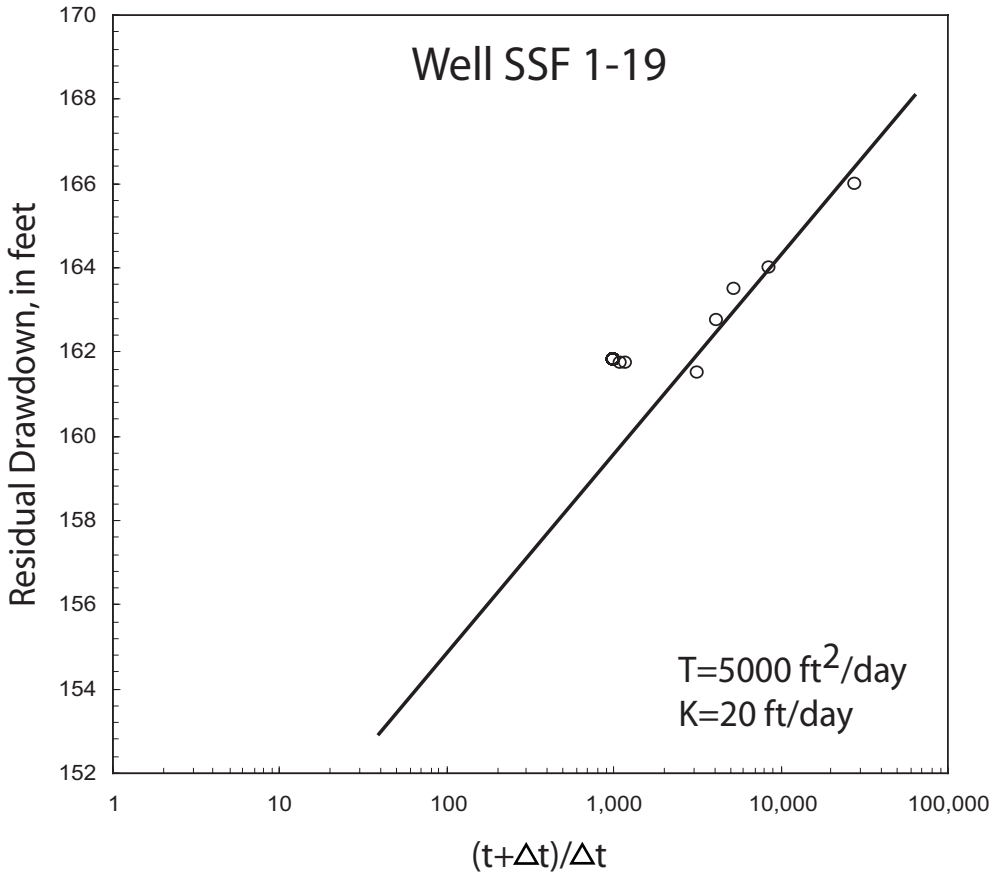

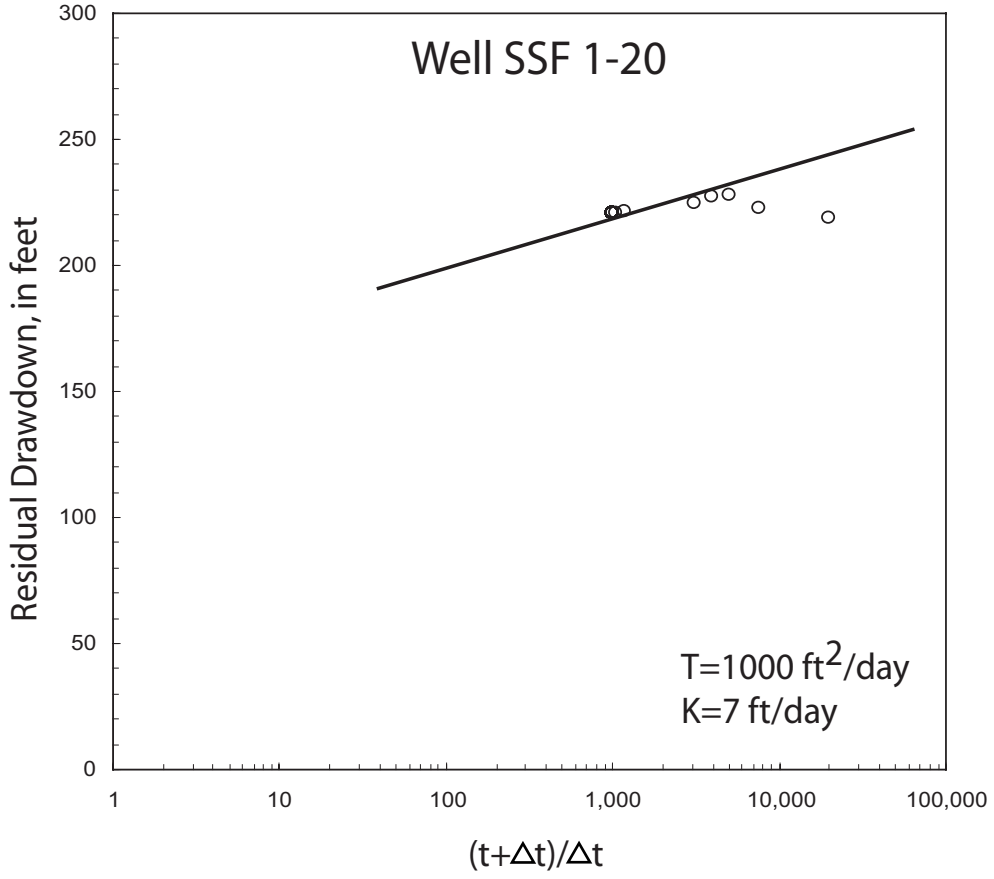

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Cooper-Jacob recovery analyses of single-well aquifer tests.

Figure 1(c)

PROJECT: 5021

DATE: 11/30/05

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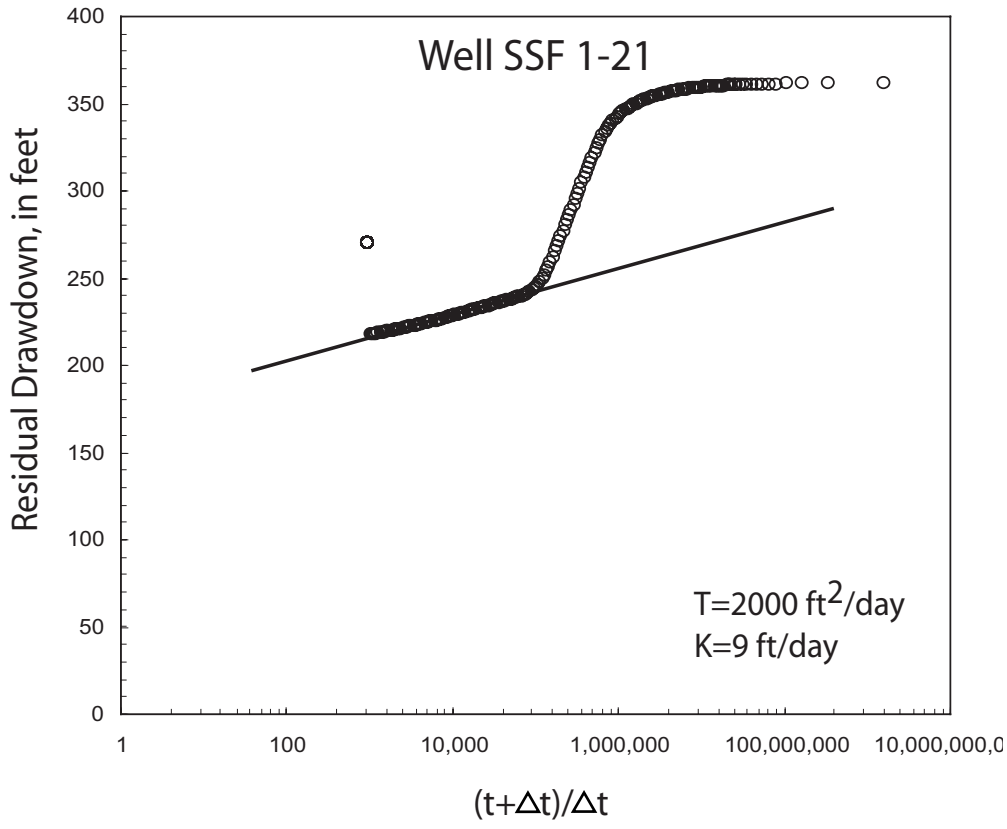

HYDROFOCUS INC.
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Cooper-Jacob recovery analyses of single-well aquifer tests.

Figure 1(d)

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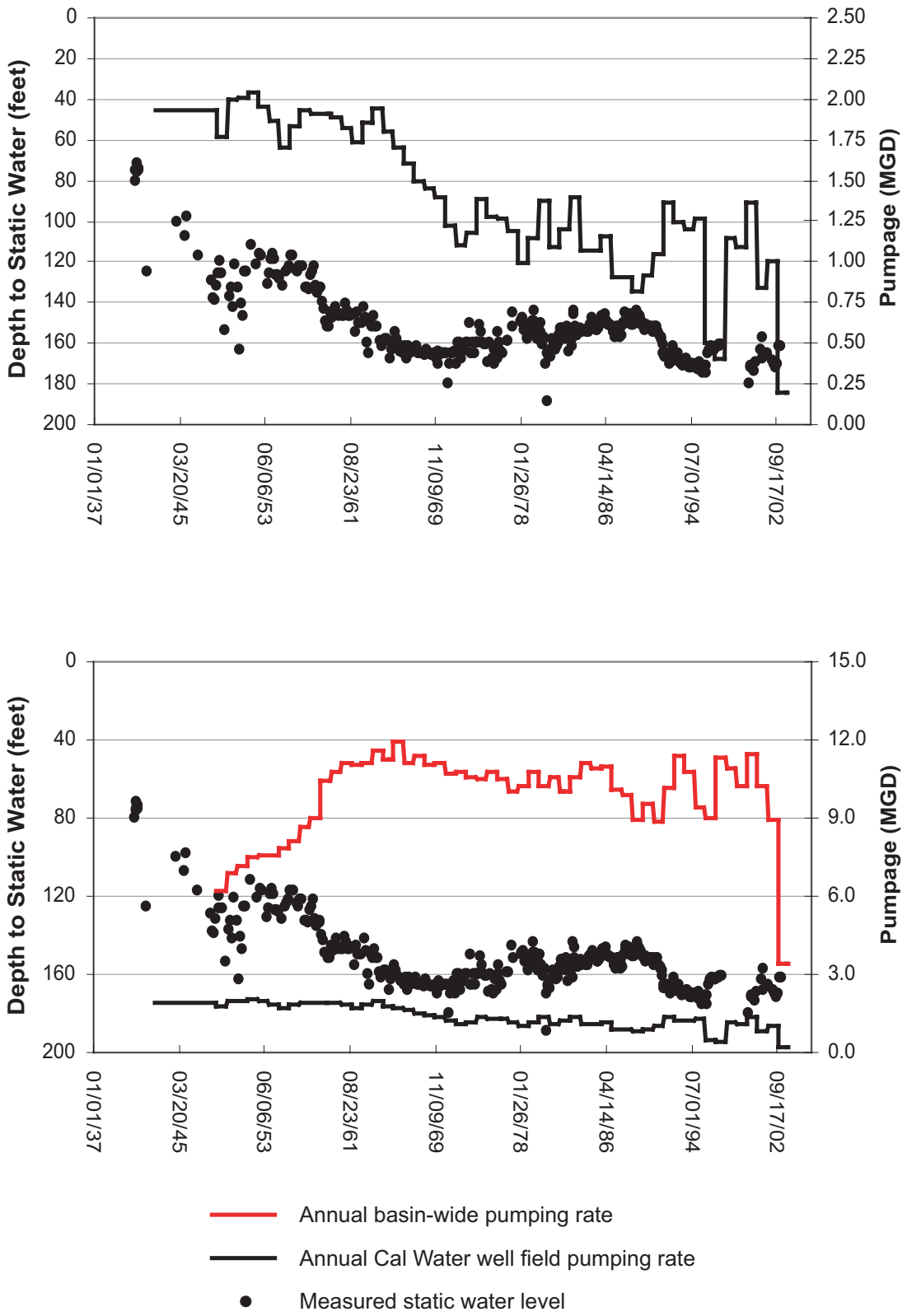
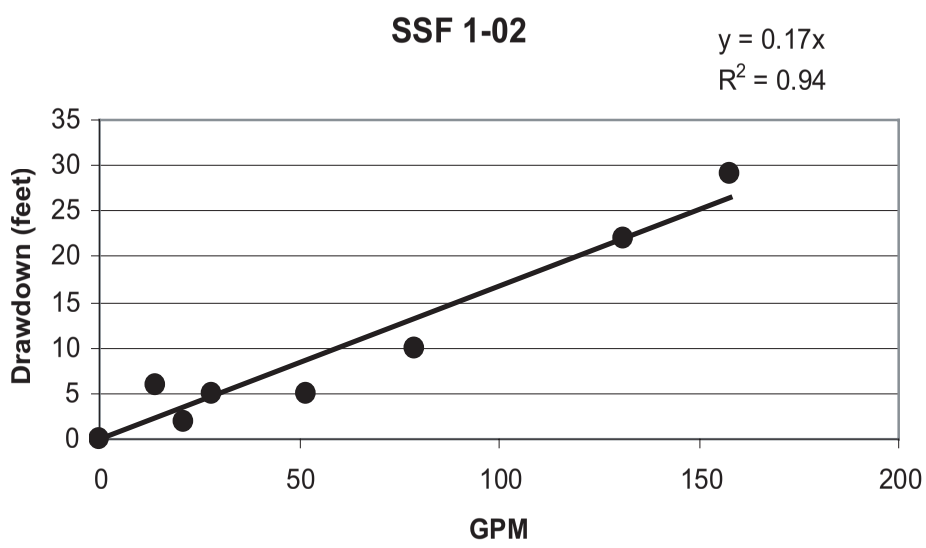
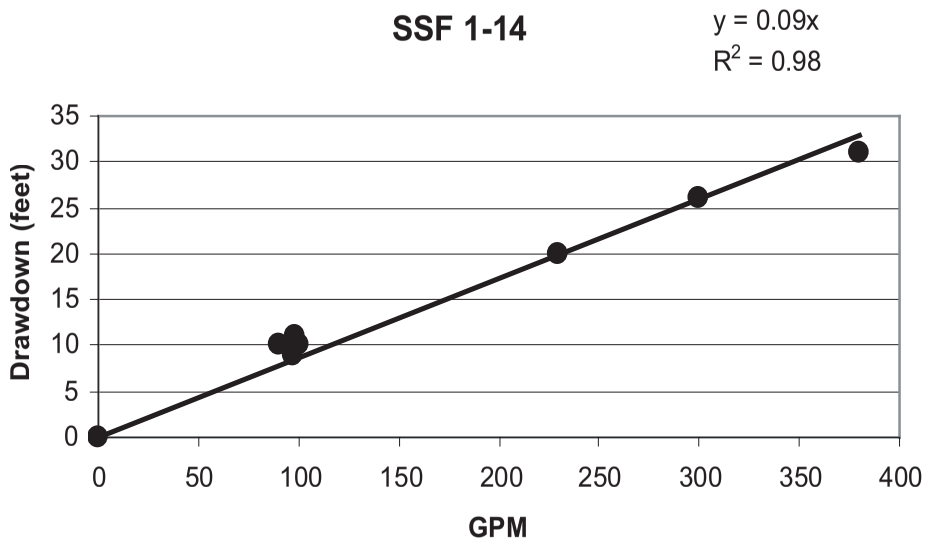
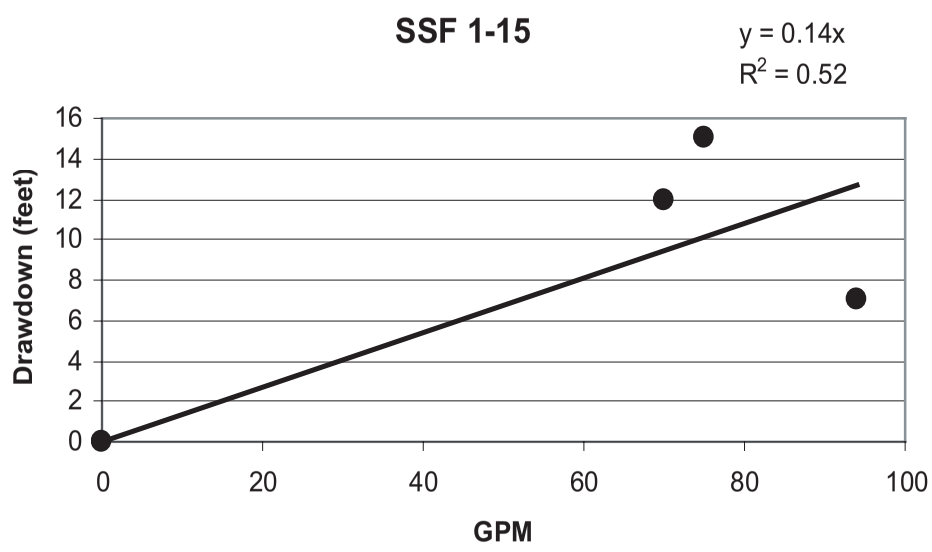
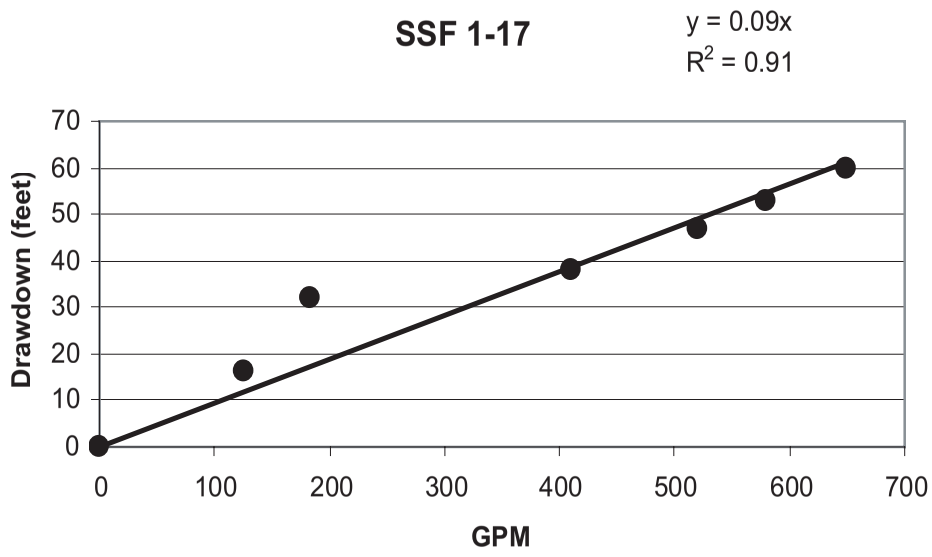


HYDROFOCUS INC. Solutions for Land and Water Resources	Historical water levels in South San Francisco Station 1 well 18 (SSF-18) and annual groundwater extraction rates, 1940-2003.	Figure 2
PROJECT: 5021	DATE: 11/30/05	









HYDROFOCUS INC.
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Observed relationship between water level drawdown and well yield (pumping rate).

Figure 3(a)

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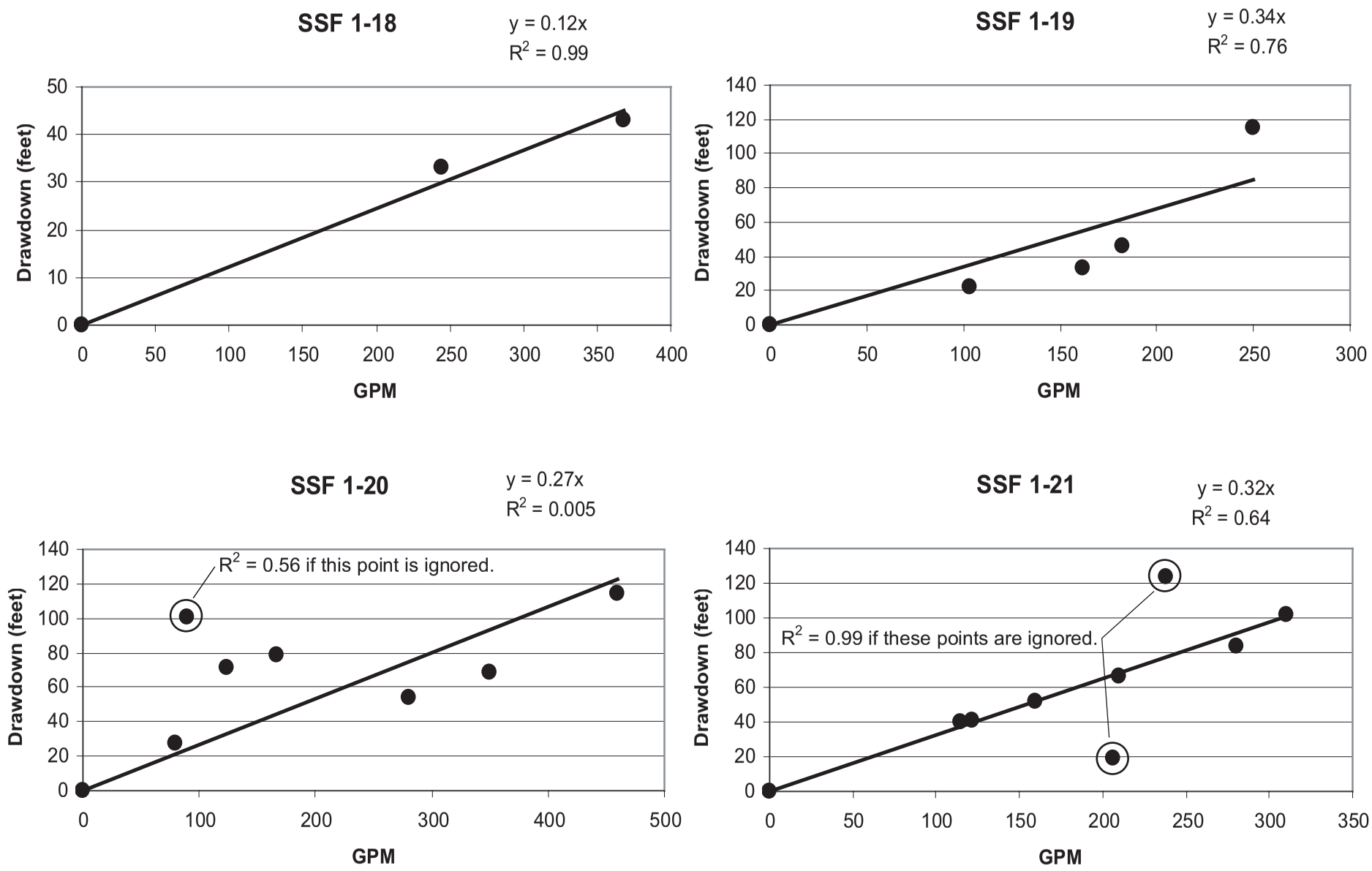

HYDROFOCUS INC.
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Observed relationship between water level drawdown and well yield (pumping rate).

Figure 3(b)

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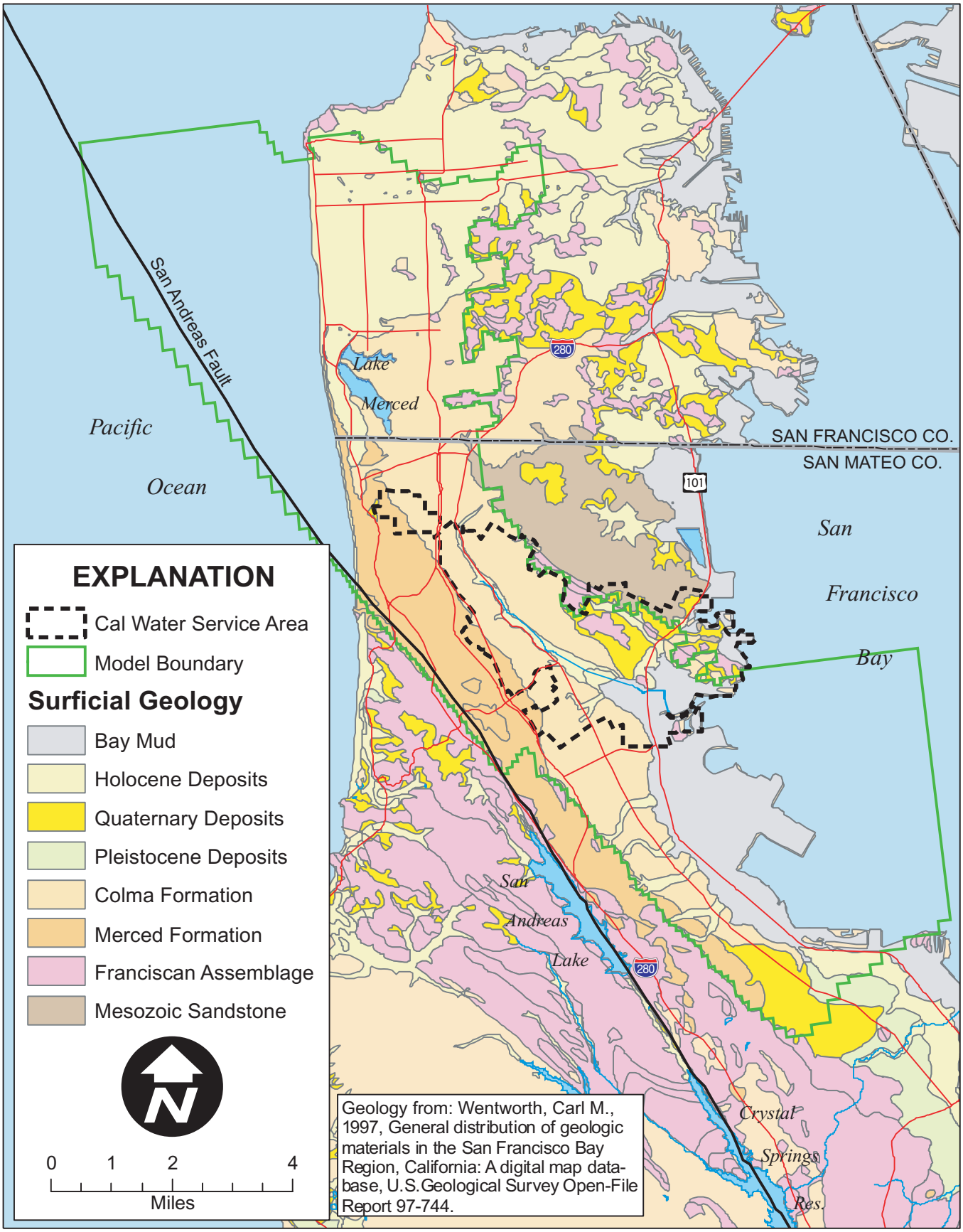

HYDROFOCUS INC
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Westside Groundwater Basin and groundwater-flow model boundaries.

Figure 4

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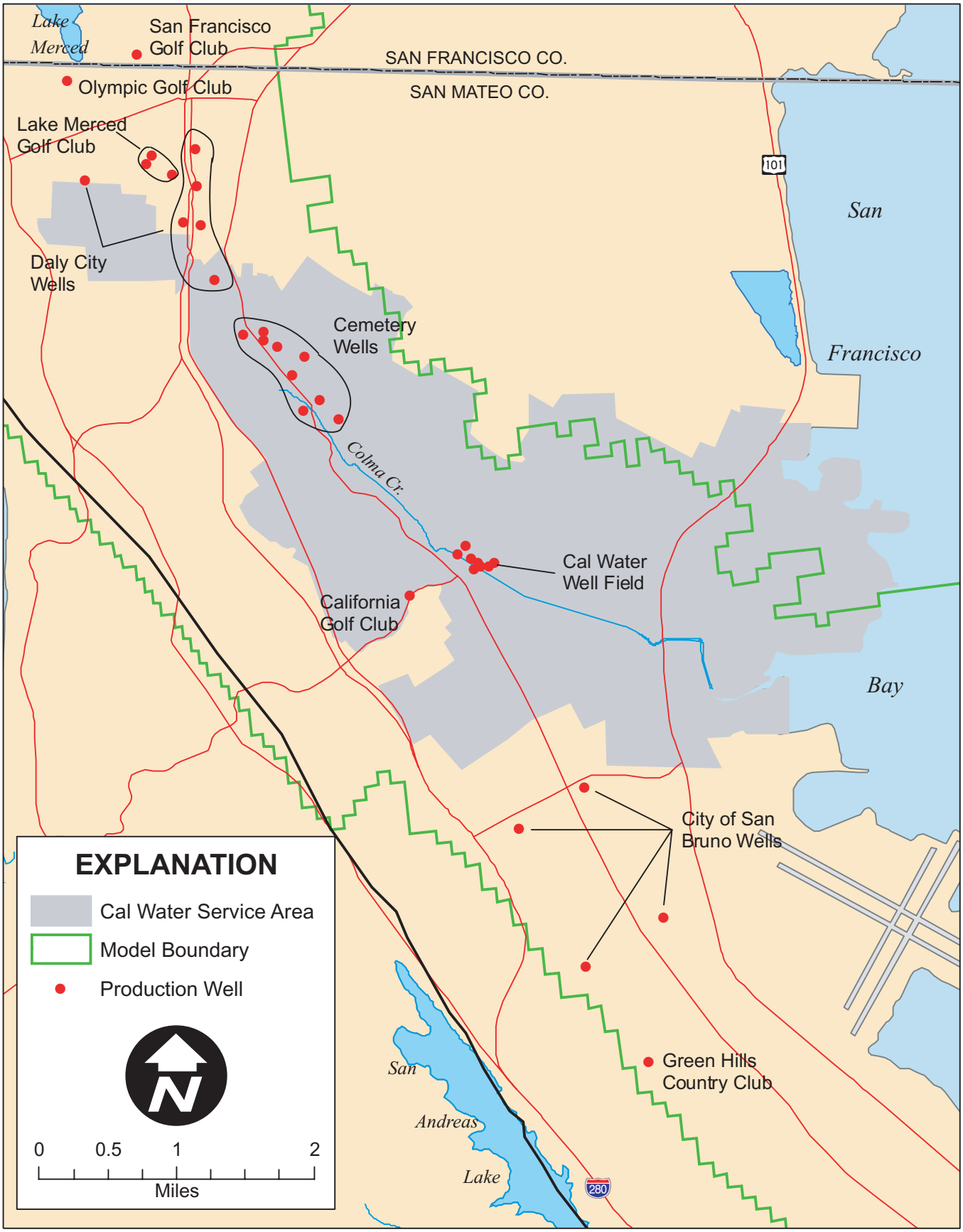

HYDROFOCUS
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California Water Service South San Francisco Facility Service Area Boundaries, Westside Groundwater Basin.

Figure 5

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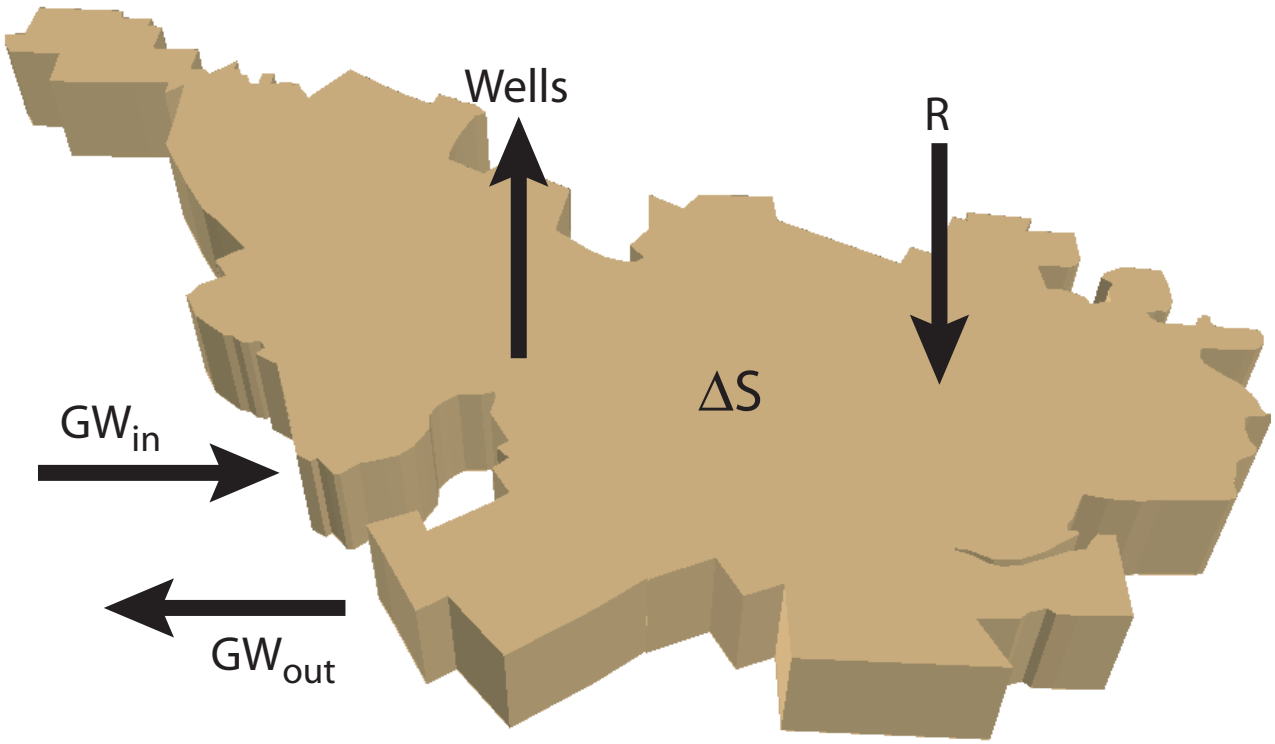

EXPLANATION

R	Recharge
Wells	Pumping from municipal and private wells
GW_{in}	Groundwater inflow
GW_{out}	Groundwater outflow
ΔS	Change in groundwater storage

HYDROFOCUS INC.
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Conceptual volumetric groundwater budget.

Figure 6

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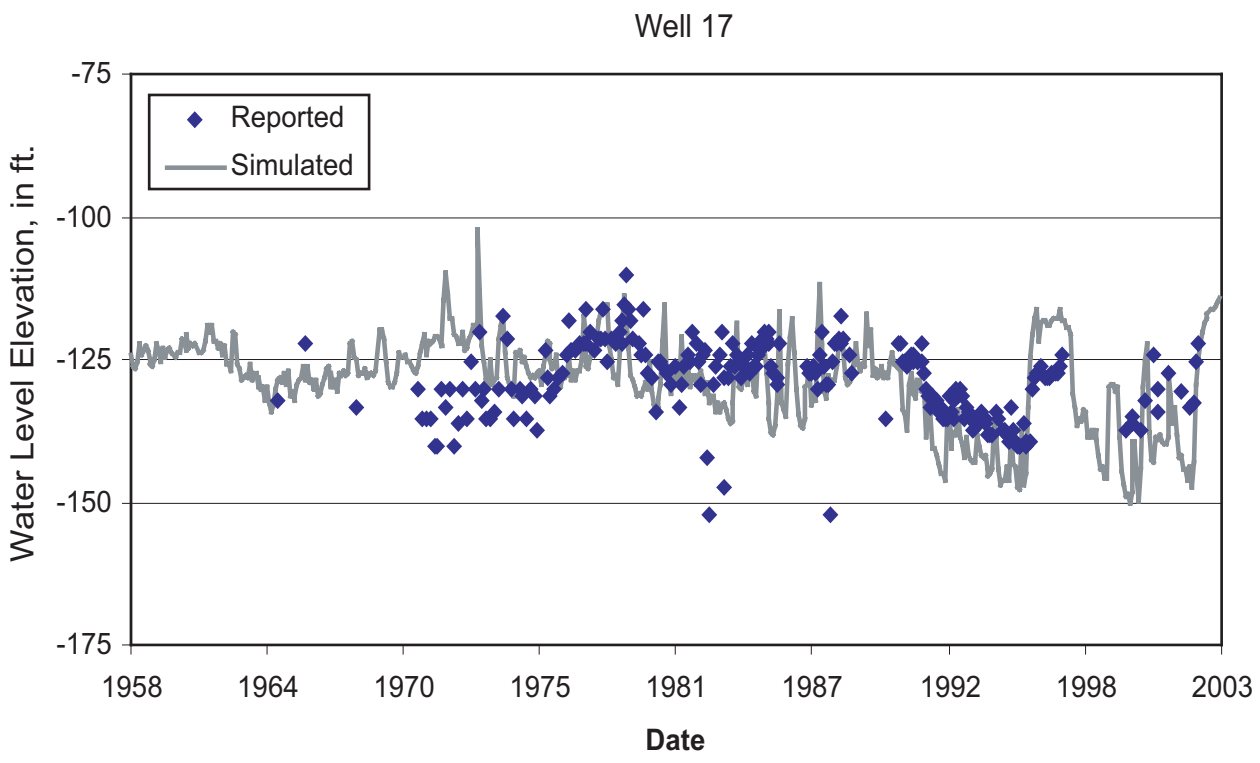
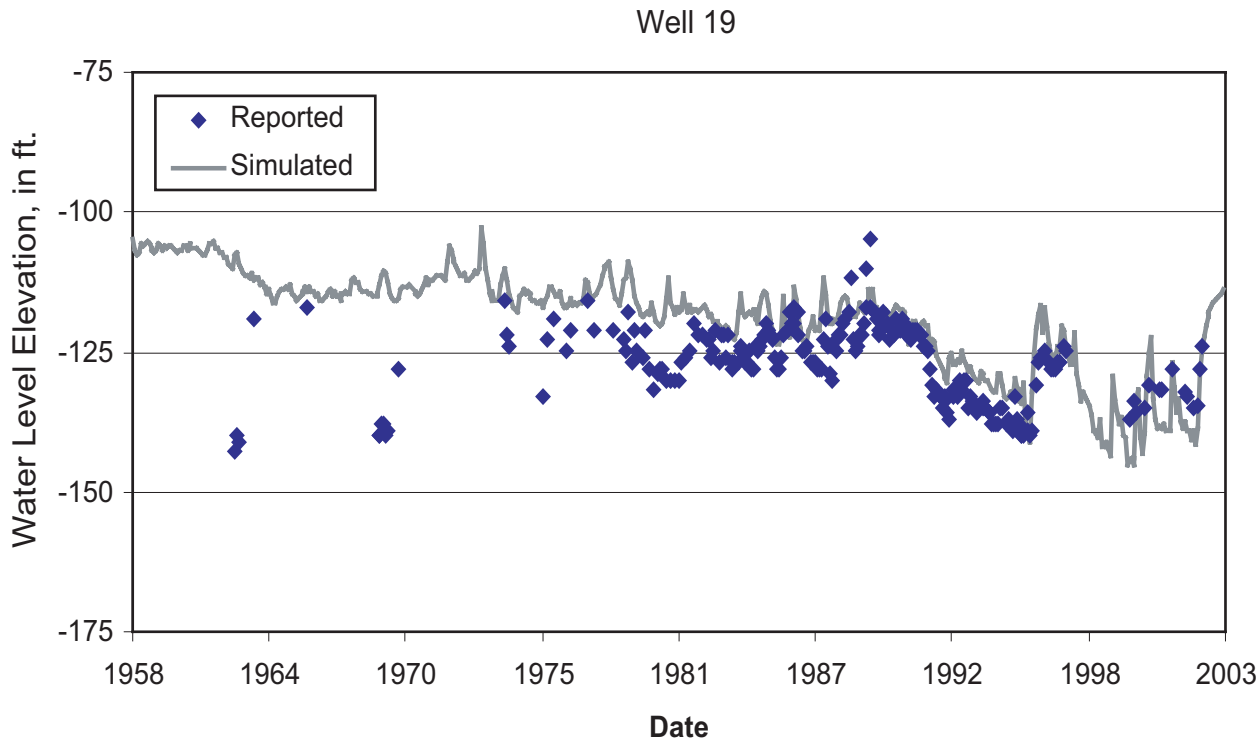
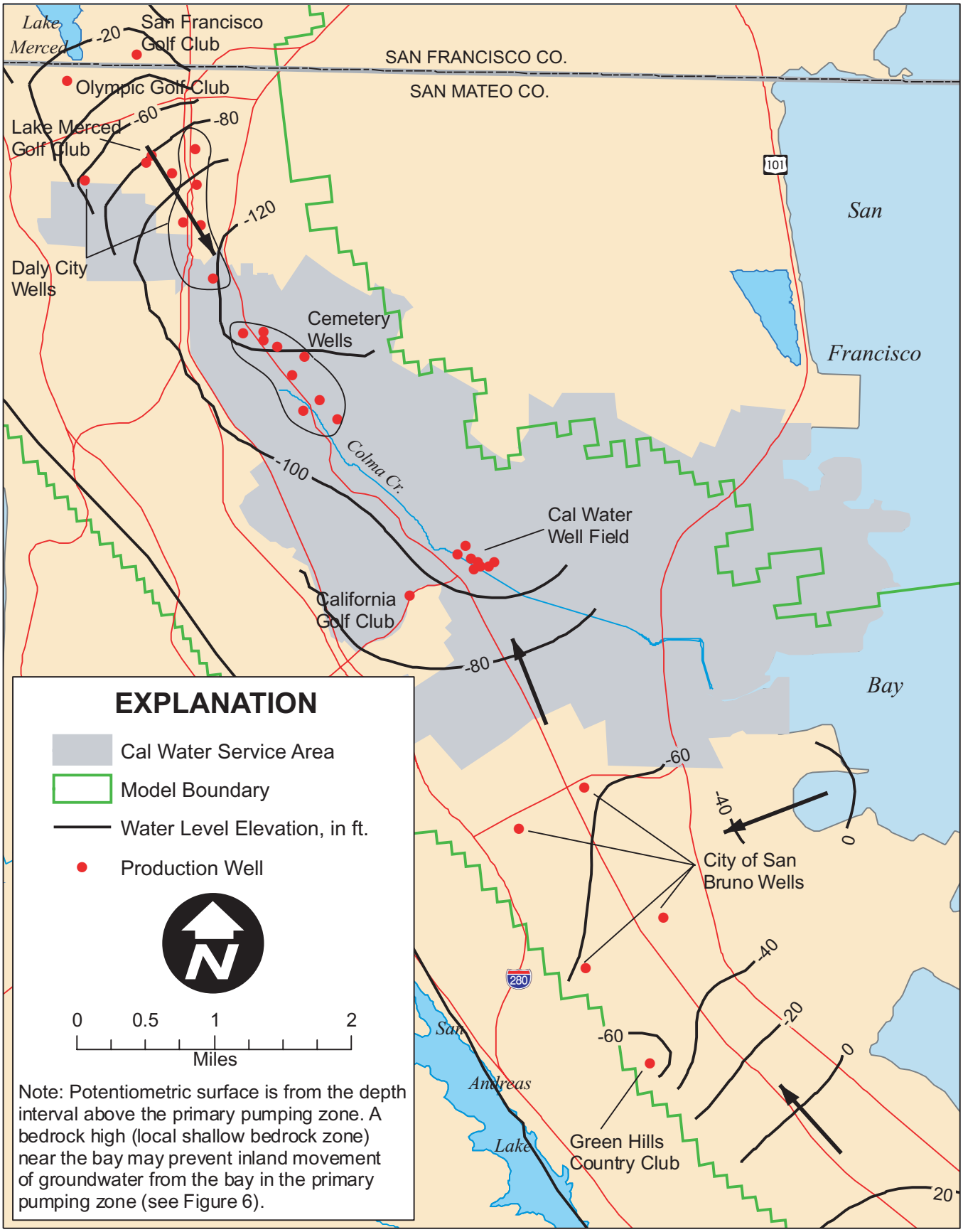




HYDROFOCUS INC. Solutions for Land and Water Resources	Reported and simulated static water levels, wells 17 and 19, 1958-2003.	Figure 7
PROJECT: 5021	DATE: 11/30/05	

Public Version



HYDROFOCUS
Solutions for Land and Water Resources

Simulated potentiometric surface, September 2003.

Figure 8

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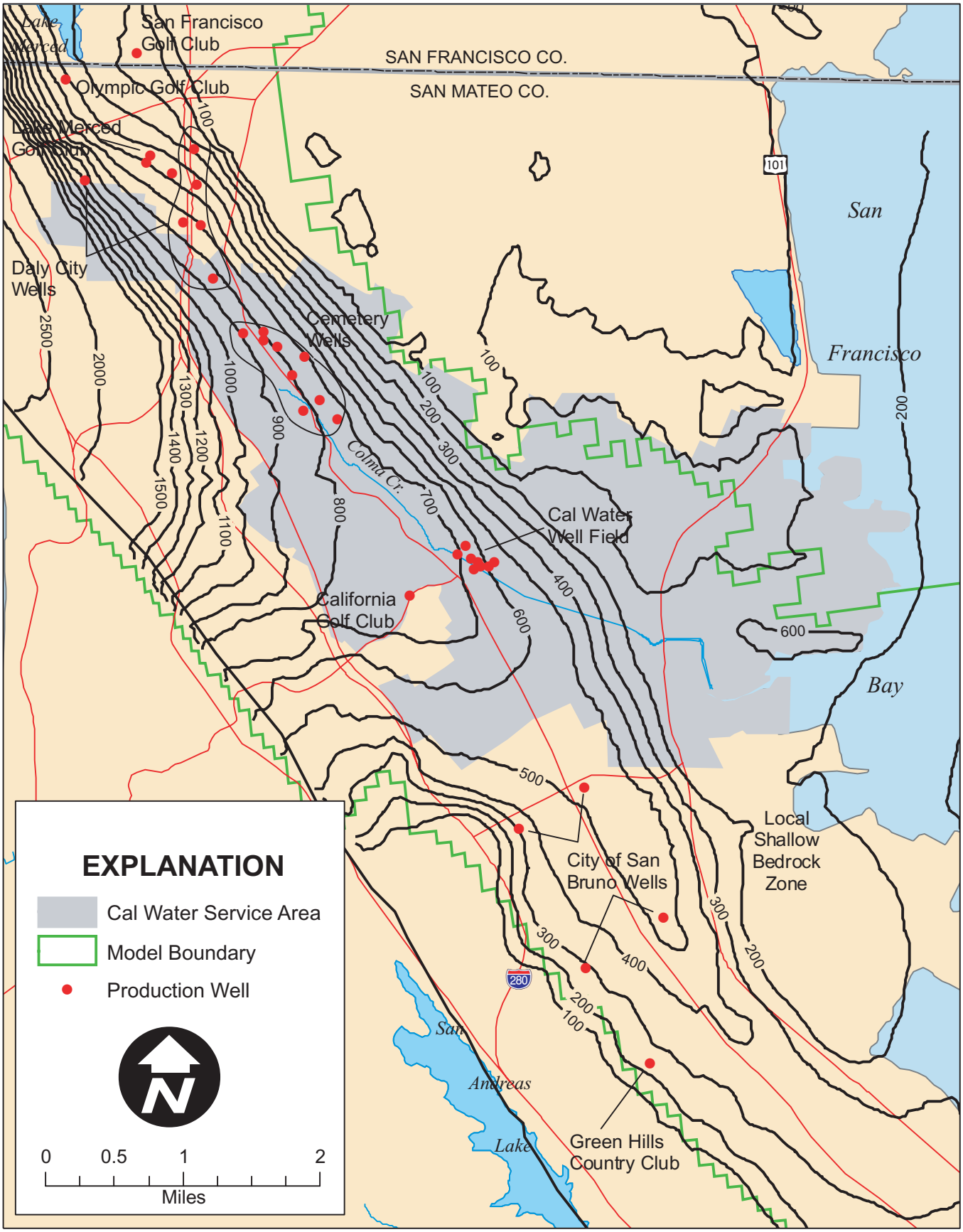

HYDROFOCUS INC
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Depth to bedrock.

Figure 9

PROJECT: 5021

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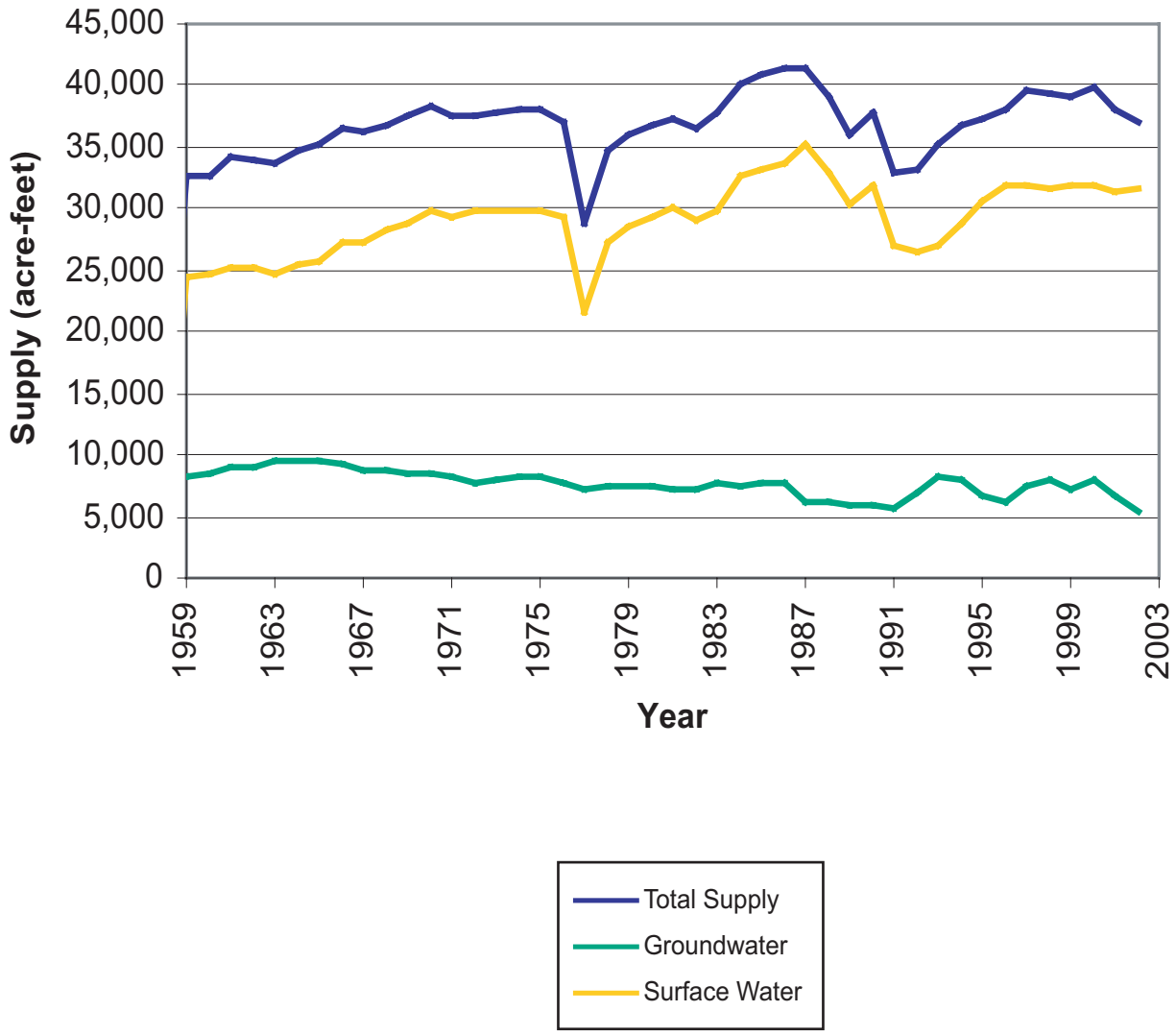

HYDROFOCUS INC. Solutions for Land and Water Resources	Relationships between total Westside Basin municipal water supply, surface water purchases, and groundwater, 1959-2002.	Figure 10
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Potential alternative well locations in the vicinity of South San Francsico Station 1.

Figure 11

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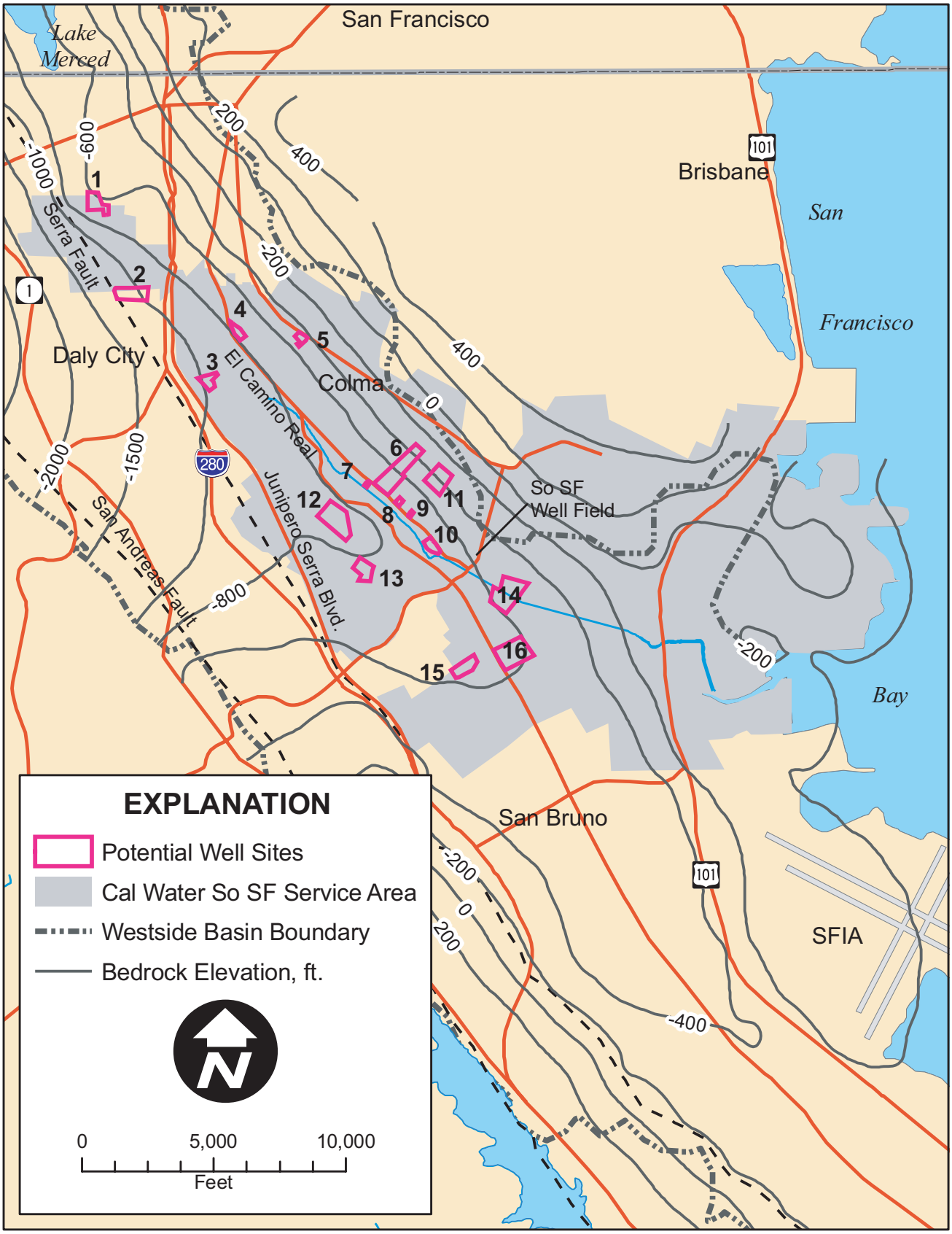

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Potential well sites and elevation of bedrock.

Figure 12

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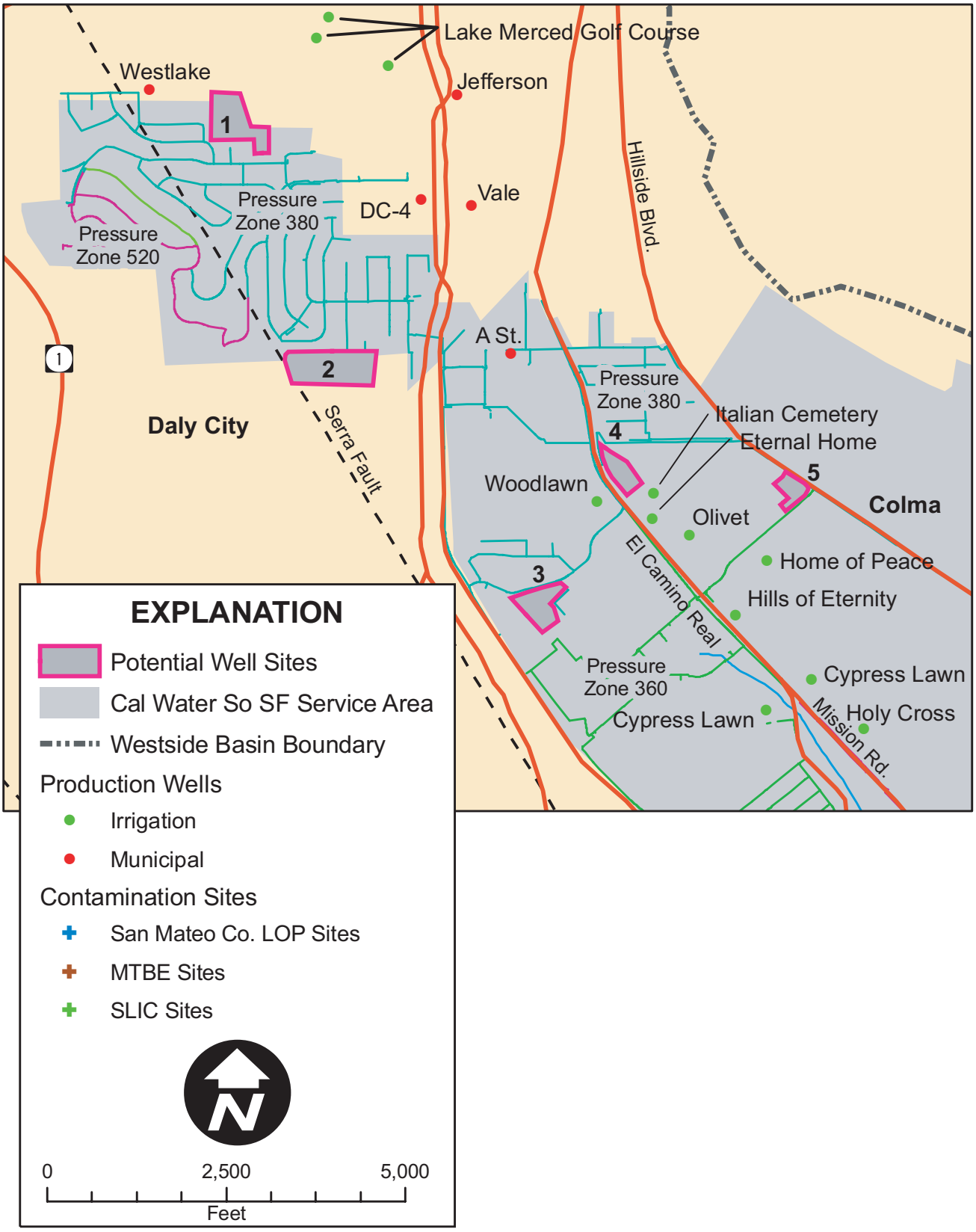

HYDROFOCUS INC. Solutions for Land and Water Resources	Potential well sites, northerly area.	Figure 13
PROJECT: 5021	DATE: 11/30/05	

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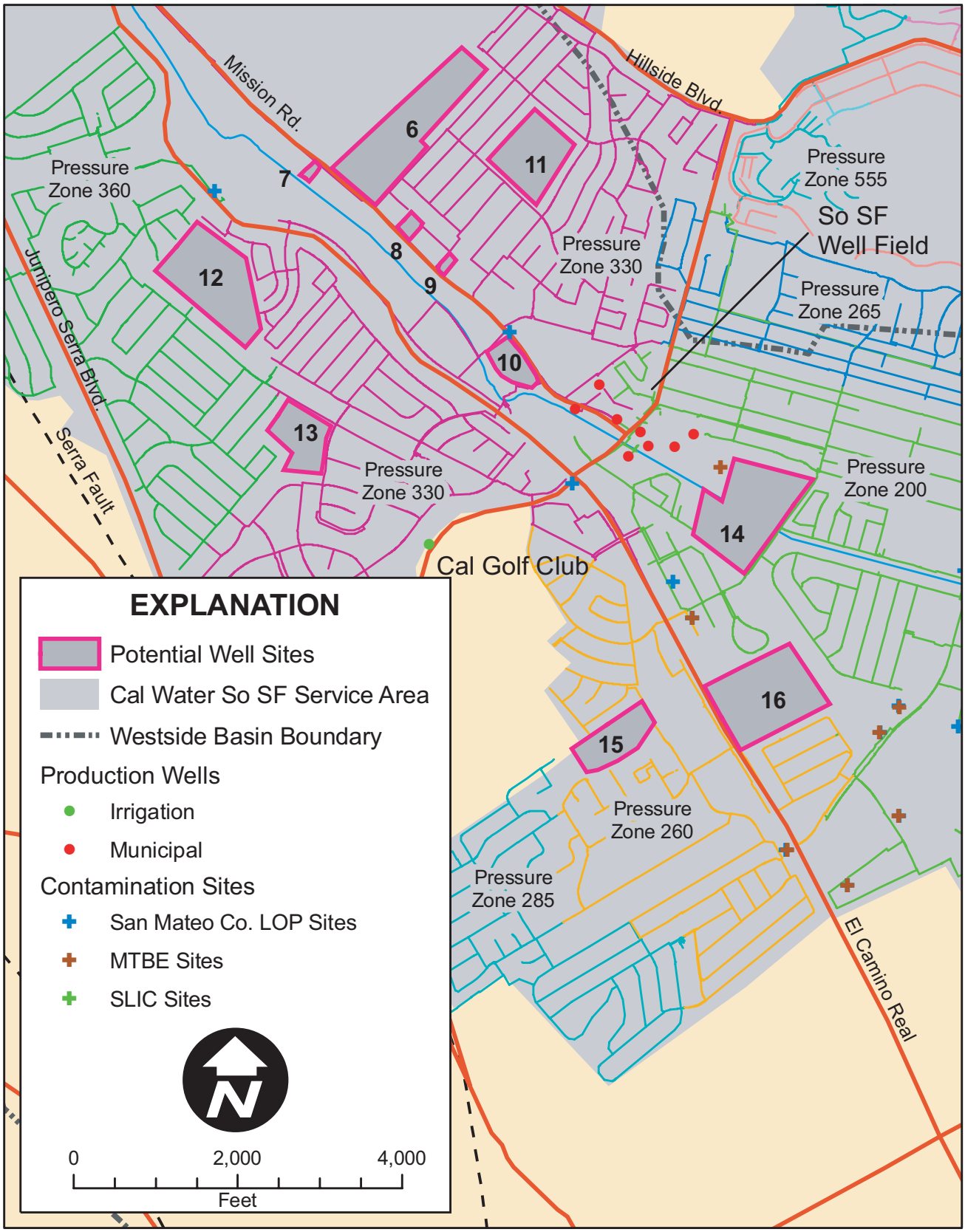

HYDROFOCUS INC
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Potential well sites, southerly area.

Figure 14

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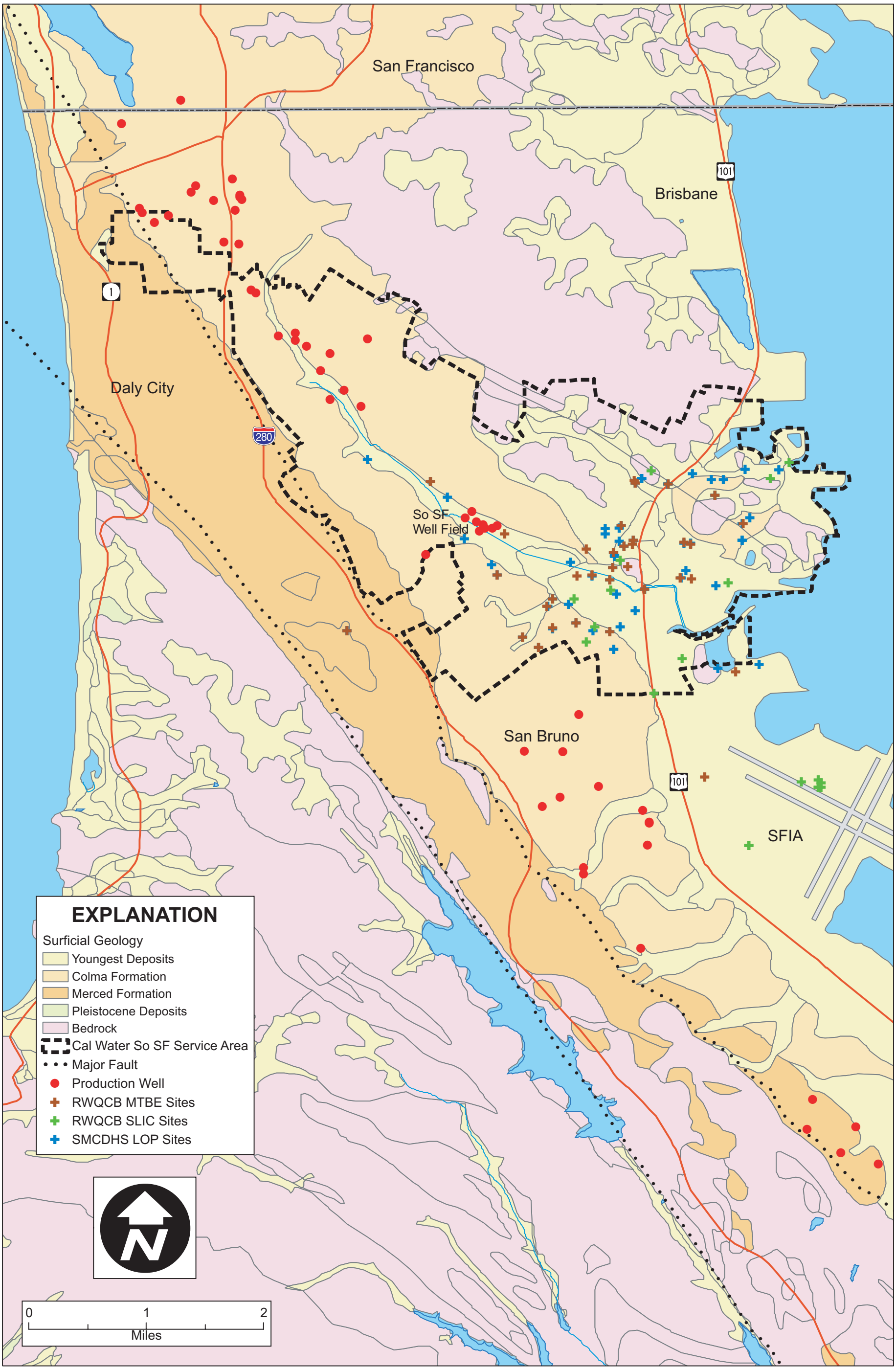

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Soil and shallow groundwater contamination site locations.

Figure 15

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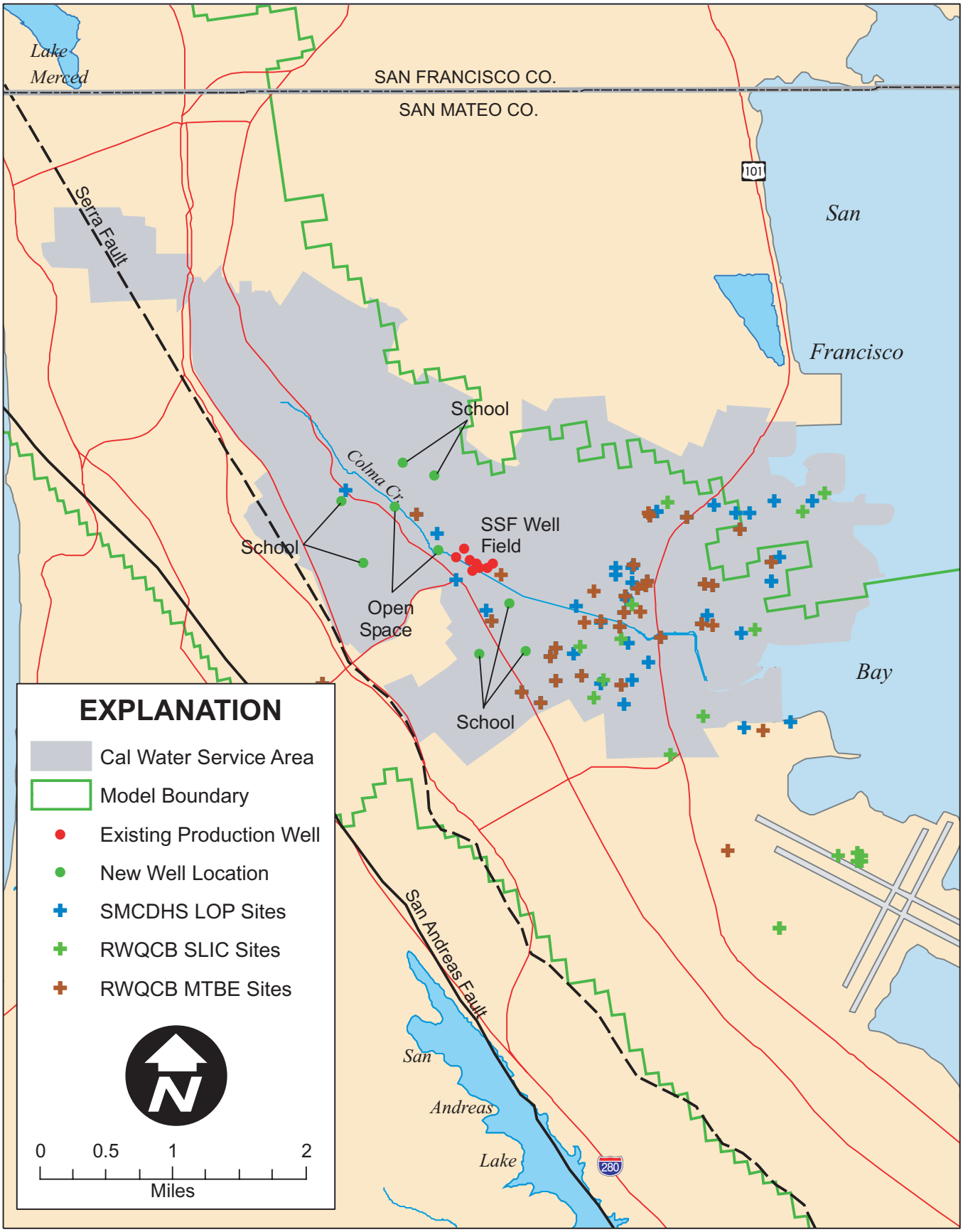

HYDROFOCUS INC
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Assumed new well locations employed in the Distributed Well Scenarios.

Figure 16

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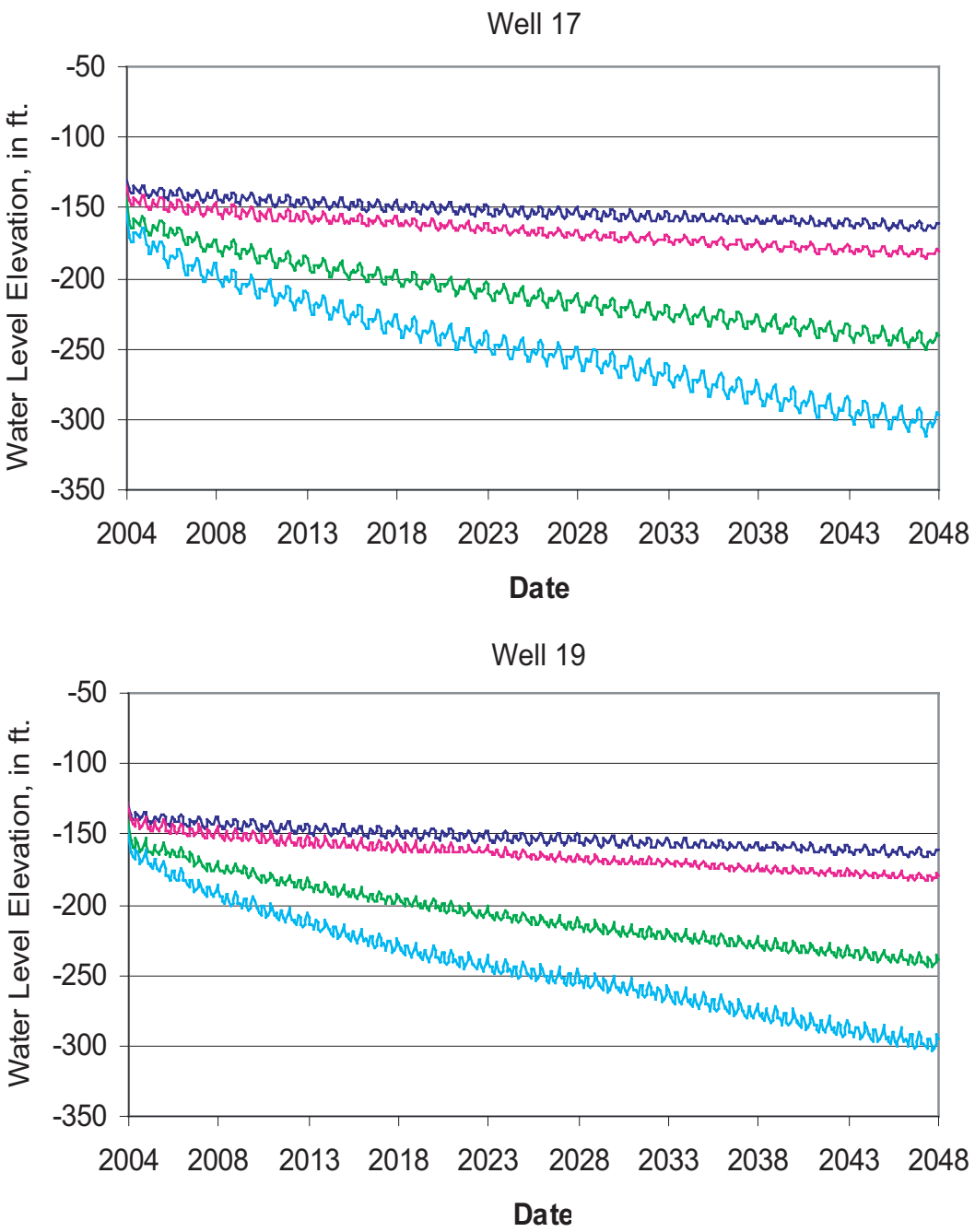

HYDROFOCUS INC. Solutions for Land and Water Resources	Simulated water levels for No-Action and Increased Supply Scenarios (existing well field), wells 17 and 19, 2004-2048.	Figure 17
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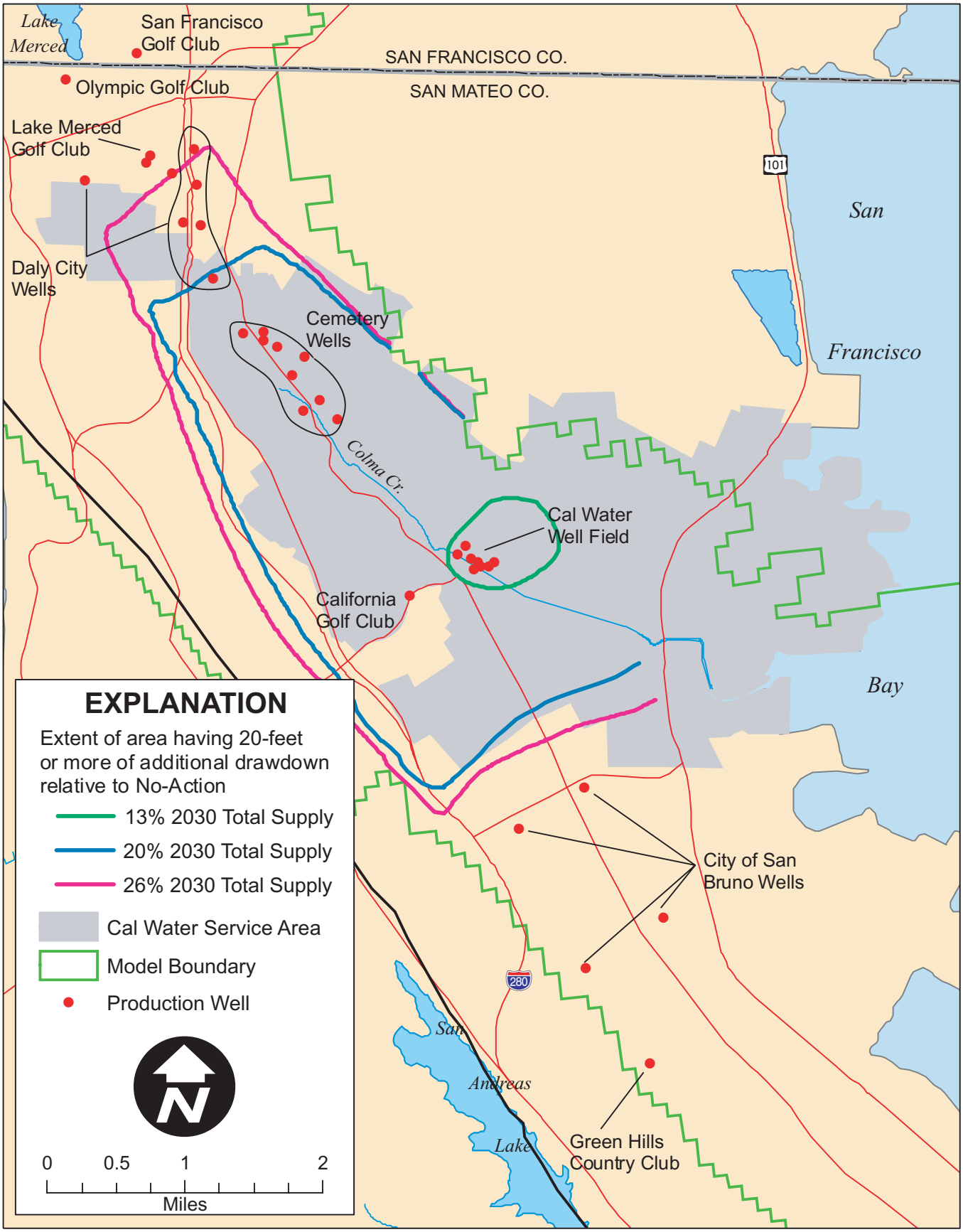
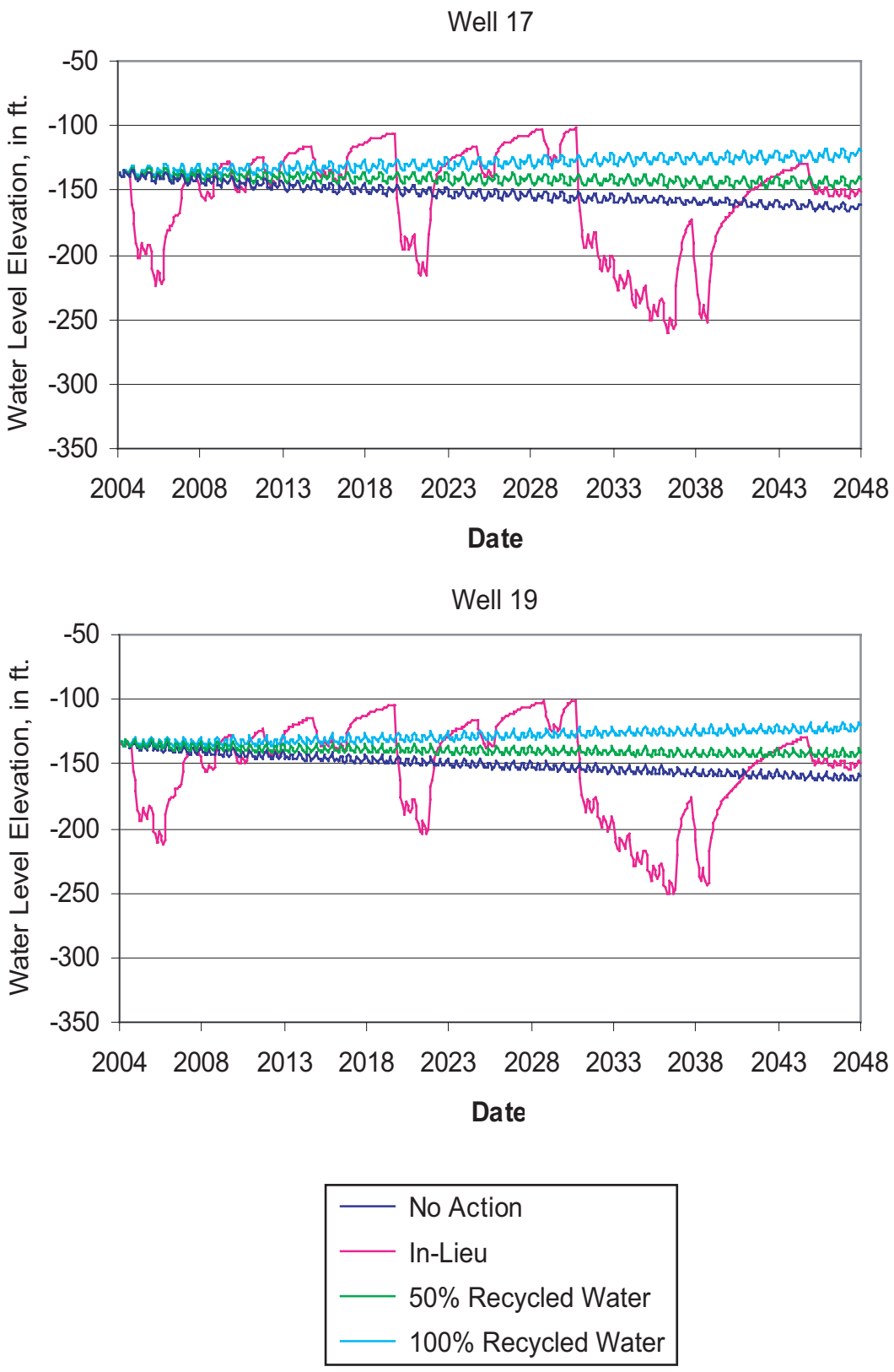


HYDROFOCUS INC Solutions for Land and Water Resources	Projected drawdown in 2048 for Increased Supply Scenarios.	Figure 18
PROJECT: 5021	DATE: 11/30/05	



HYDROFOCUS INC. Solutions for Land and Water Resources	Simulated water levels for No-Action, In Lieu, and Recycled Water Scenarios (existing well field), wells 17 and 19, 2004-2048.	Figure 19
PROJECT: 5021	DATE: 11/30/05	

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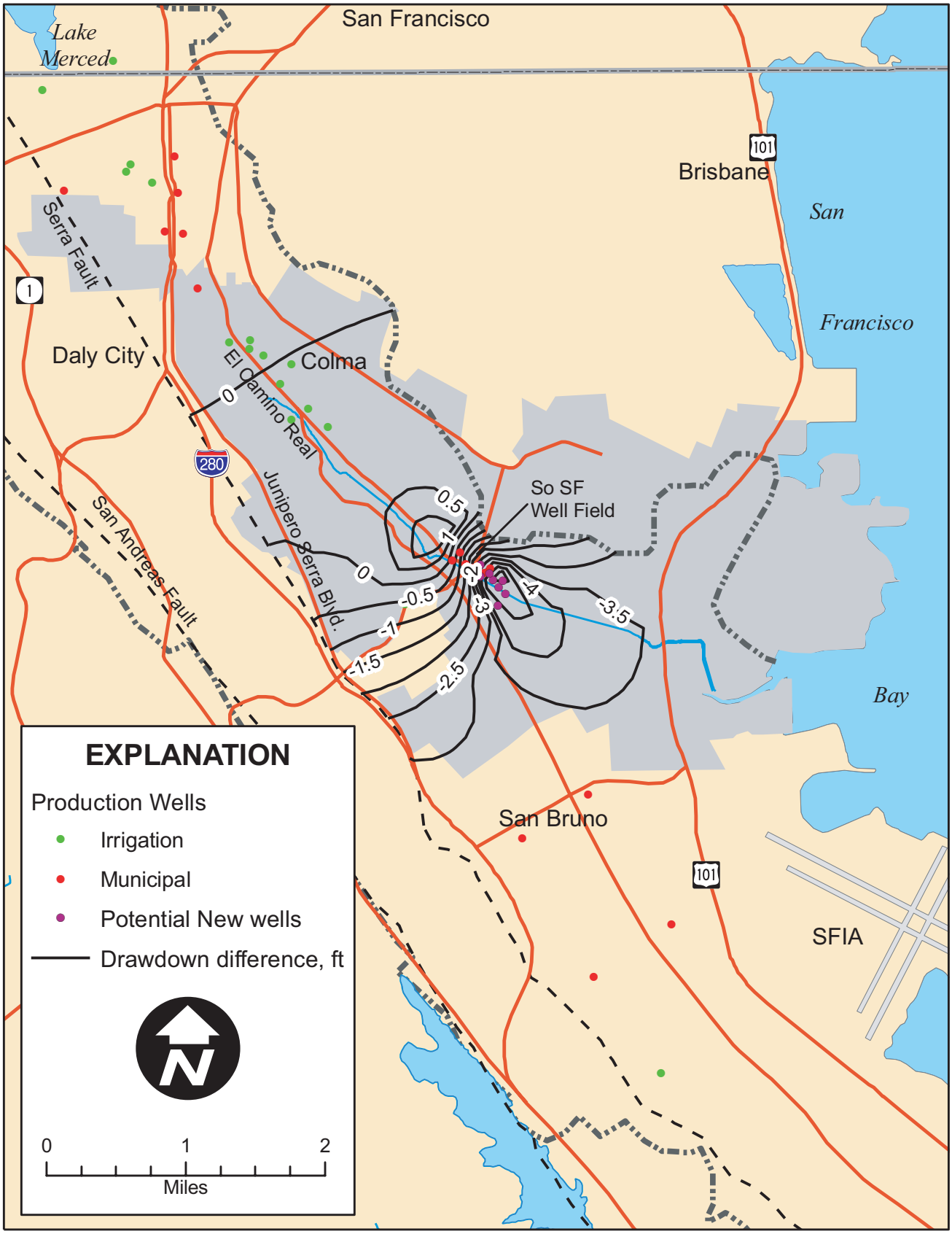

HYDROFOCUS INC
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Calculated difference in simulated drawdown between the existing wells and alternative well field configuration.

Figure 20

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Appendix F

Groundwater Quality Analysis

Public Version

Technical Memorandum
Groundwater Quality
South San Francisco Water Supply & Facilities Master Plan

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HydroFocus Technical Memorandum
Groundwater Quality
South San Francisco Water Supply & Facilities Master Plan

This technical memorandum presents the results from the groundwater quality analysis for the South San Francisco Water Supply & Facilities Master Plan that was conducted by HydroFocus Inc, as a subconsultant to CDM.

HydroFocus analyzed historical water quality data provided by Cal Water, semi-annual basin-wide monitoring data from the San Mateo County Westside Basin Clearinghouse, and information archived in San Mateo County Department of Health Services (SMCDHS) and California Regional Water Quality Control Board (RWQCB) databases to assess groundwater quality conditions in the Cal Water Service Area.

The groundwater quality analysis was designed to meet the following objectives.

- Describe temporal trends in well-water quality beneath Cal Water's existing well field. Assess constituent concentration levels that could affect Cal Water because of potential standards violations or diminished quality from a customer perspective.

- Research and map locations of contaminated and/or degraded shallow groundwater quality in the Cal Water South San Francisco Service Area.

This water quality information was used to help identify potential sites for new wells. A separate HydroFocus technical memorandum on Groundwater Supply discusses the potential new well locations.

The following topics are discussed in this technical memorandum:

- Summary of key findings
- Well construction and geologic conditions
- Well field water quality conditions
- Soil and shallow groundwater quality contamination sites
- References cited

All figures are included at the end of this technical memorandum.

SUMMARY OF KEY FINDINGS

Key findings of the groundwater quality analysis are summarized below:

- Perforated intervals for most wells bottom at depths varying from 210 to 580 feet below land surface, and therefore most wells have been constructed essentially to relatively non-water bearing bedrock. The Cal Water wells are screened primarily in marine and non-marine aquifer materials, and the sediments are typically chemically reducing as indicated by the presence of blue clay on the driller logs.

- In some wells, inorganic and organic constituent concentrations are changing with time. Increasing salinity, as measured by TDS, and particularly increasing Cl ion concentrations, may be an indicator of saltwater intrusion. The saltwater either is a diffuse saltwater front moving slowly from beneath South San Francisco Bay toward inland pumping wells, or the result of saline water slowly leaching from aquifer materials over time.

- Median concentration levels in samples from several wells exceed primary MCL's for nitrate (NO3), iron (Fe), and manganese (Mn). Fertilizer is the most probable source of NO3, and Fe and Mn occur naturally in Westside Basin sediments. High concentrations of Fe and Mn in groundwater can reduce well yield if the well screens and casings become coated with Fe and Mn precipitates. Iron-bacteria can also form biofilms on well screens and in the surrounding formation.

- Median total dissolved solids (TDS) concentrations levels in all wells exceed secondary MCL's. Hardness levels and trends generally parallel TDS concentrations, and these groundwaters are classified as "Very hard".

- Median concentration levels of organic constituents in samples exceed primary Maximum Contaminant Levels (MCL's) for only one constituent - Perchloroethylene or PCE (well 18). The primary source of PCE in groundwater is discharge from dry cleaners.

- Two different wells (14 and 17) either already exceed the MCL's for 1,2 DCPA, or are expected to exceed it within the next 5 to 6 years. The median Dichloropropane (1,2 DCPA) concentration levels in wells 14 and 17 are substantially below the MCL, but concentrations show a statistically significant upward trend. If the observed trend continues in well 14, 1,2-DCPA concentrations may exceed the primary MCL by 2010; the 1,2-DCPA concentrations in well 17 has exceeded the primary MCL since 1997. The compound 1,2 DCPA has been used as a soil fumigant to control nematodes, and is also a chemical intermediate and industrial solvent.

- Di (2-Ethylhexyl) Adipate (DEHA) is detected in all Cal Water South San Francisco well samples, and we suspect it represents contamination from plastic sample bottles and/or the PVC piping associated with the wells.

- Other compounds detected in well-water samples included 1,2,3 Trichloropropane, Di(2-ethylhexyl) phthalate, 2,4 Dichlorophenoxy acetic acid (2,4 D), and Ethylbenzene. The concentration levels of these constituents were below their respective MCL's.

- HydroFocus utilized information archived in San Mateo County Department of Health Services (SMCDHS) and Regional Water Quality Control Board (RWQCB) databases to locate and map soil and groundwater contamination sites in the Cal Water Service Area. This reconnaissance level assessment is not considered an exhaustive search for all soil and groundwater contamination sites in the Service Area. Most of the sites are located in the southwest portion of the Cal Water Service Area, and in the heavily industrialized area near South San Francisco Bay.

The remainder of this memorandum provides a detailed discussion of the analysis and findings.

WELL CONSTRUCTION AND GEOLOGIC CONDITIONS

Table 1 summarizes well construction and pumping rate information for the existing Cal Water wells. Well depths vary from 530 to 620 feet below land surface, and have been constructed essentially to relatively non-water bearing bedrock. The well screen intervals range from 120 to 580 feet below land surface.

Table 1. Well Construction and Average Pumping Rates, Cal Water Well Field.

Well Number	Total Depth (feet below land surface)	Perforated Interval (feet below land surface)	Average 1959-2003 Pumping Rate (Acre-Feet per Year)
2	?	210	122[a]
14	?	?	123
15	540	120-535	195
17	480	150-460	201[a]
18	575	231-578	330
19	530	216-528	82
20	600	380-580	266
21	620	370-580	271

a) Well operation ceased in 1996.

The Cal Water wells are screened primarily in marine and non-marine Pliocene and Pleistocene sediments (Fio and Leighton, 1995; Davis, 1966). Aquifer materials in these sediments are frequently calcareous (Christensen, 1966) and include limestone and dolomite (Davis, 1966 a, b). These sediments are typically chemically reducing as indicated by the presence of blue clay on the driller logs. The general layering of aquifers (sands and gravels) and fine-grained sediment beds (silts and clays) beneath the Cal Water well field and its vicinity is shown in Figure 1.

WELL FIELD WATER QUALITY CONDITIONS

Table 2 summarizes the water quality data obtained for the Cal Water wells for key inorganic and organic water quality constituents. The table shows primary and secondary maximum contaminant levels (MCLs) established by EPA, and indicates how the existing well water quality compares with the MCLs. Primary standards are based on health considerations. Secondary standards are based on taste, odor, color, corrosivity, foaming, and staining properties.

Constituent concentrations in some wells are changing over time. The Mann-Kendall test for trend was employed to identify wells that exhibit statistically

significant upward or downward trends (Helsel and Hirsch, 1992). A time series analysis identified statistically significant trends at the 5-percent significance level, which means there is a 5-percent chance to conclude there is no trend when in fact there is one.

Inorganic Constituents

Median[1] concentration levels in samples from several wells exceed primary MCL's for nitrate (NO3), iron (Fe), and manganese (Mn). Two of the NO3-influenced wells (14 and 19) exhibit statistically significant upward concentration trends as shown on Figure 2a, and contemporary concentrations now exceed the 45 mg/L standard; fertilizer is the most probable source of NO3. One of the Mn-influenced wells (21) exhibits a significant upward trend as shown on Figure 2b. No trends were identified in the Fe concentrations. Manganese and Fe occur naturally in Westside Basin sediments (Davis, 1966b). Aquifer materials beneath the Cal Water Service Area are typically chemically reducing, as indicated by the presence of blue clay on driller logs, and significant concentrations of Mn and Fe in groundwater is characteristic for these conditions.

Median concentration levels in all wells exceed secondary MCL's for total dissolved solids (TDS). Four of the wells (14, 15, 19, and 21) exhibit statistically significant upward concentration trends as shown on Figure 2c. Regression analysis showed that the rising TDS concentrations are correlated with sodium (r^2 = 0.69), calcium (r^2 = 0.61), magnesium (r^2 = 0.44), sufate (r^2 = 0.74), and chloride (r^2 = 0.69). Water hardness is attributable to multiple constituents, and hardness levels and trends generally parallel the observed TDS relationships. The median water hardness, in terms of equivalent calcium carbonate, range from 302 to 506 and are classified as "Very hard" (Hem, 1985).

The median chloride (Cl) ion concentration in two wells (79 mg/L in well 17, and 158 mg/L in well 21) are substantially below the secondary MCL (250 mg/L). Observed concentrations show statistically significant upward trends as shown on Figure 2d, but the trends are modest. Under these historical trends, time periods on the order of centuries would be required for Cl concentrations to reach 250 mg/L.

[1] The median is a statistical measure of the expected value similar to the average (i.e., an indication of the middle or center of the data set), but it is not mislead by a few very small or very large values.

Table 2. Constituent Concentration Levels, Federal EPA Maximum Contaminant Levels (MCLs), and Estimated Temporal Trends.

Constituent	EPA Standard (MCL's)	MCL Concentration Limit (mg/L)	Maximum Concentration in Existing Wells (mg/L)	Influenced Wells	
				Median	Trends Upward (Downward)
Inorganics					
Hardness	None	---	650 (well 15)	---	14, 15, 19, (20), 21
TDS	Secondary	500	890 (well 15)	2, 14, 15, 17, 18, 19, 20, 21	14, 15, 19, 21
Cl	Secondary	250	196 (well 21)		17, 21
NO3	Primary	45	230 (well 17)	2, 17, 18, 20	14, 19
Fe	Primary	0.3	9.9 (well 18)	15, 19	
Mn	Primary	0.05	3.4 (well 18)	18, 20, 21	21
As	Primary	0.01	0.016 (well 19)		(20)
Organics					
Dichloropropane (1,2 DCPA)	Primary	0.005	0.007 (well 17)		14, 17
Di(2-Ethylhexyl) Adipate (DEHA)	Primary	0.4	0.003 (well 19)		18
1,2,3 Trichloropropane	None	---	0.00016 (well 14)		
Perchloroethylene (PCE)	Primary	0.005	0.033 (well 18)	18	
Di(2-ethylhexyl) phthalate	Primary	0.006	0.007 (well 15)		
2,4 Dichlorophenoxy acetic acid (2,4 D)	Primary	0.07	0.0009 (well 18)		
Ethylbenzene	Primary	0.7	0.0012 (well 2)		

Note: **Median** listed well numbers have median concentrations that exceed the EPA Standard. **Trend** well numbers without parenthesis exhibit a statistically significant upward trend, and well numbers in (parenthesis) exhibit a statistically significant downward trend; well numbers not listed did not exhibit a statistically significant trend.

Salinity

Increasing salinity, as measured by TDS and Cl ion concentrations, may be an indicator of saltwater intrusion. Previous HydroFocus analyses are inconclusive regarding saltwater intrusion from South San Francisco Bay (Daly City, 2002). Specifically, data analyses indicate that one of two situations are probably occurring: (a) the saltwater front originating from beneath the bay must be diffuse and moving slowly toward inland pumping wells; or (b) rising salinity concentrations are the result of saline water slowly leaching from aquifer materials over time. Data that suggest the saltwater may originate from the bay include:

- Groundwater elevations measured in inland wells are less than mean sea level, suggesting groundwater movement is in a landward direction from beneath San Francisco Bay. The magnitude and rate of this movement is uncertain.
- Seawater-groundwater mixing lines for boron and bromide ion concentrations suggest that a seawater component explains chloride ion variability.
- Calculated salt norms using the USGS program SNORM (Bodine and Jones, 1986) indicate a seawater component is present in South San Francisco well-water samples, but mixing, mineral-water interactions, or recycling within the aquifer system has diminished its impact. The seawater component may be altered by the exchange of magnesium and sodium ions for calcium.

Alternatively, an ancient saltwater source may be slowly leaking from fine-grained sediments into the freshwater producing sand beds. Data suggesting this process may be influencing the observed salinity increases include:

- Inland movement of baywater may be limited by shallow bedrock areas located between the bay and California Water Service Area wells.
- Groundwater age-dating results indicated the water produced by two San Bruno production wells might be more than 100-years old. Groundwater velocities in the vicinity of the Cal Water Service area are therefore low, and decades to centuries would be required for bay leakage to travel through basin sediments to inland wells.
- Median chloride ion concentrations in Cal Water wells (79 to 160 mg/L) are low relative to seawater (18,000 mg/L).
- The salinity and ionic increases are modest.

Manganese, Iron and Calcium Carbonate Precipitation

High concentrations of iron and manganese in the ground water can reduce well yield if the well screens and casings become coated with iron and manganese precipitates. Iron-bacteria can also form biofilms on well screens and in the surrounding formation; the iron bacteria biofilms consist of iron oxyhydroxides, manganese oxides, and cellular matter (Walter 1997).

The analysis of well water quality data indicates a propensity of Westside Basin groundwater for precipitating iron oxyhydroxides and manganese oxides. The geochemical model PHREEQC (Parkhurst and Thorstenson, 1980) was employed to estimate the saturation index for iron and manganese oxides. The saturation index indicates whether minerals are likely to precipitate (positive value for the saturation index) or dissolve (negative value for the saturation index) in the well; a saturation index value of 0 indicates the dissolved constituents and minerals are in thermodynamic equilibrium.

The common forms of iron minerals found in well casings are amorphous iron oxyhyroxides, goethite and hematite (Driscoll, 1986). The most stable manganese oxide is pyrolusite (MnO_2). Figure 3 shows Fe and Mn mineral saturation index values for Cal Water wells. The saturation index values are substantially greater than one, indicating that Fe and Mn minerals likely precipitate in the wells.

Driscoll (1986) stated that chemical incrustation can also result from calcium carbonate mineral precipitation. Driscoll presents evidence that calcite (calcium carbonate) can form part of the incrustation in wells and associate with Fe and Mn minerals. Groundwater flowing into the well experiences a lower CO_2 partial pressure, which can result in precipitation of dissolved calcium and bicarbonate ions in the groundwater as described by the following chemical reaction.

$$Ca^{++} + 2HCO_3^- \leftrightarrow CaCO_3 + CO_2(g) + H_2O$$

Lower pressures in the well cause CO_2 to outgas from the groundwater, thus forcing the reaction to the right and precipitating $CaCO_3$ (calcite).

PHREEQC was used to estimate the potential for calcite precipitation in Cal Water wells from the calculated saturation index. Figure 3 shows that all wells but one (18) have positive values for the saturation index, suggesting that calcite likely precipitates in the affected wells. Similar calculations on water samples from Daly City and San Bruno production also indicate incrustation problems, which suggest it is probably characteristic throughout the Cal Water Service Area.

Organic Constituents

Median concentration levels in samples from only one well (18) exceed primary MCL's for only one constituent - Perchloroethylene or PCE. The primary source of PCE in groundwater is discharge from dry cleaners.

The median Dichloropropane (1,2 DCPA) concentration levels in two wells (0.0009 mg/L in well 14, and 0.004 mg/L in well 17) are substantially below the MCL (0.005 mg/L), but concentrations show a statistically significant upward trend as shown on Figure 4a. If the observed trends continue, 1,2-DCPA concentrations in well 14 may exceed the primary MCL by 2010; the 1,2-DCPA concentrations in well 17 already exceeded the primary MCL beginning in 1997. The compound 1,2 DCPA has been used as a soil fumigant to control nematodes, and is also a chemical intermediate and industrial solvent where it was found in paint strippers, varnishes and furniture polish removers. In the past 20 years, 1,2 DCPA production has declined and most of these uses have been discontinued. Today, almost all of the 1,2 DCPA is used as chemical intermediate to make perchloroethylene and other chlorinated chemicals. It is readily vaporized and broken down in sunlight, however if can be persistent if it infiltrates into the soil, where it is mobile in groundwater.

The median Di (2-Ethylhexyl) Adipate (DEHA) concentration in well 18 (0.0007 mg/L) is below the primary MCL (0.4 mg/L). The DEHA concentrations in well 18 exhibit a statistically significant upward trend, as shown on Figure 4b. However, the trend is modest and concentrations are several orders of magnitude below the MCL. DEHA is widely used as a plasticizer in polyvinyl chloride products, and can also leach from PVC plastic pipes. Because low DEHA levels are detected in all Cal Water well samples, we suspect it is contamination from plastic sample bottles and/or the PVC piping associated with the wells. If released to soil or water, DEHA is not expected to reach groundwater, and is more likely to be broken down by microbes or adhere to sediments. Other potential DEHA sources include solvents; aircraft lubricants; hydraulic fluid; bath oils, eye shadow, cologne, foundations, rouge, blush, nail-polish remover, moisturizers and indoor tanning preparations; in meat wrapping operations; fly ash from municipal waste incineration; and wastewater effluent from sewage treatment plants and chemical manufacturing plants.

Other organic contaminants detected in Cal Water well samples include:

- 1,2,3 Trichloropropane was detected in samples from wells 14, 17, 19 and 20. The measured concentrations range from 0.000076 to 0.00016 mg/L. 1,2,3 Trichloropropane is used to make other chemicals, an industrial solvent, and as a cleaning and degreasing agent. There is no standard MCL.

- Di(2-ethylhexyl) phthalate was detected in samples from wells 2, 14, 18, 19, 20 and 21. The measured concentrations range from 0.0028 to 0.0051 mg/L. Di(2-ethylhexyl) phthalate is used as a plasticizer in the manufacturing of rubber and plastic products. The Federal MCL is 0.006 mg/L.

- 2,4 Dichlorophenoxy acetic acid (2,4 D) was detected in samples from wells 14 and 18. The measured concentrations range from 0.0004 to 0.0009 mg/L, respectively. 2,4 D is widely used as a herbicide for the control of broad leaf weeds, and is readily degraded by soil microbes and water. The Federal MCL is 0.07 mg/L.

- Ethylbenzene was detected in samples from well 2 at a concentration of 0.0012 mg/L Ethylbenzene is primarily used to make styrene. It is also used as a solvent for coatings, and in making rubber and plastic wrap. The Federal MCL is 0.7 mg/L.

SOIL AND SHALLOW GROUNDWATER QUALITY CONTAMINATION SITES

HydroFocus utilized information archived in San Mateo County Department of Health Services (SMCDHS) and Regional Water Quality Control Board (RWQCB) databases to locate and map soil and groundwater contamination sites in the Cal Water Service Area. This information included: the SMCDHS Local Oversight Program (LOP) list, and the RWQCB's MTBE and SLIC (Spills, Leaks, Investigations, and Cleanups) lists. This reconnaissance level assessment is not considered an exhaustive search for all soil and groundwater contamination sites in the Service Area.

Figure 5 shows the locations of 110 sites of concern. Most of the sites are located in the southwest portion of the Cal Water Service area, and in the heavily industrialized area near South San Francisco Bay. Figure 5 was used in Task 2-1 as one of several criteria for selecting possible sites for new extraction wells. Potential locations for new wells are discussed in Appendix E. Specifically, potential new wells were located away from the industrialized zone and away from the areas having the highest density of soil and groundwater contamination sites.

Below is a detailed description of how the 110 sites of concern shown on Figure 5 were identified.

- The SMCDHS LOP list identified the addresses of 200 sites located in the Cal Water Service area. The RWQCB's GeoTracker website was used to obtain the mapping coordinates and constituents of concern for 160 of the 200 sites. Of the remaining 40 sites, 39 were located using Mapquest. Only one of the 200 sites could not be located.

Most (142) of the sites have been closed, and 57 of the 58 open sites were successfully located. The reported constituents of concern and number of open sites affected are listed below in Table 3.

Table 3. Constituents of Concern in Active San Mateo County Department of Health Services Local Oversight Program Sites.

Constituent of Concern	Number of Sites
Chromium	1
Diesel	4
Gasoline	28
Mineral Spirits	1
Oil	2
Solvents	1
Unknown	17
Not Identified	3
Sum	57

- The RWQCB MTBE List contains 63 sites for the Cal Water Service area. Geo Tracker was used to obtain mapping coordinates for 62 of the sites. Of the 62 sites, 28 sites are closed. Therefore, 34 open MTBE sites were successfully located.

- The RWQCB SLIC list contains 61 sites, and provided mapping coordinates for 12 of the 61 sites. Geo Tracker was used to obtain mapping coordinates for an additional 7 open sites. Based on the limited address information, it was concluded that most of the remaining 42 sites were probably located within the boundaries of San Francisco International Airport, and therefore outside the Cal Water Service Area.

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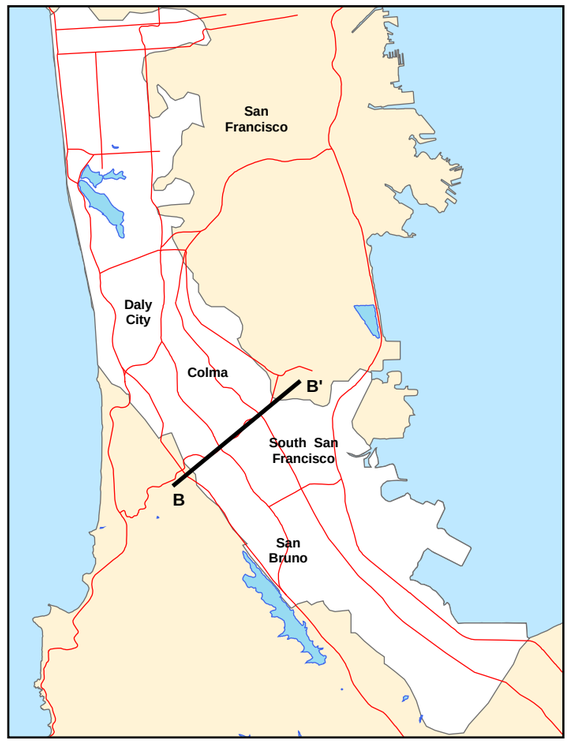
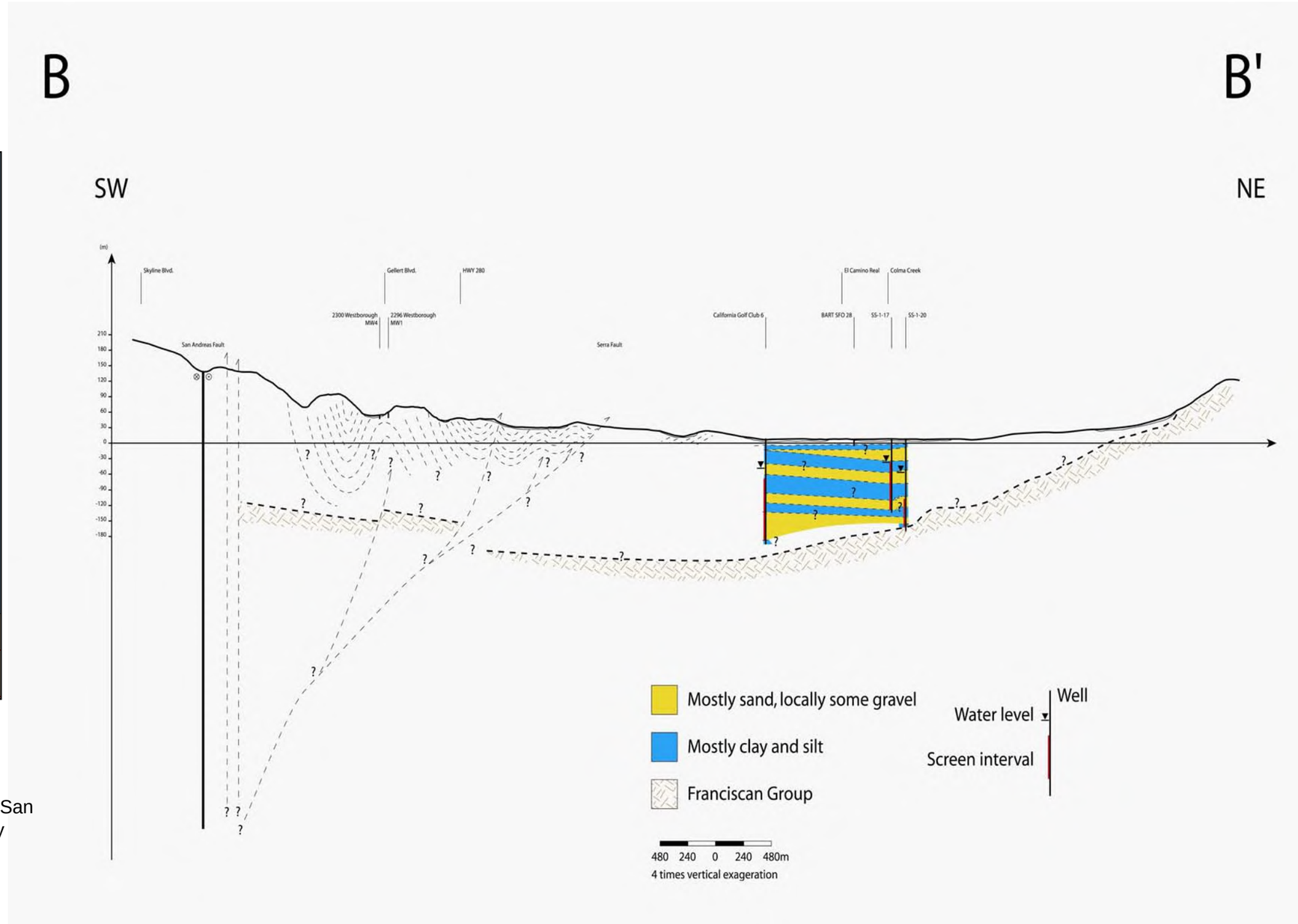
Approximate location of Section B-B'



Adapted from:

"Dimensions of the Westside Groundwater Basin, San Francisco and San Mateo Counties, California", by Erdmann H. Rogge

Thesis submitted for Master of Science
San Francisco State University
May, 2003



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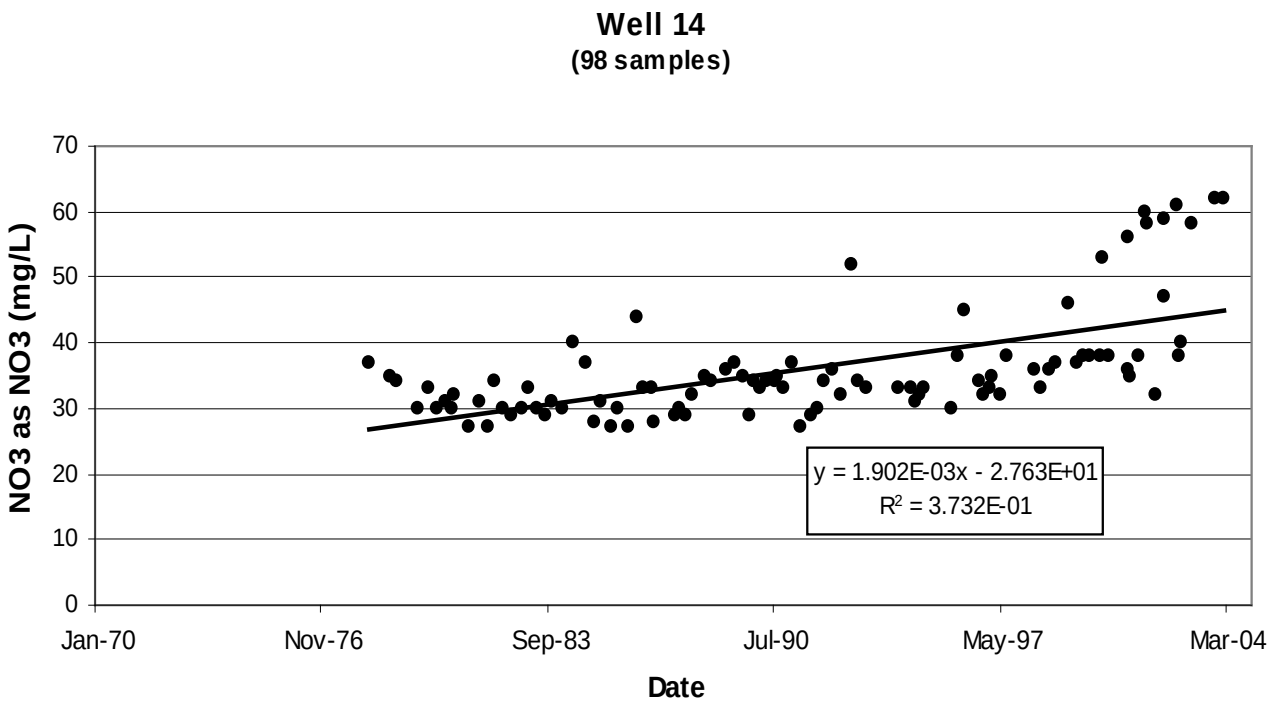
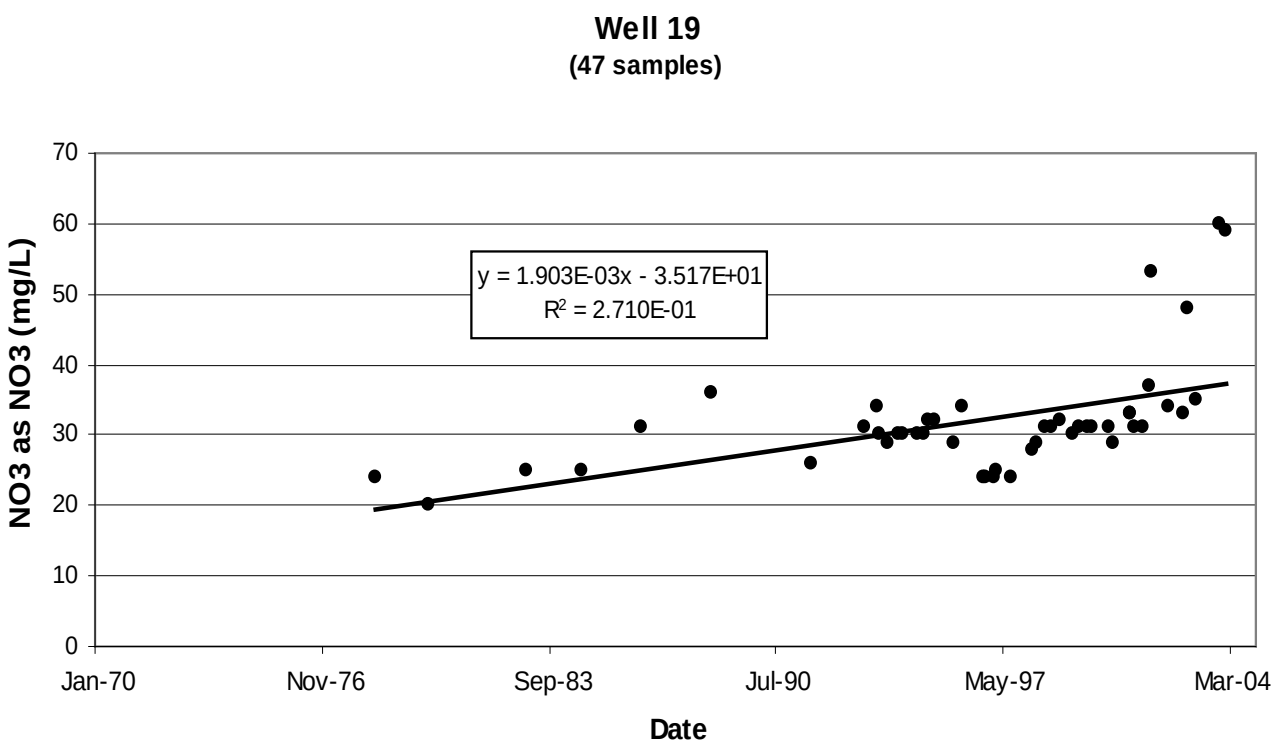
Southwest-Northeast Geohydrologic Cross-section of South San Francisco District Area.

Figure 1

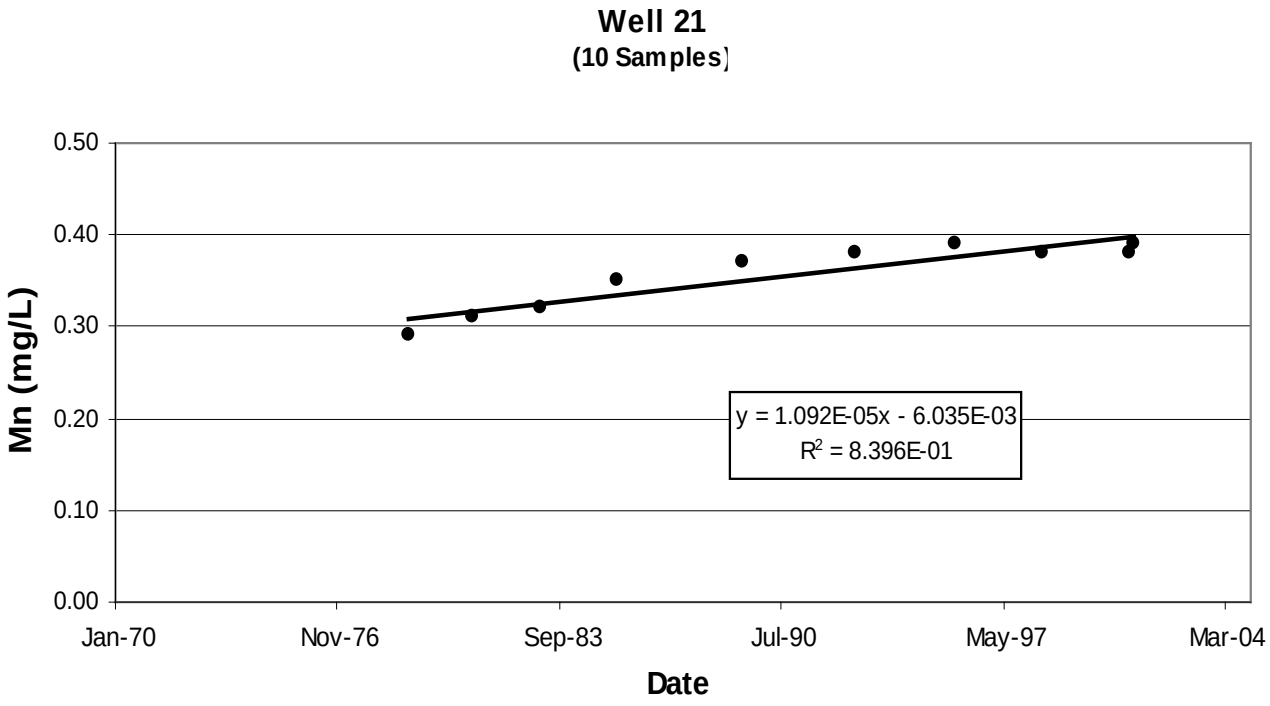
PROJECT: 5021

DATE: 5/5/06





HYDROFOCUS INC. Solutions for Land and Water Resources	Statistically significant temporal trends in nitrate concentrations.	Figure 2a
PROJECT: 5021	DATE: 2/5/05	



HYDROFOCUS INC. Solutions for Land and Water Resources	Statistically significant temporal trends in manganese concentrations.	Figure 2b
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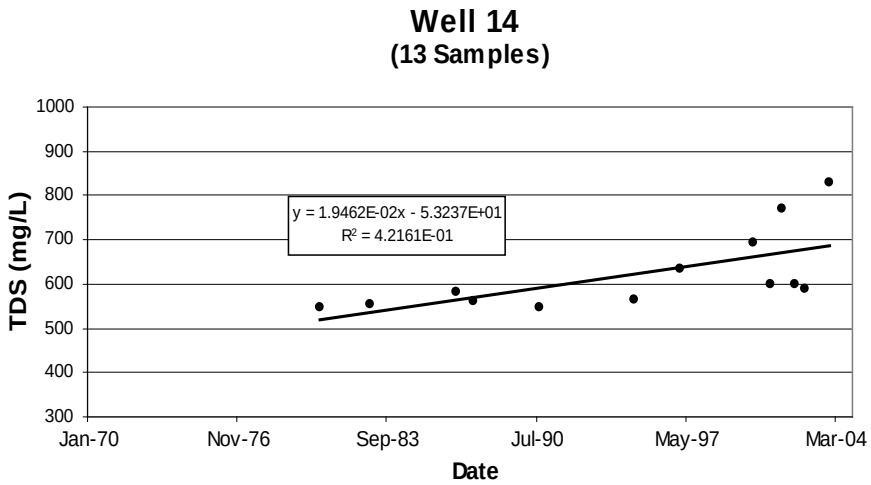

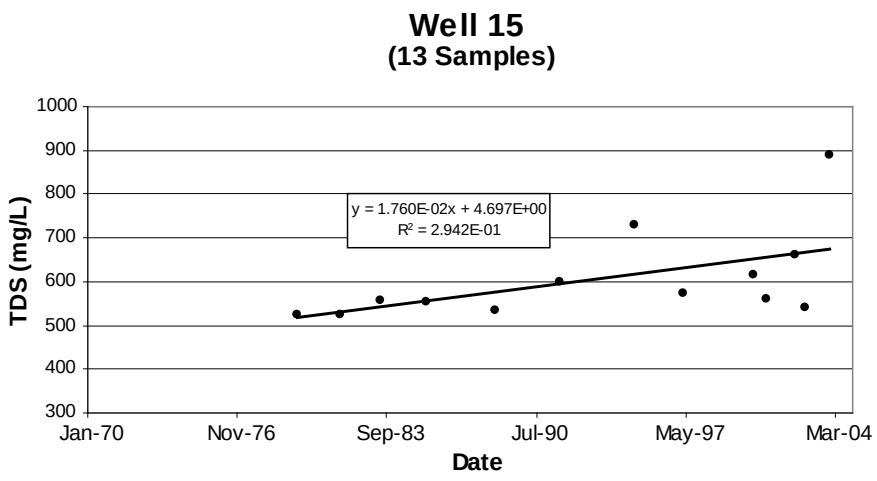

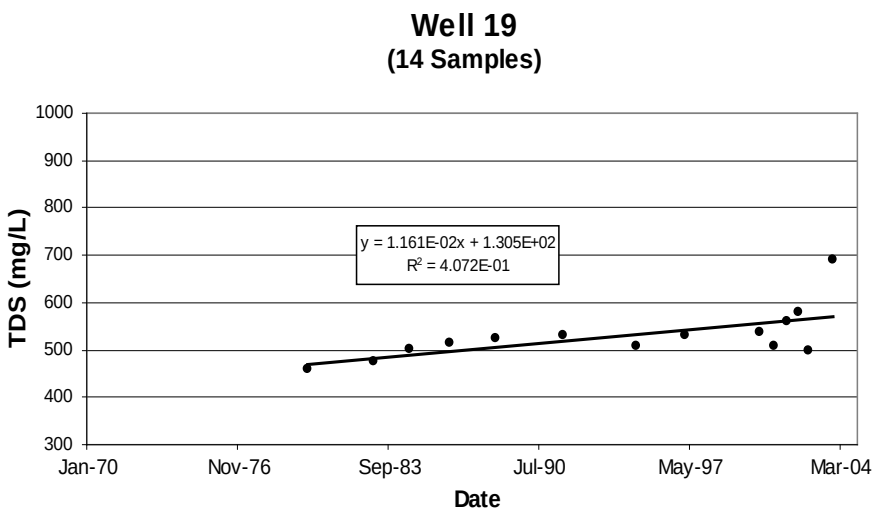

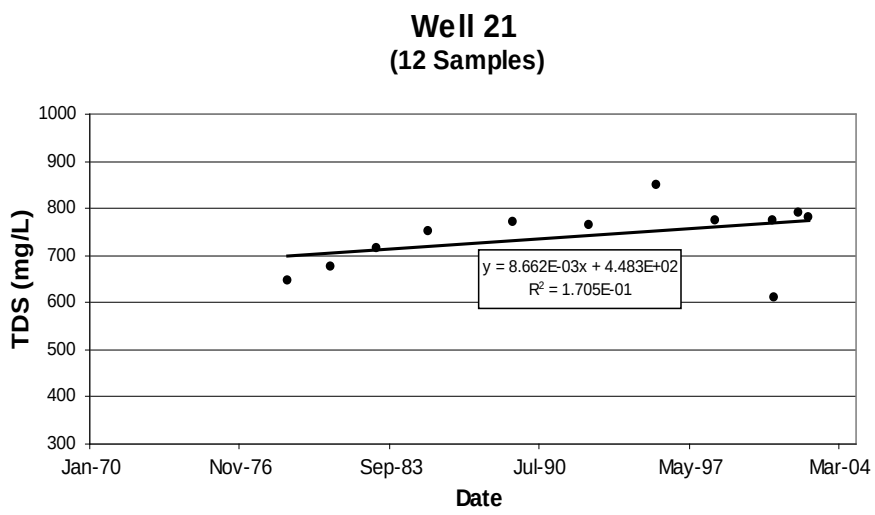

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Statistically signifcant temporal trends in TDS concentrations.

Figure 2c

PROJECT: 5021

DATE: 2/2/05

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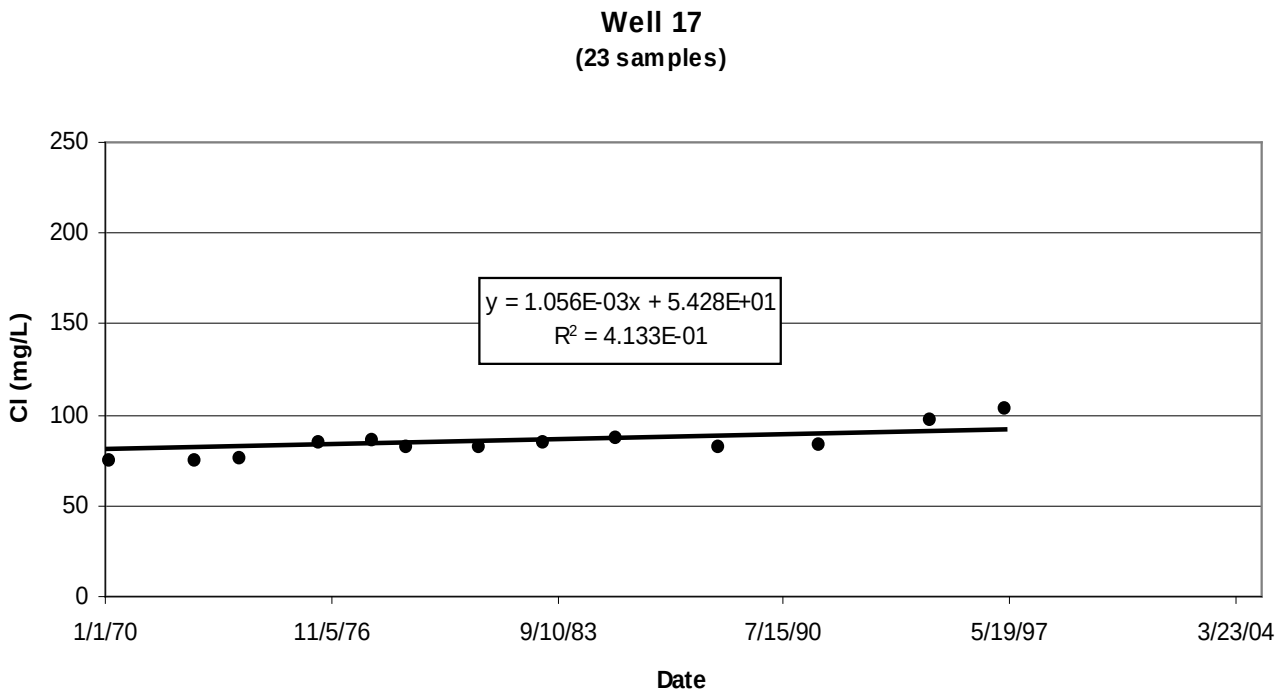

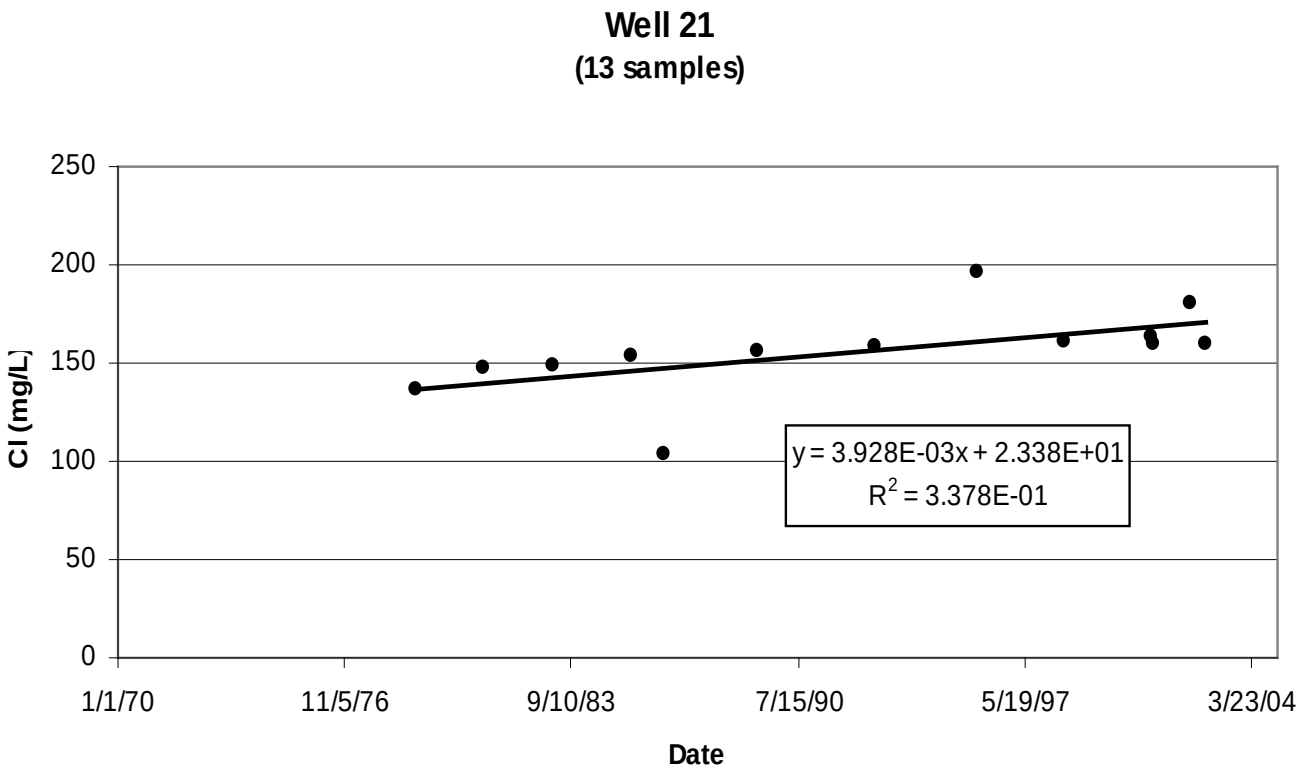

HYDROFOCUS INC. Solutions for Land and Water Resources	Statistically significant temporal trends in chloride concentrations.	Figure 2d
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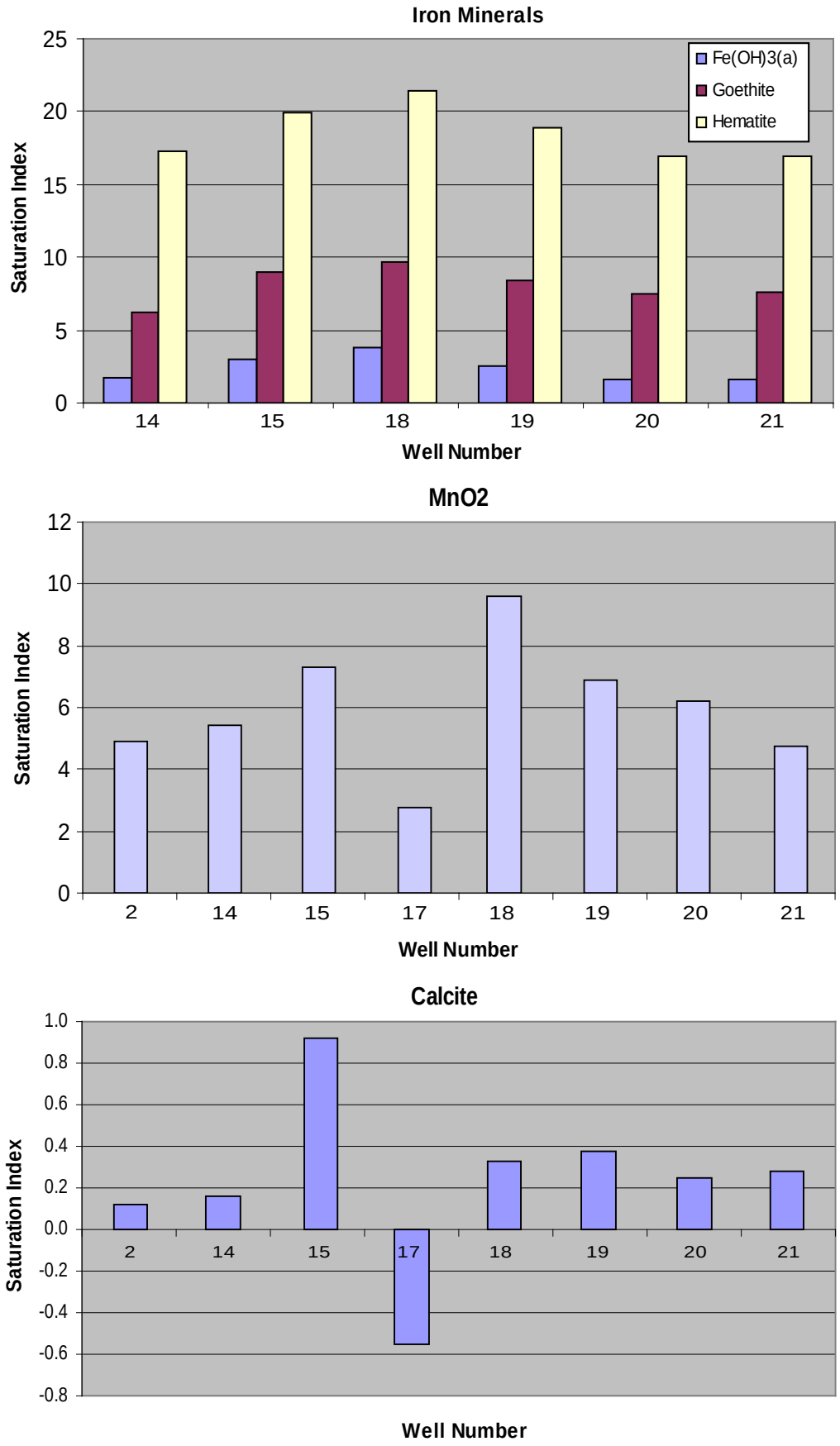

HYDROFOCUS INC. Solutions for Land and Water Resources	Saturation indicies for iron minerals, manganese oxide, and calcite.	Figure 3
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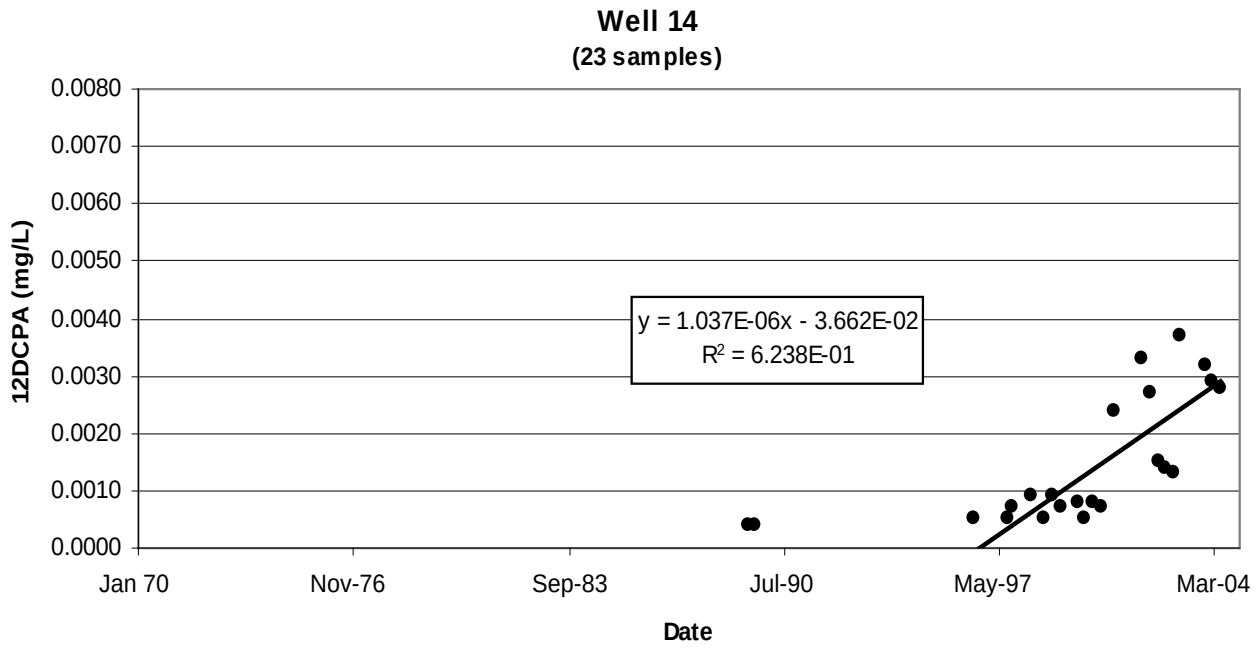

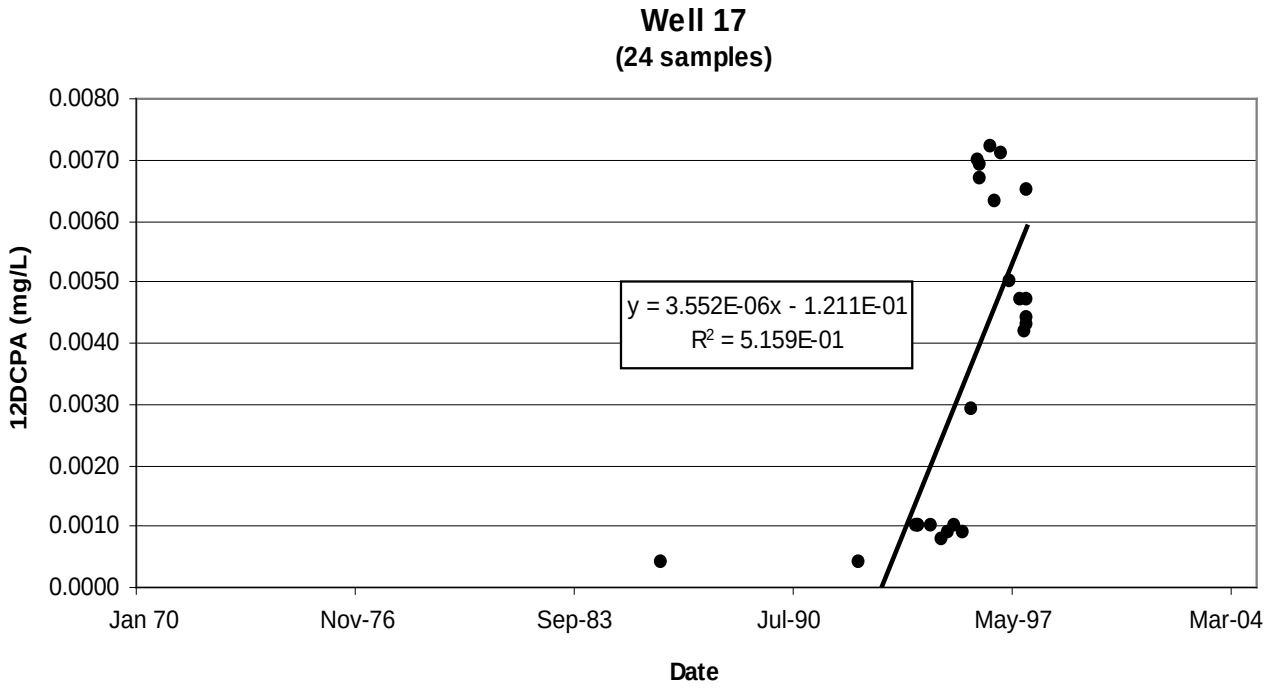

HYDROFOCUS INC. Solutions for Land and Water Resources	Statistically significant temporal trends in 12DCPA concentrations.	Figure 4a
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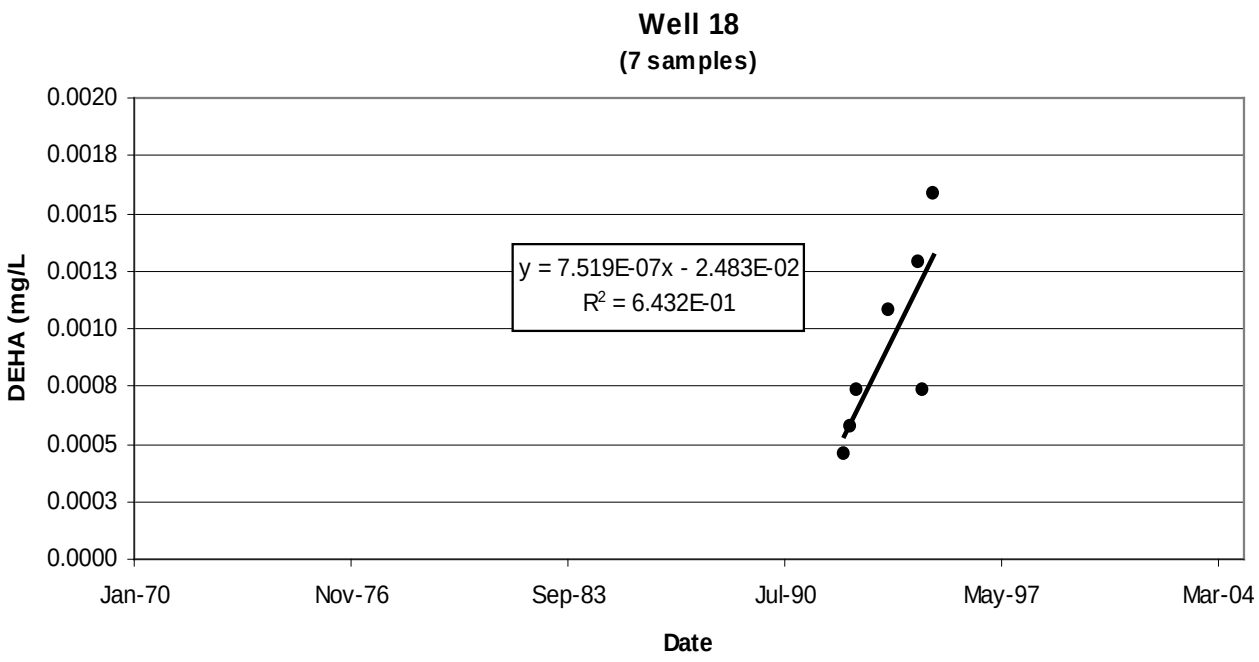

HYDROFOCUS INC. Solutions for Land and Water Resources	Statistically significant temporal trends in DEHA concentrations.	Figure 4b
PROJECT: 5021	DATE: 2/5/05	

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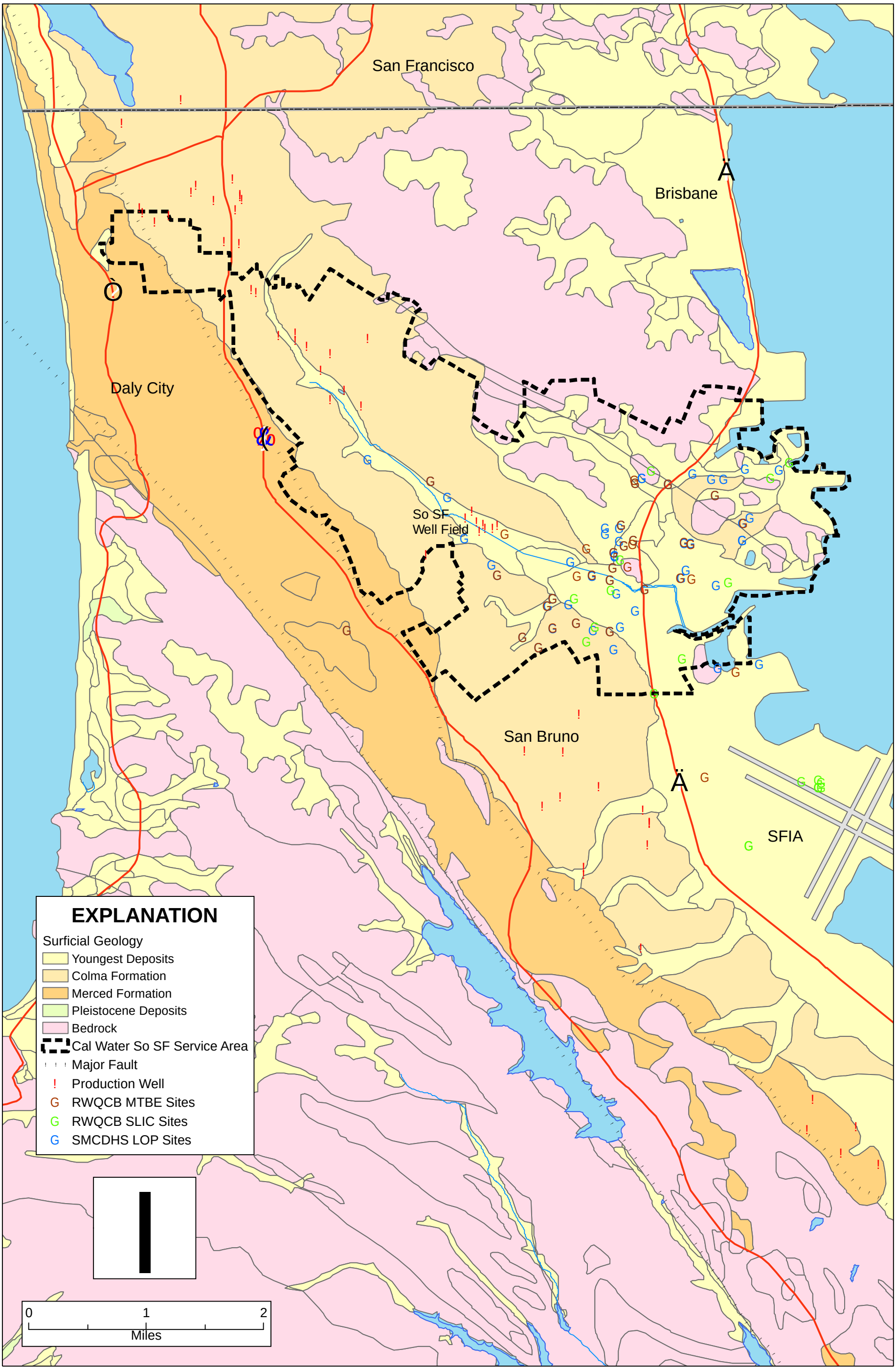

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Soil and shallow groundwater contamination site locations.

Figure 5

PROJECT: 5021

DATE: 2/2/05

Appendix G

Hydraulic Model Documentation

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South San Francisco Water Supply and Facilities Master Plan
Technical Memorandum
Hydraulic Model

Purpose

This technical memorandum presents the findings for Task 4 of the South San Francisco Water Supply and Facilities Master Plan prepared by the CDM Team for the California Water Service Company (Cal Water). The purpose of Task 4 is to develop and calibrate a computerized hydraulic model of the South San Francisco distribution system.

Overall Approach for Model Development

The computerized hydraulic model of the South San Francisco system was developed from the ArcGIS geodatabase provided by Calwater, using H20MAP software version 5.0 by MWHSoft. H20MAP is a stand-alone GIS –based program that combines spatial analysis tools and mapping functions with a versatile hydraulic model. H2OMAP also supports geocoding and multiple mapping layers which can be imported from other GIS-compatible software such as CAD, Word file, standard formats of "Shapefiles", Arcinfo coverages and others.

Cal Water provided CDM with the South San Francisco water distribution map showing existing facility locations and pressure zone boundaries, and a profile schematic diagram of the existing system. In addition, Cal Water provided CDM with GIS files containing virtually all pipes and valves in the South San Francisco system, and associated data such as pipe diameters, pipe material, pipe length, and the pressure zone where the pipe is located.

The model of the South San Francisco system contains all the pipes of all sizes in the system, as contained in Cal Water's GIS database. Modeling the entire system keeps the model in a one-to-one match with the GIS database, and is needed for geocoding addresses and allocating customer usage data to the appropriate model nodes.

For the master plan analysis, the model of the entire system was used, although the analysis focused on the 6-inch and larger pipes and ability to move water through the system. Including all the pipes in the model, even the very small (4-inch and less) diameter pipes, provides greater flexibility for future use of the model in conducting operational analyses and detailed analyses of localized areas.

The model is configured for 24-hour extended period simulations (EPS). An EPS model provides a more detailed look at system operations, such as reservoir filling

cycles, than a steady-state model that provides a snapshot for one particular demand condition, such as the average hourly demand on the maximum day.

If desired, Cal Water could skeletonize the model in the future to create a model of only the major pipelines, e.g., only pipelines 8-inch and greater in diameter. A skeletonized model is sometimes used for modeling overall system hydraulics and conveyance of water across the system through various pressure zones. Skeletonizing the model reduces the number of facilities and the time required for model execution, and can make it easier to review the results of model simulations to focus only on the key facilities. If the model is skeletonized in the future, modeled facilities should be carefully selected so that deadends at higher elevation in the zone are not eliminated when the system is evaluated for fire flow.

Modeled Facilities

Figure 1 provides an overview of the modeled pressure zones; each zone is shown in a different color. Figure 2 shows the existing system profile schematic. The Figure 3 large map in the pocket at the end of this appendix shows all the modeled water system facilities with the pipes color-coded by diameter and the pressure zone boundaries.

Below is a discussion of the various types of modeled facilities.

Pipes

Pipe locations and diameters were extracted directly from Cal Water's GIS files. Valves in the database were represented in the model as nodes. The model automatically calculated pipe length from the GIS files based on the digitized length of the pipes between nodes.

CDM estimated pipe roughness factors based on pipe material, diameter, and assumed ages, using reasonable values established by past modeling experience and from other industry sources. The GIS files contained pipe material information for most pipes. Less than 1% of the pipes did not have associated material information. For those pipes that did not have material information, the material was assumed to be either: 1) similar to other adjacent pipes, e.g., PVC would be assumed in an area of other PVC pipes; or 2) similar to the most common material type for that diameter pipe, e.g., most 2-inch pipes are cast iron.

The GIS files did not have age information. General estimates of pipe age will be assumed based on: 1) pipe diameters, e.g., very small pipes are typically older; 2) pipe material, e.g., cast iron pipes are typically older than PVC pipes; and 3) discussions with Cal Water District staff regarding their knowledge of the general ages of pipes in the system.

Later in this memo, under Model Calibration, there is a discussion of pipe roughness factors and the procedure used to adjust them as needed during model calibration.

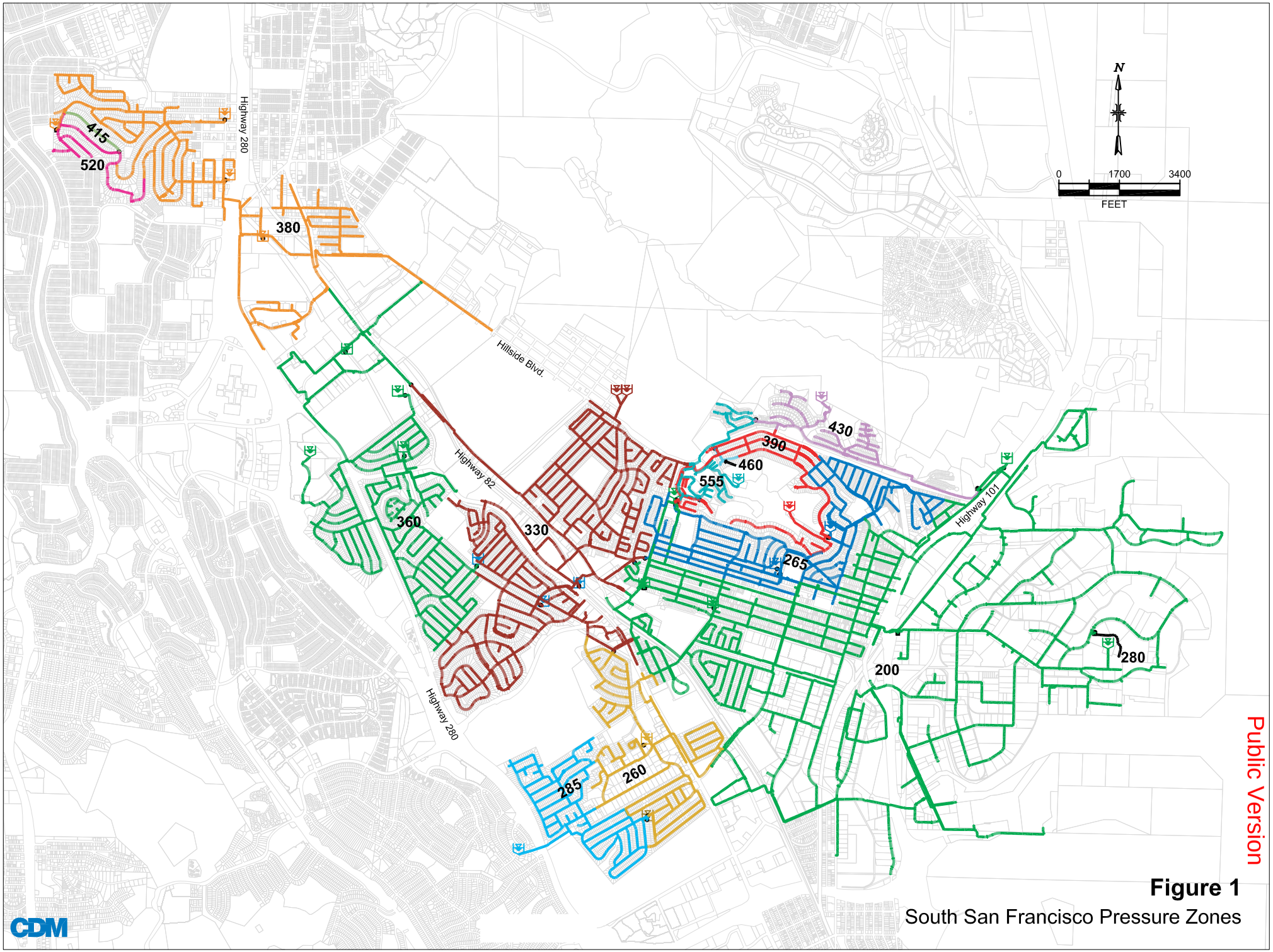

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Figure 1

South San Francisco Pressure Zones

CDM

Figure 2
South San Francisco System Schematic

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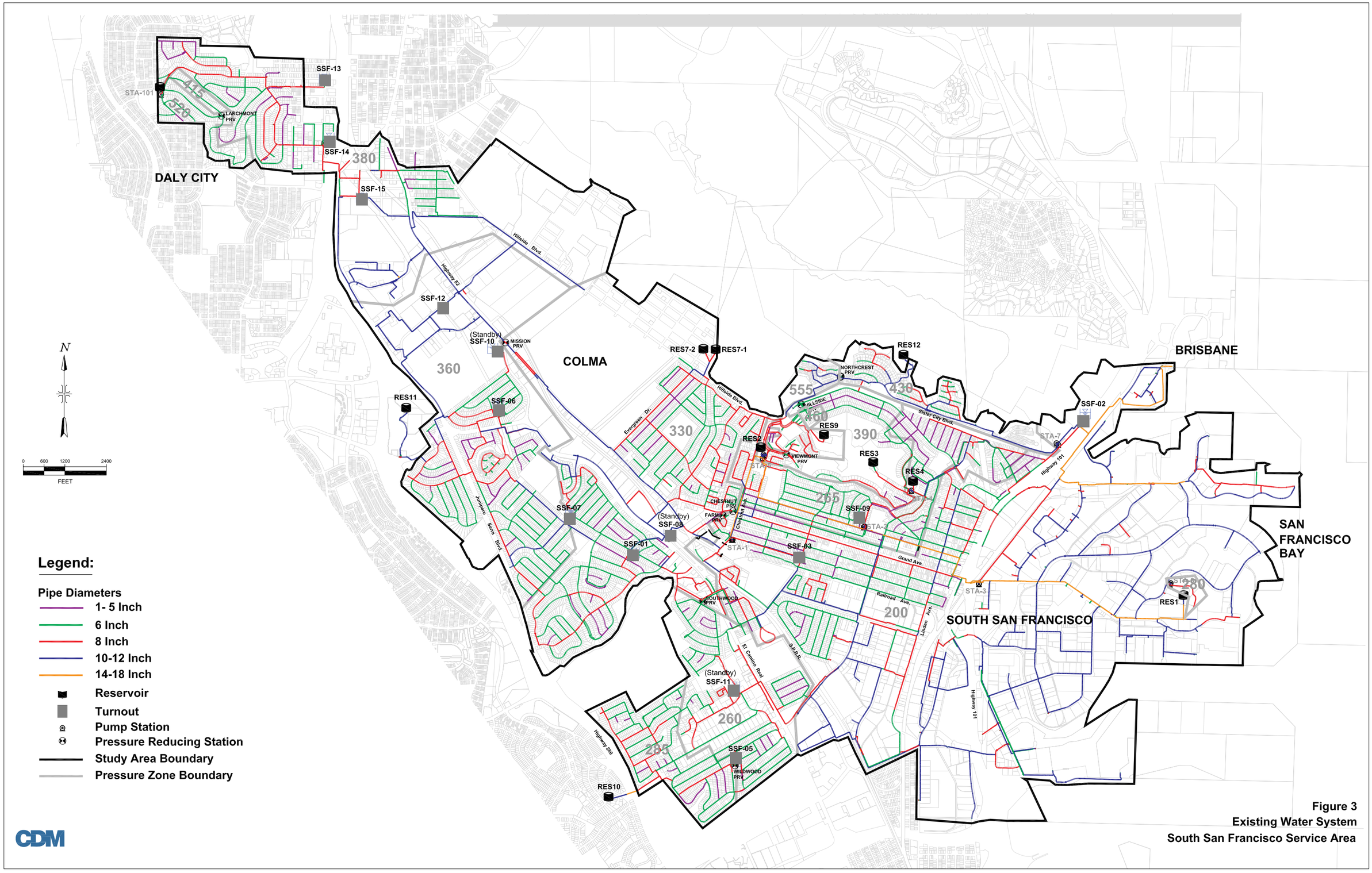

Figure 3
Existing Water System
South San Francisco Service Area

CDM

Node Elevations

Digital Elevation Models (DEMs) were used to calculate the model junction elevations. These DEMs consist of a raster grid of regularly spaced elevation values that have been primarily derived from the USGS topographic maps. For this study, 7.5 minute maps with 10 meter resolution were used.

ArcGIS 3D-Analyst extension tool was used to process the model junctions with the DEMs raster file to obtain the junction elevations.

Connectivity

Since GIS files are not typically set up with pipe-node connectivity in mind, CDM performed extensive checking to establish correct model connectivity, i.e., that the pipes are connected correctly to each other. H_2OMAP and similar software packages allow modelers to view connectivity on-screen and ensure that it matches the digitized images of pipes and nodes that represent the water system in the model.

Pumps

Cal Water provided pump design data, and pump test results from 1998 and 2003. This data was reviewed in conjunction with the system profile schematic to determine the most reasonable way to model each pump based on the available information.

Table 1 summarizes the key model information for the pumps. The pumps were modeled as single point design curves with a design flow and total dynamic head (TDH). The pumps are controlled to simulate system operations based on reservoir level control. These initial settings may be modified if appropriate based on the subsequent results.

Table 1
Pump Data

Pump Station and Pump	Elevation (ft)	Design Head (ft)	Design Flow (gpm)
Station1-A	34	166	1700
Station1-B	34	168	1700
Station1-D	34	160	1500
Station2-A	110	28	445
Station2-B	110	170	300
Station2-C	110	145	700
Station3-A	21	14	1600
Station3-B	21	35	1200
Station4-A	241	110	240
Station4-B	241	147	400
Station5-A	186	98	265
Station5-B	186	200	400
Station5-C	186	368	400
Station6-A	100	256	650

Table 1 Pump Data			
Pump Station and Pump	**Elevation (ft)**	**Design Head (ft)**	**Design Flow (gpm)**
Station6-B	100	256	650
Station6-C	100	256	650
Station6-D	100	256	650
Station7-A	50	125	550
Station7-B	50	125	550
Station101-A	320	160	200
Station101-B	320	168	450

Reservoirs

Table 2 summarizes the key model information for the reservoirs. Reservoirs were modeled to allow simulation of water level changes over time during extended period simulations, i.e., reservoir level fluctuations over the day. Reservoir dimensions, bottom elevations, and overflow elevations were taken from the system profile schematic. Minimum and maximum operating levels are specified for each reservoir.

Table 2 Reservoir Data				
Reservoirs (with Model Name)	**Volume (MG)**	**Bottom Elevation (ft)**	**Overflow Elevation (ft)**	**Diameter (ft)**
STATION-1 Clearwell	0.25	40	64	60
RES 1	1.50	172	191	116
RES 2	1.50	186	201	131
RES 3	0.05	375	391	23
RES 4 (1)	0.50	241	267	57
RES 7-1	0.25	298	327	38
RES 7-2	0.50	295	327	52
RES 9	0.50	525	554	54
RES 10	0.50	259	287	55
RES 11	1.00	323	357	71
RES 12	1.00	400	430	75
STATION-101 Tank	0.50	320	350	38

(1) RES 4 actually consists of two 0.25 MG tanks. It is modeled as one 0.5 MG tank using an equivalent diameter, since both tanks are at the same site and the same elevations.

Wells

The existing wells at Station 1 are not specifically modeled because they do not pump directly into the system. The wells pump to the treatment facility where the water is treated, and then stored in the adjacent clearwell tank prior to pumping through Station 1 into the distribution system. The Station 1 tank and pump station are modeled. These are the facilities that affect the distribution system hydraulics.

SFPUC Connections

SFPUC turnouts with a downstream pressure reducing station are modeled as a turnout at a fixed hydraulic grade line with a pressure reducing valve. CDM obtained some data on pressure settings, and has requested that Cal Water SSF District staff confirm these settings and provide the remaining outlet discharge settings at the existing PRVs. These settings will be used in the model.

SFPUC turnouts that discharge directly into the distribution system without pressure reduction are modeled as a flow controller that takes as much as needed to meet demands.

Table 3 summarizes the model data for the SFPUC connections.

Table 3
SFPUC Connections

SF Connection	***Location***	***Meter Size (inches)***	***Number/Size of Downstream PRVs***	***Outlet Pressure Setting at Downstream Side of PRV (psi)***
SSF-01	Buri Buri	10	1-8”, 1-10”	100
SSF-02	Bayshore Freeway	10	1-10”	77
SSF-03	Orange Ave.	2 – 6”	None	No PRV; direct connection to zone; SFPUC HGL 250 feet.
SSF-05	Brentwood	8	1-4”, 1-6”	117
SSF-06	Winston Manor	6	1-4”, 1-8”	88
SSF-07	San Felipe Ave.	6	1-6”	95
SSF-09	Elm Ct.	6	1-8”	42
SSF-12	Serramonte Blvd.	6	1-8”	106
SSF-13	88th St. & Sullivan St.	6	None	No PRV; delivery direct from connection to zone; SFPUC HGL 439 feet.
SSF-14	Washington & Sullivan	6	None	
SSF-15	D St. & Hill St.	6	None	
SSF-08 (standby)	Sunset	8	None	At these standby connections, the SFPUC delivery HGL is at or below the HGL of the service zone.
SSF-10 (standby)	Arlington	8	None	
SSF-11 (standby)	Blondin	8	None	

Pressure Reducing Valves

PRVs are included in the model with a setting to control the downstream pressure. Table 4 summarizes the model data for the PRVs. The PRVs settings were evaluated under existing and future conditions, and for capacity to meet fire flow and peak hour demands.

Table 4
Pressure Reducing Valves

PRV	Location	Number and Size of Valves	Outlet Pressure Setting at Downstream Side of PRV (psi)
PRV	Wildwood Dr	1-6”	86
PRV	Farm & Oak	1-6”	62
PRV	Southwood Dr.	1-6”	82
PRV	Chestnut & Grand	1-6”	112
PRV	Mission & El Camino Real	1-8”	100
PRV	Larchmont & Thornhill	1-4”	80
PRV	Hillside & Lincoln (390)	1-6”	52
PRV	Viewmont & Stonegate	1-6”	42
PRV	Northcrest & Windcrest	1-2”, 1-6”	58
PRV	Hillside & Lincoln (460)	1-2”, 1-6”	84

Demand Allocations

Demands were allocated to the appropriate junctions (nodes) of the water system hydraulic model. Below is a description of the process for allocating existing and future demands.

Existing Demands

The allocation of existing demands used the detailed water consumption data by individual customer account provided by Cal Water from their water billing database. The year 2003 customer data (average daily demand for each customer) was allocated to the nearest model node using GIS and model tools. A 5 percent multiplier was applied to the allocated consumption data to incorporate system losses (losses between supply source and customer). This method of allocating existing demands automatically accounts for large users and for variations in usage (demand per service) among different types of residential and non-residential customers.

The street addresses for each customer account were geo-coded using GIS tools and geographic data from TeleAtlas North America Inc. Once the customer addresses were geocoded, then the water usage data could be allocated to the model nodes. Geocoding is the process of assigning x and y coordinates to an address by comparing the descriptive addresses in the billing database to those present in the GIS layer of street center lines.

After the geocoding process was complete, the "Demand Allocator" extension in H2OMAP was used to allocate demands to water junctions. The closest pipe method was selected to assign demands to either the closest upstream or downstream nodes of each pipe. The demands that are routed to the nearest node may be assigned in full or may be split in a weighted fashion between the nodes connecting the pipe.

For each of the nodes, all billing records by revenue class are summed to represent the total demand imposed on that node by using. The billing revenue class was preserved in the model by keeping each revenue class in a separate demand field.

Table 5 shows the existing demands by pressure zone that were allocated to the model nodes.

Table 5
Existing Modeled Demands by Pressure Zone

Zone	Existing Demands including 5% System Losses (gpm)	(mgd)
200	3005	4.33
260	358	0.52
265	357	0.51
280	79	0.11
285	173	0.25
330	829	1.19
360	511	0.74
380	429	0.62
390	101	0.15
415	9	0.01
430	71	0.10
460	2	0.00
520	40	0.06
555	80	0.12
Total	**6044 gpm**	**8.7 mgd**

The geocoding engine assigns a score to each candidate in order to determine how closely each one matches the address that is geocoded. Each potential candidate is assigned a score from 0 to 100. The score of potential candidate will be lower if address components are misspelled (for example, the street name is misspelled), incorrect (for example, the street number of the address does not fall within the address range for the candidate), or missing (for example, if the street name in the billing database not exist in GIS layer).

These scores were evaluated to determine the accuracy of the geocoding process. The Cal Water billing database has 16184 records for year 2003 with 5700 gpm total water usage (not including 5% system losses). Of the total records, 96 percent received a score between 80 and 100 indicating that they were allocated correctly. Only 4 percent

received a score below 80 indicating that they were not geocoded correctly for the allocation. The 4 percent of records below 80 was only 130 gpm, or 2 percent of the total usage. Of the 130 gpm that were not correctly geocoded, CDM manually allocated 100 gpm to the nearest node by using reference maps. The remaining 30 gpm comprised only a half a percent of the total usage and were for accounts less than 1 gpm per account that will not significantly affect the results.

Future Demands

For future demands, the system-wide future service and demand information developed as part of the master plan (as discussed in Sections 2 and 3 of the master plan report) provided the basis for determining where future incremental increases in services and demands within the study area would occur. Incremental future demands were determined based on planning information regarding future development projects and redevelopment areas obtained from local planning agencies (City of South San Francisco, Town of Colma, and County of San Mateo). For the buildout model scenario, these additional future demands were allocated to model nodes.

Information on proposed development projects was also obtained from local planning agencies. Table 6 contains a list of the development projects. These are specific projects that have progressed to the point of development applications, tentative maps, improvement plans, and/or approval for construction. Typically these projects are relatively near-term projects that would be implemented over the next 5 to 10 years. In addition to these projects, future development will also include other projects not yet proposed by developers but that would be allowable by the General Plan at ultimate buildout.

The incremental future system demands were determined by using the near term proposed projects and the South San Francisco General Plan. The projected ultimate system demand is 11.0 mgd, an increase of 2.26 mgd from existing demands.

Table 6 lists the near term projects by project name, land use type and the estimated demands for each development. Demand for each development was estimated by using an average unit demand factor for each land use type. The total estimated demand from the proposed near term projects is 475 gpm. (0.68 mgd).

The South San Francisco General Plan lists the allowable future development by planning sub-area as of 1999, which includes the near-term projects as well as other future projects not yet proposed. Figure 4 shows the boundaries of the planning subareas. Based on the future land uses identified in the General Plan, an average unit demand was used to estimate the total incremental future demand by planning subarea. GIS tools were used to locate the proposed projects and the redevelopment areas within each sub-area. The demands for the specific proposed projects were subtracted from the total incremental future demand of the planning subarea, and the remainder was distributed within the identified redevelopment areas.

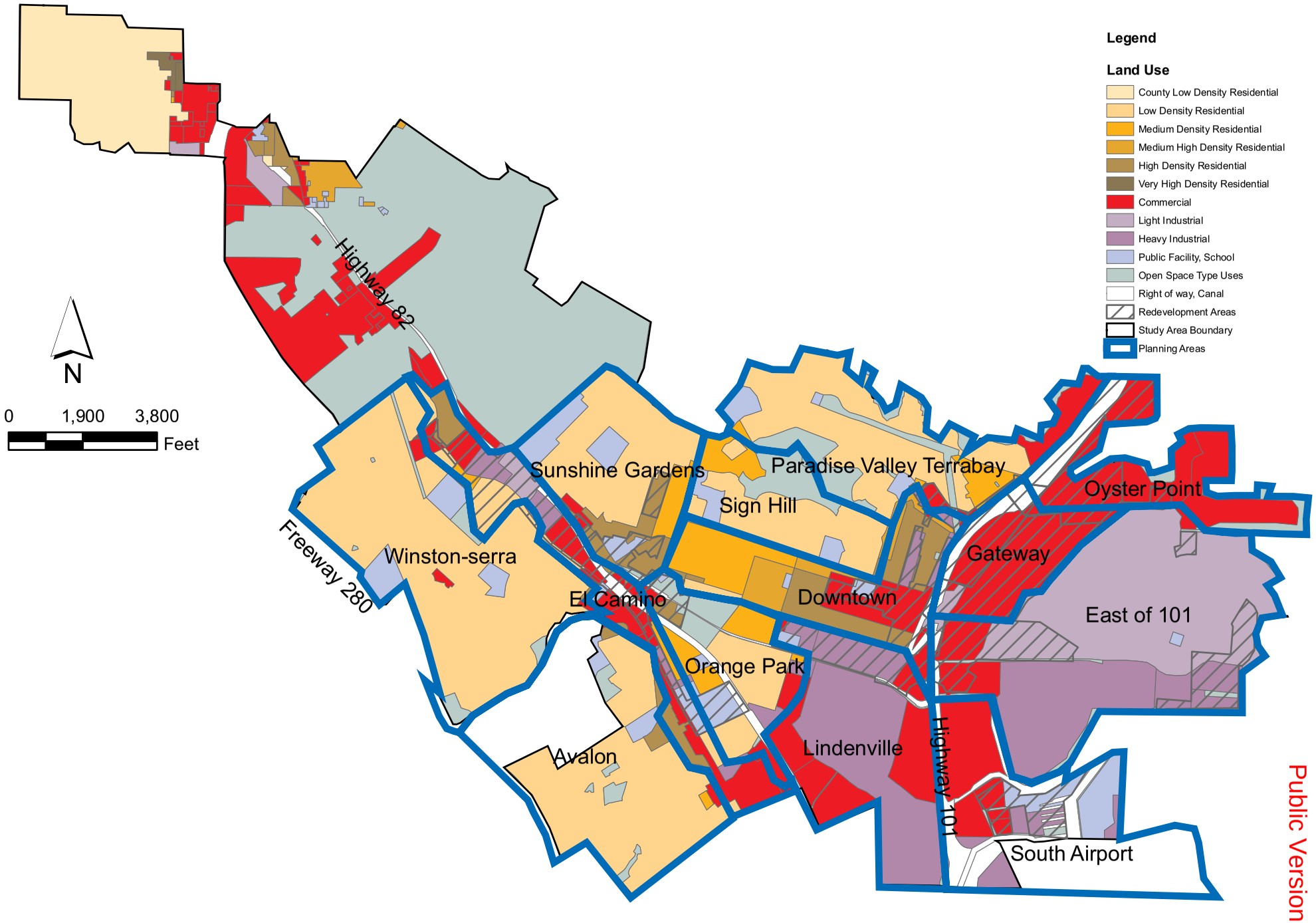

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Figure 4
Planning Sub-Areas

Table 6
Proposed Development Projects in the Study Area

General Plan - Planning Subarea	Project Name	Address	Major Land Use	Proposed Use	Current Status	Estimated Demands (gpm)
Gateway	Zymed Laboratories	561-571 Eccles Avenue, South San Francisco	Research & Development (R&D)	Conversion from manufacturing/warehouse 36,900 SF, 2.1 acres	Phase I Complete 10/01 Phase II Nearing Completion Time Extended	2.9
	Stuhlmuller Property Co.	180 Oyster Point Blvd., South San Francisco	Office	Office 3-Stories 20,000 SF Garage - At Grade, 2.35 Acre Site	Approved - Jan 05; Building under construction; estimated occupation 2006	3.1
	Malcolm Office Building	230 Oyster Pt Blvd, South San Francisco	Office	50,000 SF; Garage: 4 stories, 3.54 acres	Plans under review	4.8
	Kaiser Medical Facility	200 Oyster Point Blvd., South San Francisco	Medical office	Medical Treatment Facility, 19,200 sf / 1.64 acre site	Approved - Jan 05; Construction to start in 2005	2.2
	681 Gateway Specific Plan District	681 Gateway Blvd., South San Francisco	R&D	4-story bldg, 121,098 SF, 6-level parking garage, 8.2 acres	681 - Conversion from office to R&D / Building plans under review	11.2
Lindenville	Canal Street, LTD	401 & 425 South Canal St., South San Francisco	Office	25,000 SF (2 12,483 SF bldgs), 1.51 acres	Construction almost complete; Building Permit expires April, 05	2.1
East of 101	Britannia East Grand	Easterly terminus of East Grand Ave., South San Francisco	Office/R&D	785,000 SF; Childcare: 8,000 SF; Fitness center: 5,000 SF; Residential/Retail: 8,000 SF; Garages: 2 5/7 levels	Site Demo complete; Parking Garage under construction	31.5
	Sand Hill Property Company	345 East Grand Ave., South San Francisco	Office	210,000 SF, 2 floors, 6-level garage, conversion of existing building, 5.76 acres	Approved April 2002; project on hold	7.8
	333-351 Allerton R&D	333-351 Allerton Ave., South San Francisco	R&D	Conversion of Warehouse to 64,103 sf / Multi-Tenant Office/R&D	Approved - 9/04 Under Construction	5.0
	Bayside Area Development, LLC	285 East Grand Ave., 345 Allerton Ave., South San Francisco	R&D	61,770 sf Multi-Tenant Office R&D on 2.89 acres	Approved 11/04	3.9
	Alexandria Real Estate Equities	East Jamie Court, Haskins Way	R&D	2 bldgs, 133,000 SF, 6.1 acres; Bldg 1. 2 stories over parking level, 57,700 SF; Bldg 2. 3 stories, 75,300 SF	Approved November 2002; Time Extension to 12/05	8.3
	Slough Estates	333 Oyster Point Blvd	R&D	Office/R&D, 3 Bldgs, totaling 315,444 SF, Bldg A -four stories, 113, 222 SF; Bldg B - four stories,121,593 SF; Bldg C - three stories, 80,629 SF / Parking is provided at a ratio of 2.8 spaces per 1,000 SF	Planning Commission approved project - 2/05	24.6
	249 E. Grand Avenue, Office/R&D Project	249 E. Grand	R&D	4 Office/R&D buildings totaling approximately 500,000 sf, 4-level Parking Garage on a 15.75 acre site	Preliminary Review	21.4

Table 6
Proposed Development Projects in the Study Area

General Plan - Planning Subarea	Project Name	Address	Major Land Use	Proposed Use	Current Status	Estimated Demands (gpm)
East of 101 (cont.)	Britannia Pointe Grand Business Park	East Grand Ave / Harbor Way	R&D	Expansion of an Existing 20.3 Acre Business Park Office/R&D, 3 Bldgs, 167,000 SF, 8.3 Acre Site,	Conceptual plans under review	11.3
	Genentech Building 31	1631 Grandview Drive	Office	5 story bldg, 152,000 SF	Under Review	11.9
	Genentech Building 32	1541 Grandview Drive	Office	5 story bldg, 125,000 SF	Completed in December 2003	9.8
	Genentech Building 33	1633 Grandview Dr., South San Francisco	Office	5-story bldg, 127,000 SF	Construction underway; estimated completion 2005	9.9
	Genentech Building 34	1633 Grandview Dr., South San Francisco	Office	5-story bldg, 120,000 SF	Approval expected March 2005; construction to start in 2005	9.4
	Genentech Building 37 & garage	353 Point San Bruno, South San Francisco	Garage	Demolition of an existing 16,361 SF industrial bldg, construction of 7-level parking garage for 617 vehicles	Approved February 2004 Construction almost complete	
El Camino	Bally Total Fitness	180 El Camino Real	Commercial	Conversion of 40,000 sf bldg from retail to recreation	Under construction	3.1
	Century Theatres	410 Noor Ave., South San Francisco	Commercial	Construction of a 2,412-seat, 14-plex movie complex and amusement arcade within existing bldg pad	Under review; project may be incorporated into other development projects	8.4
	Fairfield Transit Village Plan	1600 El Camino Real, South San Francisco	Residential	Mixed use commercial/residential project adjacent to BART station and in the El Camino Real corridor, RDA - 361 apartment units, up to 50,000 SF of commercial space, including grocery store, pedestrian improvements on McLellan Dr.	Construction underway; Trader Joe's opened in Spring, 2005; Resident units under construction, due to be completed in 2006	3.9
				361 Apts		43.9
	Park Station Lofts	1410 El Camino Real		High density residential project with 99 units	Construction plans under review	12.0
Oyster Point	Bay West Cove Terrabay Specific Plan	Oyster Point Blvd/East of U.S. 101, South San Francisco	Commercial	Planning Area 1: Office/R&D: 600,000 SF, Restaurant/Retail: 20,000 SF, 20,000 SF of additional office	Approved 11/00; construction estimated to start in 2005-2006	25.0
			Office, R&D	Planning Area 2/3: 564,000 SF - Office/R&D, 10,000 SF - Restaurant/Retail, Childcare (80-100 children)		22.4
				Planning Area 4: 350 rooms	Approved 11/00: project on hold	14.6
			Office, R&D, Commercial	9-story 233,354 SF - Office, Three 4-story R&D Bldgs totaling 388,622 SF, 20,000 SF - Restaurant & Retail 5 level parking garage - 16 acre site	Approved 10/01	21.8

Table 6
Proposed Development Projects in the Study Area

General Plan - Planning Subarea	Project Name	Address	Major Land Use	Proposed Use	Current Status	Estimated Demands (gpm)
Downtown	111 Chestnut Ave.	111 Chestnut Ave., South San Francisco	Residential	8 condos, 0.45 acres	Construction plans under review	1.0
Sunshine Gardens	Oak Avenue Apartments	90 Oak Ave., South San Francisco	Residential	15 apartments, 0.45 acres	Approved June 2002; construction plans ready to be issued; construction estimated 2005-2006	1.8
	Phase II/III Terrabay Specific Plan	Grand Ave. & Oak Ave., South San Francisco	Residential	Less than 100 units of affordable housing	Informal review underway; construction estimated to begin in 2005; construction estimated to be complete in 2006	16.6
Sign Hill	Hillside Homes	Hillside Blvd & Stonegate Dr., South San Francisco	Residential	16 units	Approved; construction estimated to start in 2005; construction estimated to be complete in 2006	1.9
Paradise Valley/Terrabay	Phase II/III Terrabay Specific Plan	West side of US 101, north of Hillside Blvd., South San Francisco	Residential	Business commercial - 18 acres, 665,000 SF office with 10,000 SF support retail, performing arts center and 100-child day care center	Conceptual plans under review; construction estimated to begin in 2006; construction complete in 2007-2008.	24.5
	Phase II/III Terrabay Specific Plan	West side of US 101, No of Hillside Blvd	Open Space	Open Space / Recreation, 8.22 Acre Parcel - to be conveyed to the City of South San Francisco	In progress	
	Phase II/III Terrabay Specific Plan	West side of US 101, No of Hillside Blvd	Residential	Residential -14 Acre Parcel (Medium Density), 70 units paired housing in 35 structures	Under construction	11.6
	Phase II/III Terrabay Specific Plan	1 Mandalay Place, South San Francisco	Residential	Residential (Medium Density), 1 Acre parcel, 112 Condo units. Terrabay Precise Plan modified June 02 to change bedroom count & height (lower) of Condo tower	Complete	13.6
	Phase II/III Terrabay Specific Plan	Directly West of 1 Mandalay Place, South San Francisco	Residential, Commercial, Recreational	An application for 275,000 sq ft Office, 235,000 sq ft Commercial, a Multiplex Cinema, 37,000 sq ft of Restaurant and 336 Residential Units in a Highrise Condo (180 units), Townhouse (68 units) and Flat (88 units) configuration. A history walk, indoor/outdoor Performing Arts Center, a supervised play area for children and plazas and open spaces	Under review	21.3

Table 6
Proposed Development Projects in the Study Area

General Plan - Planning Subarea	Project Name	Address	Major Land Use	Proposed Use	Current Status	Estimated Demands (gpm)
Paradise Valley/Terrabay (Cont.)						40.8
	Phase II/III Terrabay Specific Plan	Directly West of 1 Mandalay Place, South San Francisco	Commercial	Buffer Parcel, 2.69 Acre Parcel - Zoned Business Commercial to permit ONLY limited parking	On hold by Developer	3.7
	Phase II/III Terrabay Specific Plan	West of Highway 101 nearby SSF-02	Open Space	Open Space - 25.73 Acre Parcel for Open Space, butterfly habitat, wetlands mitigation & possible hiking trail. Property to be conveyed to the County for inclusion in San Bruno Mountain County/State Park	Trust for Public Lands (TPL) purchased the property to convey to the County.	
					TOTAL	**47.3 (0.7 mgd)**

For each of the nodes, the incremental future demands applied at node are identified in the database, and the billing revenue classes are also identified in a separate demand field.

Diurnal Pattern

A diurnal pattern is required for extended period simulations. A diurnal pattern shows the hourly variations in customer demand (hourly peaking factors) over a 24-hour period. Diurnal patterns are typically developed from historic hourly flow data that is analyzed to determine variations in customer demands that have been adjusted to account for flows going into storage or passed through to other zones, i.e., during parts of the day, some flows in the system may be going to re-fill storage rather than to meet customer demands. If this detailed system-specific information is not available, then CDM reviews diurnal pattern information developed by other agencies to recommend a typical diurnal pattern for the analysis. For this master plan, system-specific hourly data was not available; therefore, the diurnal pattern is based on available information developed for the City of San Francisco system.

Figure 5 shows the diurnal pattern for the South San Francisco system. Figure 5 is a dimensionless profile that shows the ratio of the hourly flow to the average daily flow rate over a 24-hour period (starting with 0 hours at midnight). The hourly factors are applied to the average daily flow to obtain the hourly flow rates. It is based on diurnal patterns developed for the City of San Francisco system in the early 2000's using actual hourly flow data. These diurnal patterns reflect the variation of customer demands over a 24-hour period. The diurnal pattern for customer demand accounts for use of storage within the system, e.g., filling of storage and taking water out of storage to meet demands.

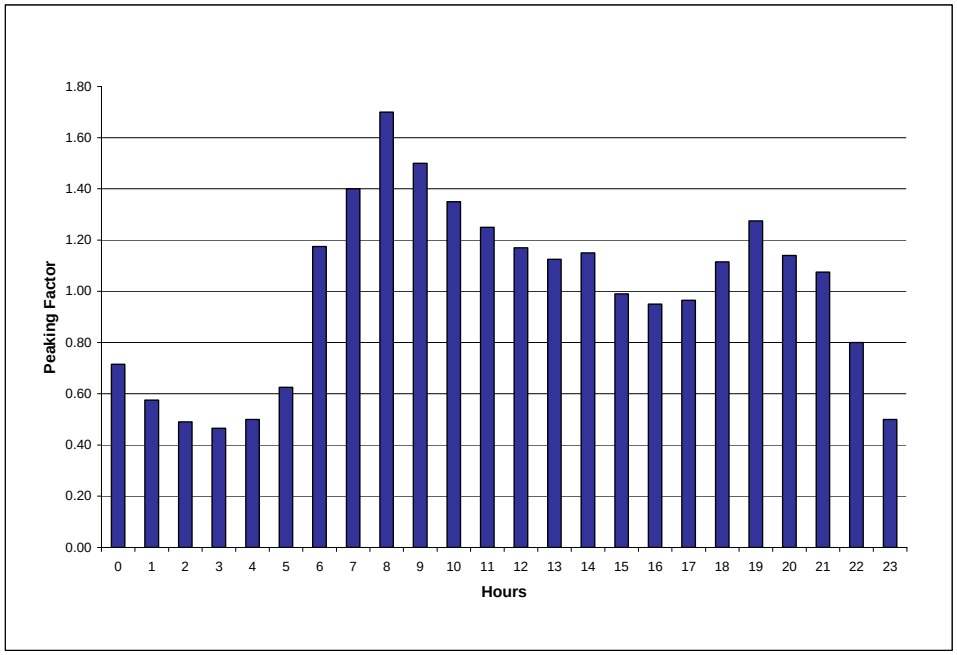

Figure 5
Proposed Diurnal Pattern

SFPUC also developed diurnal patterns for the Peninsula and for the South Bay to represent deliveries to the SFPUC turnouts to these areas. However, the Peninsula delivery diurnal curve is not an accurate reflection of customer demand within the Cal Water system, since some of the water delivered goes into Cal Water's South San Francisco storage facilities during some periods while water is taken out of storage to meet customer demand during other periods. The delivery diurnal pattern masks the effect of storage on the customer demand variations in the South San Francisco system.

In the future, if Cal Water obtains system-specific hourly flow data over a 24-hour period for the system as a whole and/or by pressure zone, that reflects customer demands and accounts for use of storage, this hourly information could be used to develop system-specific diurnal patterns for the South San Francisco system.

Model Calibration

Purpose of Model Calibration

The purpose of model calibration was to adjust pipe roughness values to more closely match the head losses and pressures actually observed during hydrant tests. Based on the hydrant flow test data, the observed pressure drop at the residual hydrant over the duration of the test is related to the diameter and roughness of the pipe in the vicinity of the tested hydrants. This relationship is the basis for the adjustments in roughness values made during model calibration. The methodology and findings are described in more detail below.

Hydrant Flow Tests

Cal Water staff conducted hydrant tests on March 24 and March 25, 2005 at 16 locations within the South San Francisco system. Figure 6 shows the locations of the hydrant tests used for the calibration runs. These locations included at least one location in each major zone. Two or three locations were tested in the largest zones that are spread out over a greater area, such as the 200 Zone. No tests were conducted in a few very small zones served by PRVs, since a calibration effort was not warranted for those zones.

The specific locations were identified based on the following characteristics: 1) not too close to a reservoir or turnout; 2) on a 6-, 8-, or 10-inch pipe - since if pipes are too large, it is difficult to generate sufficient head loss during a hydrant test to detect changes due to pipe roughness; and 3) accessibility and safety considerations for staff conducting the tests.

The first step in the hydrant tests was to record the static pressure at each test location. Then, the flow hydrant was opened and the pitot pressure, which can be correlated to hydrant flow rate, and the residual pressure were measured with the hydrant open and flowing. The observed flow rate was then determined based on the observed pitot pressure.

In most cases, static and residual pressures were taken on a hose bib located on an adjacent service connection of equal elevation to the hydrant test location. The only exceptions were one location where the reading was taken at an adjacent hydrant, and one location where the reading was taken on the system side port of a backflow prevention device.

For hydrant testing, Cal Water utilizes diffusers with built-in pitot gauges procured from Pollard. Pollard provides an instrument-specific chart that relates flowrate to pitot pressure. Flow rates can also be calculated based on equations in the National Fire Protection Association (NFPA) Manual 291 "Recommended Practice for Fire Flow Testing and Marking of Hydrants". Pitot pressures typically fluctuate during testing and an "average" is typically used. A pressure fluctuation of +/- 2 psi would result in a flow rate variation of +/- 4 to 10 percent.

Input Data for Calibration Runs

As noted above, hydrant testing was conducted on March 24 and 25, 2005. Cal Water provided CDM with system data for the days of the tests, along with hydrant test data. The system data included: circular charts and spreadsheets of reservoir levels, circular charts of pump operations, and daily production records for pump stations and turnouts. The system data was used in the model calibration runs to set reservoir levels, pump on/off status, and turnout head/flow conditions to simulate actual system conditions during the hydrant tests.

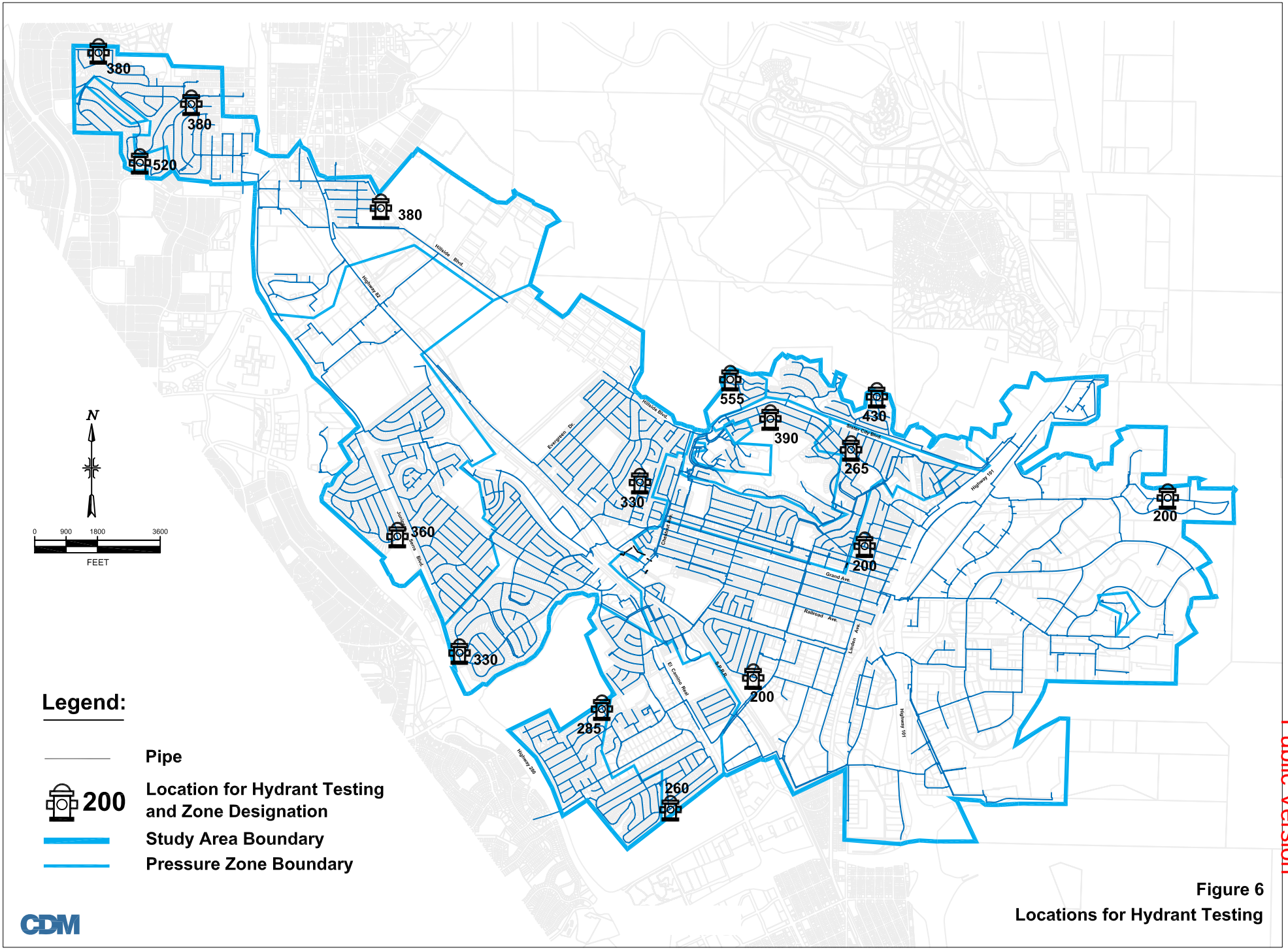

Figure 6
Locations for Hydrant Testing

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Eighteen calibration scenarios were set up for the model simulations. Each calibration run represented instantaneous conditions at the time of the hydrant test. Daily production records for the two test days were provided by Cal Water and model average daily demands were adjusted to match daily production.

A model run for each hydrant test was set up and system demands in the model were adjusted using a multiplier from the diurnal pattern to simulate the demands at the time of the hydrant test. Because the diurnal curve used in the model is general for the entire system, model demands are expected to approximate actual demands at the time of the test, which were not known.

Calibration Method

Pipe roughness values in the model are represented by the Hazen-Williams roughness coefficient, or C-value, which is inversely proportional to head loss. High C-values correspond to relatively smooth pipes with small head losses. Most pipelines in good condition or with interior linings have C-values ranging from 120 to 140. Pipelines with extensive corrosion, such as unlined cast-iron mains, could have C-values as low as 70 or 80 which corresponds to relatively rough pipes with higher head losses. During the calibration process, in areas where modeled pressure drops were larger than observed pressure drops, the C-values are increased, and vice versa.

Table 7 summarizes the preliminary pipe roughness factors (C-values) used as a starting point for the calibration process. Pipeline data provided by Cal Water from its GIS included pipeline diameter and material types; age information was not available. Therefore, preliminary C-values were based on pipeline diameter and material types. The preliminary factors in Table 6 are typical values based on CDM experience with other water systems in the area, industry standards such as AWWA, and other sources, including Haestad, and relevant text books.

Table 7
Preliminary Pipe Roughness Factors Used as Starting Point for Calibration Process

Pipe Material	*Percent of Pipe in System*	*Diameters of Existing Pipes (in)*	*Preliminary C-Values*
Asbestos Cement, Transite, Concrete Cylinder Pipe, Cement Lined & Coated Pipe	61%	4-18	130
Cast Iron - unlined	23%	1-18	85-120
Ductile Iron	8%	2-18	120
Copper	< 0.3%	1-2	120
Polyethylene, Polyvinyl Chloride	6%	4-16	130
Steel	2%	1-14	120-130

The preliminary factors (C-values) were adjusted as needed during the model calibration process described in the subsequent sections. The recommended roughness factors based on the calibration findings are presented later in this memo.

Once the hydraulic model was set up for each calibration model scenario using system data provided by Cal Water, each scenario was run for the following two conditions:

1) With no flow at the hydrant location to simulate closed hydrant or "static" conditions; and

2) With a demand equal to the hydrant flow applied at the hydrant location to simulate flowing hydrant conditions.

For static conditions, model results were compared with operating data to make sure results were consistent with observations. For example, model results were reviewed to make sure tanks were filling, draining or closed, consistent with system data.

Modeled static pressures were also compared with actual (observed) static (pre-test) pressures. However, these comparisons were not used for calibration purposes because, under low flow conditions, modifying roughness values does not produce a large change in static pressure. An error in static pressure is most likely due to another source, such as errors in ground elevation. Modeled ground elevations were assigned using a Digital Elevation Model (DEM) derived from USGS topographic maps. DEMs with a 10-meter (33-foot) resolution were used.

Locations where large differences in static pressure were observed are noted as areas requiring potential future refinement (in the summary table of calibration results discussed later in this section). CDM also recommends that for future hydrant testing, Cal Water consider using GPS units to verify hydrant test elevations. This information could then be used to further refine the model.

Once model results were checked, the difference in pressure between the two runs (non-flowing hydrant and flowing hydrant) was compared with the pressure drop observed during hydrant testing. By comparing the pressure drop rather than modeled and measured pressures, potential errors due to incorrect model elevations were eliminated.

The calibration process consisted of changing pipe roughness values until the difference between observed and modeled pressure drops reached a minimum or acceptably low value. The model was considered to be calibrated when the modeled pressure drop was within +/- 5 percent of observed pressure drops. This is the AWWA Engineering Computer Applications Committee recommended criterion for

model calibration for models to be used for planning applications.[1] Generally, roughness factor adjustments were made to groups of pipes based on pipe material and diameter. The model database discussed in the draft Task 4 Tech Memo and the facilities inventory in the draft Task 3 Tech Memo contain detailed information on pipe material and diameter.

In some instances, model results could not be adjusted to obtain results within +/- 5 percent of observed values, without selecting unrealistic Hazen-Williams C-values. Some possible sources of error that may cause poor agreement between modeled and observed pressures include: errors or anomalies in model data or model configuration, node elevation errors, not modeling all small diameter pipes, outdated or unknown pump curves, uncertainties in estimated pipe roughness factors, not having complete information on system conditions during the field tests, and poorly calibrated measuring equipment.

For locations with significant differences between modeled and observed pressures, the following steps were taken to investigate the source of differences:

- Elevation verification - checked node and reservoir elevations in the model.
- Geometric verification – checked for missing pipes or incorrect diameters in the model.
- If the pressure difference was still significant after conducting the above two steps, the distribution of supply from tanks, pumps, and/or turnouts was then investigated, to see whether the results may have been affected by the way these sources are modeled. The relative contribution of supply from the various sources may significantly affect headlosses in the system.

Where model results could not be resolved with observed data, CDM identified the most likely causes and recommended actions for Cal Water to investigate to identify possible sources of error. Cal Water then provided additional information to refine the calibration.

The additional information addressed the following issues identified in the initial calibration runs:

- In Zone 265, a hydrant test was conducted at Hillside Drive and Franklin Avenue. This location is just north of and is supplied by Reservoir 4, via a loop of 4, 6, and 8-inch diameter pipelines. The hydrant test showed a pressure drop of 44 psi at a flow of 2,272 gpm compared to a pressure drop of 101 psi predicted by the model. Of the 101 psi head drop predicted in the model, 80 psi is generated through the loop of 4, 6, and 8-inch diameter pipelines. The measured static head during the test was

[1] AWWA Engineering Computer Applications Committee, 1999."Calibration Guidelines for Water Distribution System Modeling." 1999 AWWA Information Management Technology Conference Proceedings.

78 psi which corresponds to hydraulic grade line of 296 feet (78 psi plus ground elevation of 116 feet equals an HGL of 296 feet). This HGL is much higher than the HGL of the nearby Reservoir 4, indicating either a pressure measurement error, or incorrect model elevation. At the time of test, the reservoir was 92 percent full and draining, with a corresponding HGL of 265 feet.

Even by adjusting C-values to the limit of the reasonable range, it was not possible to closely match the measured pressure. This mismatch between measured and modeled might be due to several reasons, such as inaccurate pitot gauge reading, mis-reported outlet size of the hose, possible open valve (zone gate) from adjacent zones 390 or 430, or incorrect pipeline sizes.

- In Zone 380, the two hydrant tests were conducted at Maddux Drive and Foothill Drive. The area, located at the northwest corner of the Cal Water service area, is supplied from turnout SSF-13, turnout SSF-15, and Station 101 Reservoir via 8-inch diameter pipelines. The first test was conducted with turnout SSF-13 on-line, with a flow rate of 690 gpm. The second test was conducted with turnout SSF-13 off-line, with a flow rate of 650 gpm. The modeled static pressures are within 2 to 4 psi of the measured pressure. However, the measured pressure drop is 97 to 105 psi and the modeled pressure drop is only 23 to 45 psi. All model data for the area was checked for consistency with the available information. The measured headlosses appear very high. Even adjusting C-values to the limit of the reasonable range, it was not possible to closely match the measured pressure. Potential sources of error included: unknown field conditions that were not modeled such as a closed or partially closed valve, most likely along Maddux Drive, or incorrectly reported hydrant outlet size.

- In Zone 430, a hydrant test was conducted at Heritage Street and Pinnacle Street. This area is supplied from Northcrest PRV Station, Pump Station 7 and Reservoir 12 via 12-inch diameter pipeline. However, the piping in the immediate vicinity of the test location is 570 feet of single feed 8-inch diameter pipeline. The hydrant test showed a measured pressure drop of 16 psi at a flow of 2239 gpm compared to a modeled pressure drop of 33 psi predicted by the model. Adjusting C values from 120 to 135 only improved the pressure by 6 psi and did not account for all the pressure difference. The low pressure drop from the field data appears suspect. Based on the Hazen-Williams equation, the estimated headloss in the single feed 8-inch pipe (570 feet) in Heritage Street leading to the hydrant location would be 46 feet (20 psi); which does not include any head loss in the 12-inch pipe (3600 feet) long from Reservoir 12 to West Street. The difference between the measured and modeled pressures could be due to inaccurate pitot measurement reading, incorrect pipe diameters (bottlenecks) in the model, or incorrectly reported outlet hose size.

Final Calibration Results

During the calibration process, revisions were made to the model as needed in order to: correct geometric anomalies in the modeled system, and adjust the pipe roughness factors to reasonable values. Table 8 summarizes final results from the calibration analysis after all adjustments were made to the model. The last column of Table 8 summarizes the additional information provided by Cal Water for the calibration refinements.

Field information provided by Cal Water listed in the table includes: test number, test location, test date and time, hydrant outlet size, pitot pressure, measured static pressure and measured residual pressure. Using the test location description, CDM located the correct hydrant on Cal Water maps, and selected the nearest model node (or added a model node if needed) to represent the hydrant location.

The hydrant flow rate was computed from the pitot pressure reading and the static HGL was computed from the model elevation and static pressure reading. The right columns of Table 8 show the observed flow calculated from the field data, the comparison of measured and modeled static pressure, the comparison of the measured and modeled residual pressures, and the measured and modeled pressure drops.

For seventeen out of eighteen hydrant tests, the measured pressure drop and the modeled pressure drop are within 5 psi. Of these seventeen tests, eleven had results within 2 psi. This indicates good agreement at these locations. Only one location had a pressure drop greater than 5 psi, and it was at 10 psi.

Recommended Roughness Factors (C-Values)

Based on the calibration analysis, C values in the model were adjusted to improve the agreement between the observed field data and predicted model results. For each calibration location, adjustments to pipe roughness were compiled taking into account the diameter and material. Adjustments to C-values were then applied to pipes with the same attributes in that pressure zone.

Table 9 summarizes the recommended overall roughness values for use in the Task 5 facilities analyses. These values are based on the calibration analysis, and are also consistent with the reasonable values typically specified in standard references. For planning purposes, relatively conservative values were selected to provide a factor of safety for aging of pipes over time.

The ranges shown in Table 9 are due to the fact that the C-value varies between zones based on the results of the calibration adjustments. For example, the C-value for an 8-inch asbestos cement pipe in one zone may be different than that for an 8-inch asbestos cement pipe in another zone.

Table 8
Summary of Hydrant Flow Test Data and Calibration Results

Hydrant Test Data Provided by Cal Water						Data Computed by CDM				Static Pressure (psi)			Residual Pressure (psi)			Pressure Drop (psi)			
Zone	*Test No.*	*Test Location*	*Test Date*	*Outlet Size (in)*	*Pitot Pressure (psi)*	*Model Node ID*	*Computed Hydrant Flow (gpm)*	*Assumed Ground Elevation (feet)*	*Computed Static HGL (feet)*	*Measured by Cal Water*	*Modeled*	*ΔP*	*Measured by Cal Water*	*Modeled*	*ΔP*	*Measured*	*Modeled*	*ΔP*	**Comments on Calibration Refinements with Additional Data Provided by Cal Water**
200	200 A	Fir Ave., 200' N of Myrtle Ave.	3/25/2005	2.5	47	12056	1149	19	204	80	78	2	64	63	1	16	15	1	
200	200 B	California Ave. 7 Maple Ave.	3/24/2005	2.5	37	5458	1020	62	201	60	61	-1	52	53	-1	8	8	0	
200	200 C	2nd hyd W of E. Basin Rd & E. Basin Cir.	3/24/2005	4.5	33	6540	3120	0	194	84	84	0	58	59	-1	26	25	1	
260	260	Manor Dr. &b Springwood Dr.	3/25/2005	2.5	39	9064	1047	92	268	76	76	0	64	61	3	12	15	-3	
265	265	Hillside Dr. & Franklin Ave.	3/24/2005	4.5	17.5	286	2272	116	296	78	62	16	34	16	18	44	46	-2	Revised based on pipeline improvement information in the vicinity of the test location provided by Cal Water on 9/9/05. With the pipe improvements modeled, the results closely match.
285	285	Ponderosa Rd. & Comerwood Ct.	3/25/2005	2.5	23	8618	804	103	311	90	100	-10	38	50	-12	52	50	2	
330	330 A	Estate Ct. & Willow Ave	3/25/2005	4.5	28	8250	2874	129	332	88	82	6	52	42	10	36	40	-4	
330	330 B	Escanyo Dr. & Alta Mesa Dr.	3/24/2005	2.5	23	7600	804	228	334	46	47	-1	34	34	0	12	13	-1	
360	360	Longford Dr., 1st hydrant north of Dundee	3/24/2005	2.5	42	12176	1086	221	387	72	58	14	58	44	14	14	14	0	
380	380	Maddux Dr. & 87th	8/3/2005	2.5	33	2676	1883	164	414	108	111	-3	62	70	-8	46	41	5	Revised based on additional hydrant testing and pressure monitoring data in the area provided by Cal Water on 8/5/05. Using the additional data, the results closely match.
380	380 B	"D" St. 400' E of Clark Ave.	3/24/2005	4.5	10	2376	1717	217	471	110	96	14	20	6	14	90	90	0	
380	380 C, Test 1 (1)	Washington St. bet. McArthur Dr. & Sweetwood Dr.	3/24/2005	2.5	37	3322	1020	135	454	138	131	7	108	102	6	30	29	1	
380	380 C, Test 2 (2)	Washington St. bet. McArthur Dr. & Sweetwood Dr.	3/24/2005	2.5	33	3322	963	135	454	138	130	8	94	84	10	44	46	-2	
390	390	Larch Ave. & Kearney St.	3/24/2005	2.5	23	10276	804	135	297	70	66	4	30	28	2	40	38	2	
430	430	Heritage St. & Pinnacle St.	3/24/2005	4.5	17	5354	2239	297	426	56	56	0	40	23	17	16	26	-10	Revised based on additional hydrant test and pressure monitoring data in this area provided by Cal Water on 8/5/05. Both initial and followup tests in this area were consistent.C-values in the model were adjusted to the upper range typical of the pipe types (150 for PVC pipes and 135 for DI pipes). This improved the agreement between measured and modeled values. However, model is still overpredicting the headloss in the area. Pipe diameters in the vicinity could be field verified to determine if the modeled pipe diameters are accurate. If pipes are larger than modeled, headloss would be lower and results may more closely match measured values.
520	520	Larchmont Dr, 300' from end	3/24/2005	2.5	16	12428	671	287	490	88	87	1	38	34	4	50	53	-3	
555	555	Baycrest Way 250' W of Viewcrest Cir.	3/24/2005	4.5	13	10300	1958	334	542	90	91	-1	38	34	4	52	57	-5	

(1) For this test, supply from SFPUC Connection SSF-13 available.
(2) For this test, supply from SFPUC Connection SSF-13 removed.

Table 9 Recommended Pipe Roughness Factors for Hydraulic Evaluation Based on Calibration Analysis (C-Values)			
Pipe Material	**Diameters of Existing Pipes (in)**	**Preliminary C-Values**	**Recommended C-Values from Calibration**
Asbestos Cement, Transite, Concrete Cylinder Pipe, Cement Lined and Coated Pipe Asbestos Cement	4	130	100-130
	6	130	100-130
	8	130	100-130
	10-18	130	130-135
Cast Iron	1-4	85-120	85
	6-12	85-120	100-110
	16-18	120	120
Ductile Iron	4	120	85-120
	6-8	120	120-135
	10-18	120	120-135
Copper	1-2	120	130
Polyethylene, Polyvinyl Chloride	4-16	130	130-135[(1)]
Steel	1-14	120-130	120-135

(1) In the 430 zone, PVC pipe has a C-value of 150 based on the hydrant test results. This is the only zone with a C-value that high.

Overall Calibration Findings

In general, definitive standards to assess the accuracy of model calibration for water distribution system have yet to be agreed upon or established. A general criterion suggested by the AWWA Engineering Computer Applications Committee is that the difference between measured and modeled values should be within a range of +-5 psi for a model to be considered calibrated for planning applications.

The overall calibration results based on the available data indicate that the model is a reasonable representation of the system. Fourteen out of eighteen test locations were within 5 psi of the measured pressure drop, with ten of these locations within 2 psi of the measured pressure drop.

At the other four locations (including one location where two tests were done), there were greater differences between the measured and modeled pressures. These locations are discussed in detail earlier in this addendum under "Calibration Results". The discrepancies may be due to inaccuracy of field measurements, partially closed valve(s) which were not modeled, or lack of detailed information on pump curves (modeled as single design points based on the available data). For each location, CDM has identified data checks that Cal Water can do to possibly resolve discrepancies between modeled results and observed conditions. In our judgment after careful

review of the results, even if these discrepancies cannot be resolved, the model is providing reasonable results for these portions of the system.

Overall, the model is predicting reasonable results and can be used to predict system performance under future demand conditions.

Model Verification

Purpose of Model Verification

To verify the validity of the calibrated hydraulic model, CDM simulated historic operating conditions on the following days selected by Cal Water:

- Maximum demand day of June 16, 2004; and
- Minimum demand day of January 23, 2004.

For the model verification, model results are compared with the actual (observed) system data. If the model is reasonably accurate, modeled pump station flows and suction and discharge pressures should match actual (observed) flows and pressures, and modeled reservoir levels should track actual (observed) levels.

Depending on the data available, different levels of verification can be performed. Where detailed information is available (zone inflows, outflow and reservoir levels) that allows calculation of pressure zone demands, hourly zone demands can be calculated. The model is then set up to reproduce both observed demands and operating conditions (pump starts/stops), and model results are reviewed to determine how well the model predicts zone operations (pump station flows, suction and discharge pressures, reservoir levels). Similarly, if pump station flow, suction and discharge pressure information is available, the pump total dynamic head and flow, based on measurements, can be compared with pump performance in the model, and model results adjusted to get the best fit of actual pump performance conditions.

Where system information is incomplete and a diurnal curve cannot be constructed, the model is run for a 24-hour period with the daily system demand set to match actual daily demand, and model trends are reviewed for consistency with operating data, recognizing that hourly trends may differ from observed. Although this comparison is more qualitative, the model's ability to represent observed conditions can still be assessed by evaluating parameters such as reservoir level operating ranges, and degree of cycling, to determine consistency with observed conditions. Because flows are typically not recorded at pump stations or regulating stations in the Cal Water South San Francisco system, model verification used this second approach.

Input Data for Verification Runs

Cal Water provided system data for the selected days for CDM's use in the verification. This data, summarized in Appendix 1, was used as follows:

- For tanks, circular charts were provided showing hourly water elevation data. Initial reservoir levels at midnight were set to match those on the circular charts.
- For pump stations, limited data was provided. Circular charts mostly showed discharge pressure and suction pressure or pump flows.
- For turnouts, circular charts were provided showing pressure settings.
- Daily production records for supply sources including turnouts, wells, and pump stations were used to determine the total system demand and the distribution of supply to the system.

CDM assumed the following model input data:

- Pressure settings at the PRV stations in the system from Tables 3 and 4.
- Pump design point curve from Table 1 (based on pump test data).

Verification Methods and Results

If the model is an accurate representation of the physical system, modeled pump station suction and discharge pressures should reasonably match observed pressures, and modeled reservoirs should operate within similar levels and cycling frequencies as observed conditions. To assess accuracy, the two 24-hour simulations were set up, to represent maximum day and minimum day conditions, and model trends were compared to the observed data for both days. Available suction pressures, discharge pressures, and reservoir level trends were used as the basis of comparison.

The calibrated model from the hydrant test calibration was used for the verification runs. For both the maximum day and the minimum day verifications, the modeled results generally tracked system performance trends. The pump and turnout flows were set to match the field data. The modeled results for reservoir level trends for both days closely matched the actual reservoir levels throughout the day.

Overall, model results showed all reservoir levels for summer day and winter day verifications were in good agreement with the measured data. Model results varied from 1 to 3 feet of the measured data with similar data trends. Eight out of ten reservoirs, modeled levels were within 1 foot of the measured levels. The remaining reservoirs were within 1 to 3 feet of the measured levels.

The verification runs with the available system data indicate that the calibrated model provides a reasonable representation of the system performance under both high and low demand conditions. Consistency of reservoir level trends was the primary

criterion used to evaluate consistency between the actual data and modeled results. Good to excellent results are typically considered to be those where hourly reservoir levels match within one foot. Eight out of ten reservoirs met this criterion.

Table 10 summarizes the key results from the verification runs for each reservoir and pump station. Appendix 2 provides plots showing the hourly measured and modeled water level at each reservoir for the maximum (summer) day simulation. Appendix 3 provides plots showing the hourly measured and modeled water levels at each reservoir for the minimum (winter) day simulation.

Since actual diurnal trends could not be modeled, the comparisons consisted of evaluating reservoir levels and cycling trends for consistency with operating data and comparing modeled pump station pressures with observed. Differences between model results and observed conditions could be due to incorrect friction losses in the zone, or due to pumps operating at different flow rates in the model than in the field. Without more detailed information regarding pump station flow rates, discrepancies can be difficult to resolve. Where differences were observed, these are discussed and recommendations for possible Cal Water actions identified to resolve discrepancies.

Table 10
Summary of Verification Results

Facility	***Summary of Results***	
	Maximum (Summer) Day	***Minimum (Winter) Day***
Reservoirs		
RES 1	No change in reservoir levels remained at 11.5 feet	No change in reservoir levels remained 10 feet
RES 2	Model results were in agreement with measured data in the first 10 hours after that model results varied within 2.5 ft of measured data.	Measured data was incomplete
RES 3	Model results were in good agreement with measured data matching the minimum and maximum levels with a reasonable trend.	Model results were in good agreement with measured data matching the minimum and maximum levels with a reasonable trend.
RES 4	Model results were in good agreement with measured data where modeled levels were within 1 foot of measured levels	Model results were in agreement with measured data in the first 11 hours after that model results varied within 2. ft of measured data with similar trend.
RES 7-1	Data provided (circular chart) was not legible	Model results were in good agreement with measured data where modeled levels were within 1 foot of measured levels
RES 7-2	Data provided (circular chart) was not legible	No change in reservoir levels remained at 25.5 feet
RES 9	Model results were in good agreement with measured data where modeled levels were within 1.5 feet of measured levels	Model results were in good agreement with measured data where modeled levels were within 1.0 feet of measured levels

Table 10 Summary of Verification Results		
	Summary of Results	
Facility	Maximum (Summer) Day	Minimum (Winter) Day
RES 10	Model results were in good agreement with measured data where modeled levels were within 1.0 feet of measured levels	Model results were in good agreement with measured data where modeled levels were within 1.0 feet of measured levels
RES 11	Model results were in good agreement with measured data where modeled levels were within 1.0 feet of measured levels	Model results were in good agreement with measured data where modeled levels were within 1.0 feet of measured levels
RES 12	Model results were in good agreement with measured data where modeled levels were within 1.0 feet of measured levels	Model results were in good agreement with measured data where modeled levels were within 1.0 feet of measured levels
Broadmoor	Model results were in good agreement with measured data where modeled levels were within 1.0 feet of measured levels, except for the first two hours.	Model results were in good agreement with measured data where modeled levels were within 1.0 feet of measured levels, except for the first 4 hours.
Pump Stations		
Station 2	Modeled discharge pressures were within 5 psi of the measured pressure with similar trend	Measured discharge pressure is 115 psi. This does not agree with the same pump station for summer day operation. This is further discussed in the text.
Station 5B	Modeled discharge pressures were within 6.5 psi of the measured pressure with matching trend	Pump was off
Station 5C	Pump was off	Modeled discharge pressures were within 5 psi of the measured pressure with matching trend
Station 6	Modeled discharge pressures varied within the same range as the measured pressure, except that the trend is mismatching because model reports results only at hourly intervals	Modeled discharge pressures varied within the same range as the measured pressure, except that the trend is mismatching because model reports results only at hourly intervals
Station 7	Modeled discharge pressures were within 1 psi of the measured pressure with similar trend	Modeled discharge pressures were within 1 psi of the measured pressure with similar trend
Broadmoor	Modeled discharge pressures varied within the same range as the measured pressure, except that the trend is mismatching because model reports results only at hourly intervals	Modeled discharge pressures varied within the same range as the measured pressure, except that the trend is mismatching because model reports results only at hourly intervals

For the summer day verification, model results after hour 10 for Reservoir 2 did not closely match the measured data. This could be caused by Station 5 Pump Station where pumps could be pumping more than what the model is predicting.

For Pump Station 2, the discharge pressure for summer day was 80 psi as shown on the circular chart. For the same pump station, for winter day, the pressure shown on the circular chart is 115 psi. It is possible that the winter day chart was mis-labeled.

Suction and discharge pressures were not provided for all pump stations. For those that data was provided, model results showed similar trends to measured data with pressure varying up to 6.5 psi. This difference in pressure may be attributed to discrepancy in elevation between the model and the field, or due to different operating conditions in the model than in the field (e.g. different headloss through the zone, or pump operating at a different point on the curve). The elevations in the model are from the system facility profile provided by Cal Water where pump stations are shown at the same bottom elevation as the nearby reservoir.

Results indicate that the model reasonably predicts pump station pressures and is suitable for planning-level studies. As a future refinement, Cal Water may want to consider confirming elevations of pressure gages and performing pump efficiency tests that would provide more points on the pump curves to further refine pump operations in the model.

Appendix 1 to Hydraulic Model Tech Memo

System Data Provided by Cal Water For Verification Analyses

TABLE 1-1
SYSTEM DATA PROVIDED FOR MAXIMUM (SUMMER) DAY VERIFICATION
(June 16, 2004)

Tank Data				
Tank ID	**Levels**			**Comments**
RES1	Yes			
RES10	Yes			
RES11	Yes			
RES12	Yes			
RES2	Yes			
RES3	Yes			
RES4	Yes			
RES7-1	Yes			Not Legible
RES7-2	Yes			Not Legible
RES9	Yes			
BORADMOOR	Yes			
Pump Station Data				
ID	**Suction (psi)**	**Dischage (psi)**	**Flow (gpm)**	**Comments**
STATION101-A	Off	Off	Off	
STATION101-B	No	Incomplete data	No	
STATION6-A	Off	Off	Off	
STATION6-B	No	Yes	No	
STATION7-A	Yes	Yes	No	
STATION7-B	Yes	Yes	No	
STATION3-A	Yes	Yes	Off	Production data shows Station 3 was not operating
STATION3-B	Yes	Yes	Off	Production data shows Station 3 was not operating
STATION2-A	No	Yes	No	
STATION2-B	Off	Off	Off	
STATION2-C	Off	Off	Off	
STATION5-B	Off	Off	Off	
STATION5-C	No	Yes	No	
STATION5-A	No	No	No	No data provided
STATION4-A	Off	Off	Off	
STATION4-B	No	Yes	No	
STATION1-A	No	Yes	No	
STATION1-B	Off	Off	Off	
STATION1-D	Off	Off	Off	
Turnouts				
PRV	**Flow (gpm)**			
SSF-01-PRV	1828			
SSF-02-PRV	2889			
SSF-05-PRV	533			
SSF-06-PRV	608			
SSF-07-PRV	OFF			
SSF-08-PRV	OFF			
SSF-09-PRV	738			
SSF-10-PRV	OFF			
SSF-11-PRV	OFF			
SSF-12-PRV	OFF			
FCV				
SSF-03A	1271			
SSF-03B	-			
SSF-13	OFF			
SSF-14	OFF			
SSF-15-V	853			
SSF-DCWD-2	57			
Total (gpm)	8777			
Total (mgd)	12.6			

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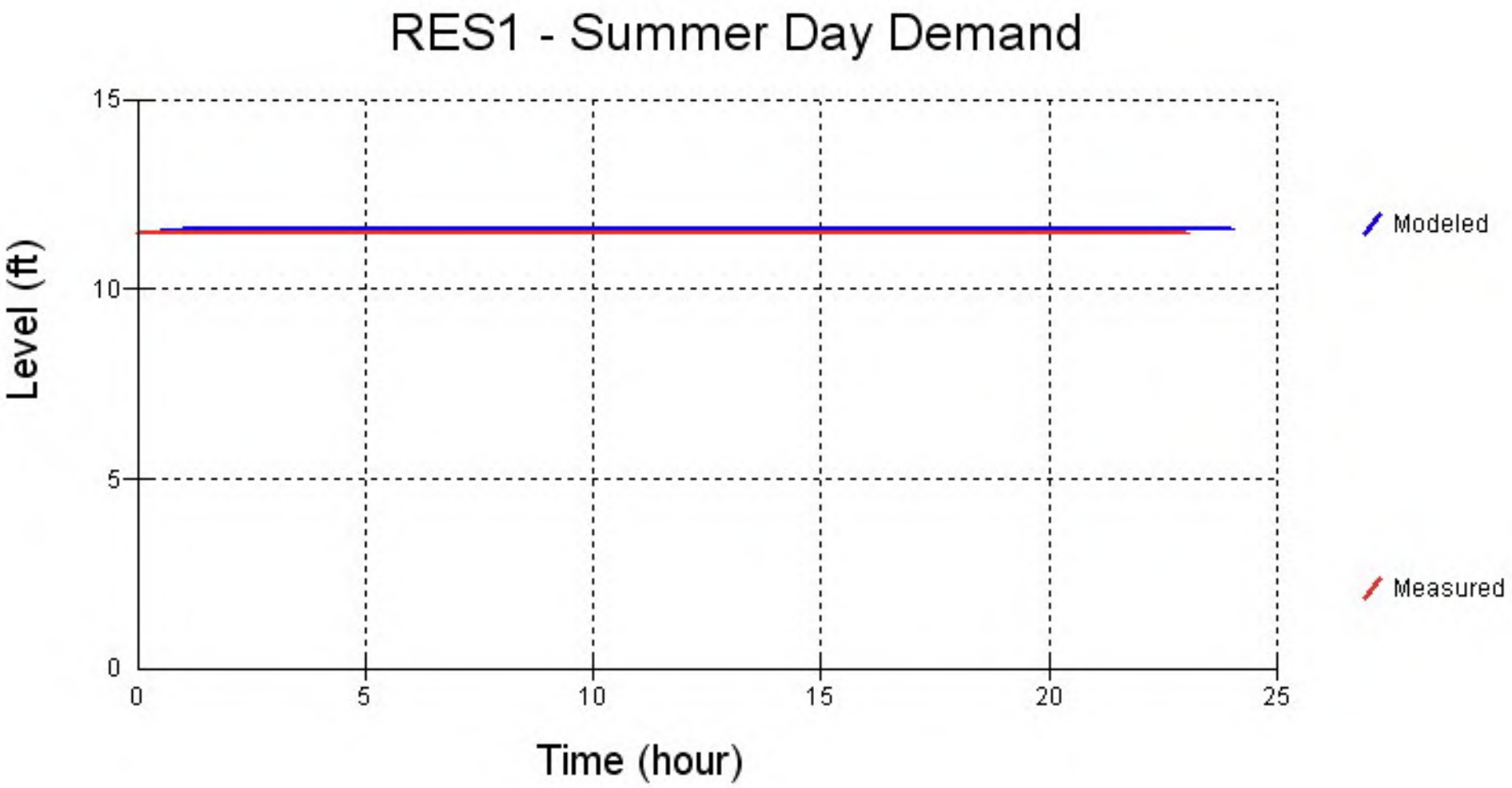
TABLE 1-2
SYSTEM DATA PROVIDED FOR MINIMUM (WINTER) DAY VERIFICATION
(January 23, 2004)

Tank Data				
ID	**Levels (ft)**			**Comments**
RES1	Yes			
RES10	Yes			
RES11	Yes			
RES12	Yes			
RES2	Yes			Incomplete data
RES3	Yes			
RES4	Yes			
RES7-1	Yes			
RES7-2	Yes			
RES9	Yes			
BORADMOOR	Yes			
Pump Station Data				
ID	**Suction (psi)**	**Dischage (psi)**	**Flow (gpm)**	**Comments**
STATION101-A	Off	Off	Off	
STATION101-B	No	Yes	No	
STATION6-A	Off	Off	Off	
STATION6-B	No	Yes	No	
STATION7-A	Yes	Yes	No	
STATION7-B	Yes	Yes	No	
STATION3-A	Yes	Yes	Off	Production data shows Station 3 was not operating
STATION3-B	Yes	Yes	Off	Production data shows Station 3 was not operating
STATION2-A	Off	Off	Off	
STATION2-B	Off	Off	Off	
STATION2-C	No	Yes	No	
STATION5-B	No	Yes	No	
STATION5-C	No	Yes	No	
STATION5-A	No	No	No	No data provided
STATION4-A	Off	Off	Off	
STATION4-B	No	Yes	No	
STATION1-A	Off	Off	Off	Production data shows Station 3 was not operating
STATION1-B	Off	Off	Off	
STATION1-D	Off	Off	Off	
Turnouts				
PRV	**Flow (gpm)**	**Setting (psi)**		
SSF-01-PRV	1019	110		
SSF-02-PRV	368	71		
SSF-05-PRV	347	85		
SSF-06-PRV	338	85		
SSF-07-PRV	OFF	96		
SSF-08-PRV	OFF	-		
SSF-09-PRV	246	42		
SSF-10-PRV	OFF	-		
SSF-11-PRV	OFF	-		
SSF-12-PRV	OFF	106		
FCV				
SSF-03A	1553			
SSF-03B	-			
SSF-13	OFF			
SSF-14	OFF			
SSF-15-V	281			
Total (gpm)	4151			
Total (mgd)	6.0			

Appendix 2 to Hydraulic Model Tech Memo

Plots of Measured and Modeled Reservoir Levels For Maximum (Summer) Day Verification



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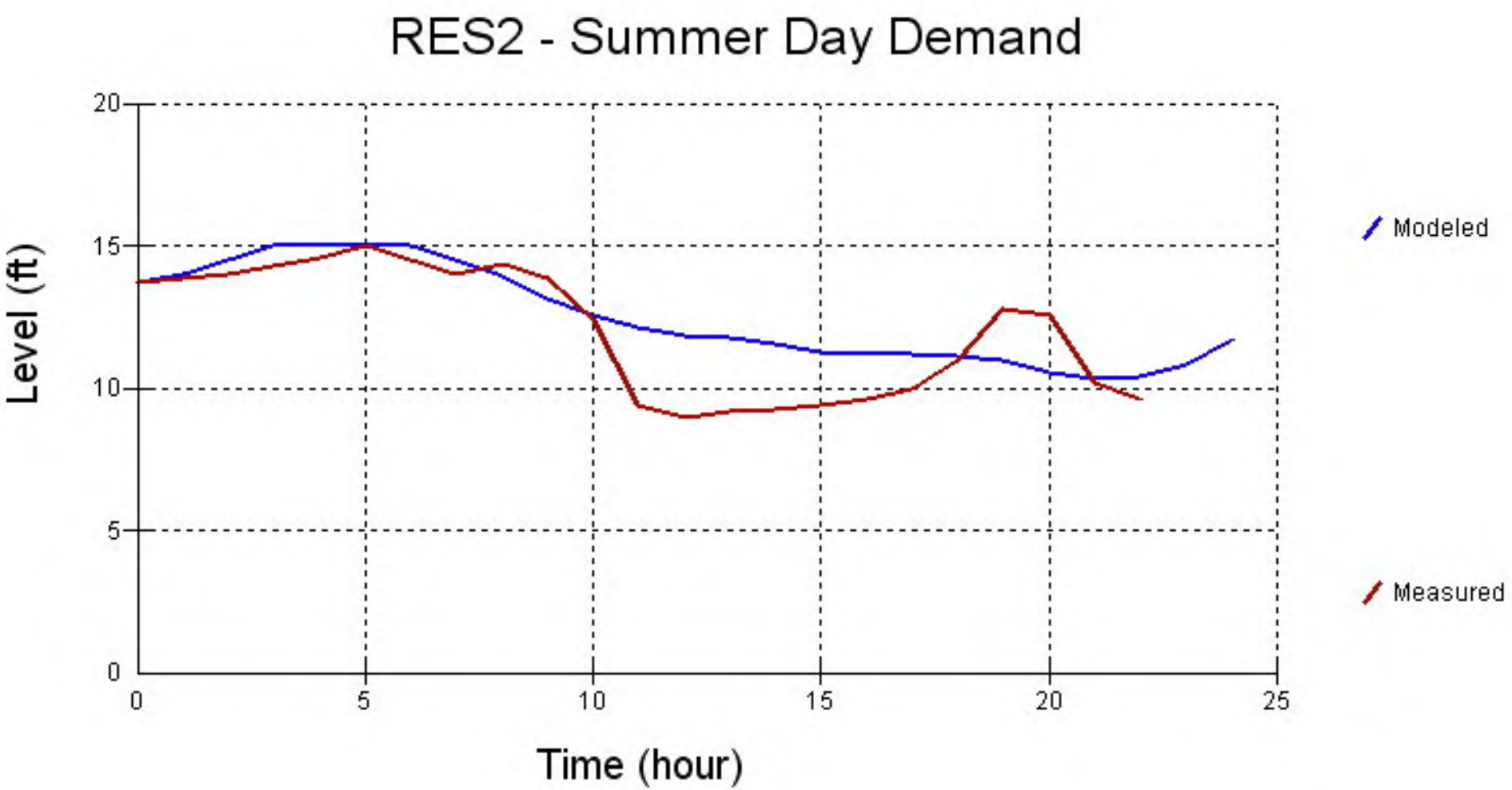

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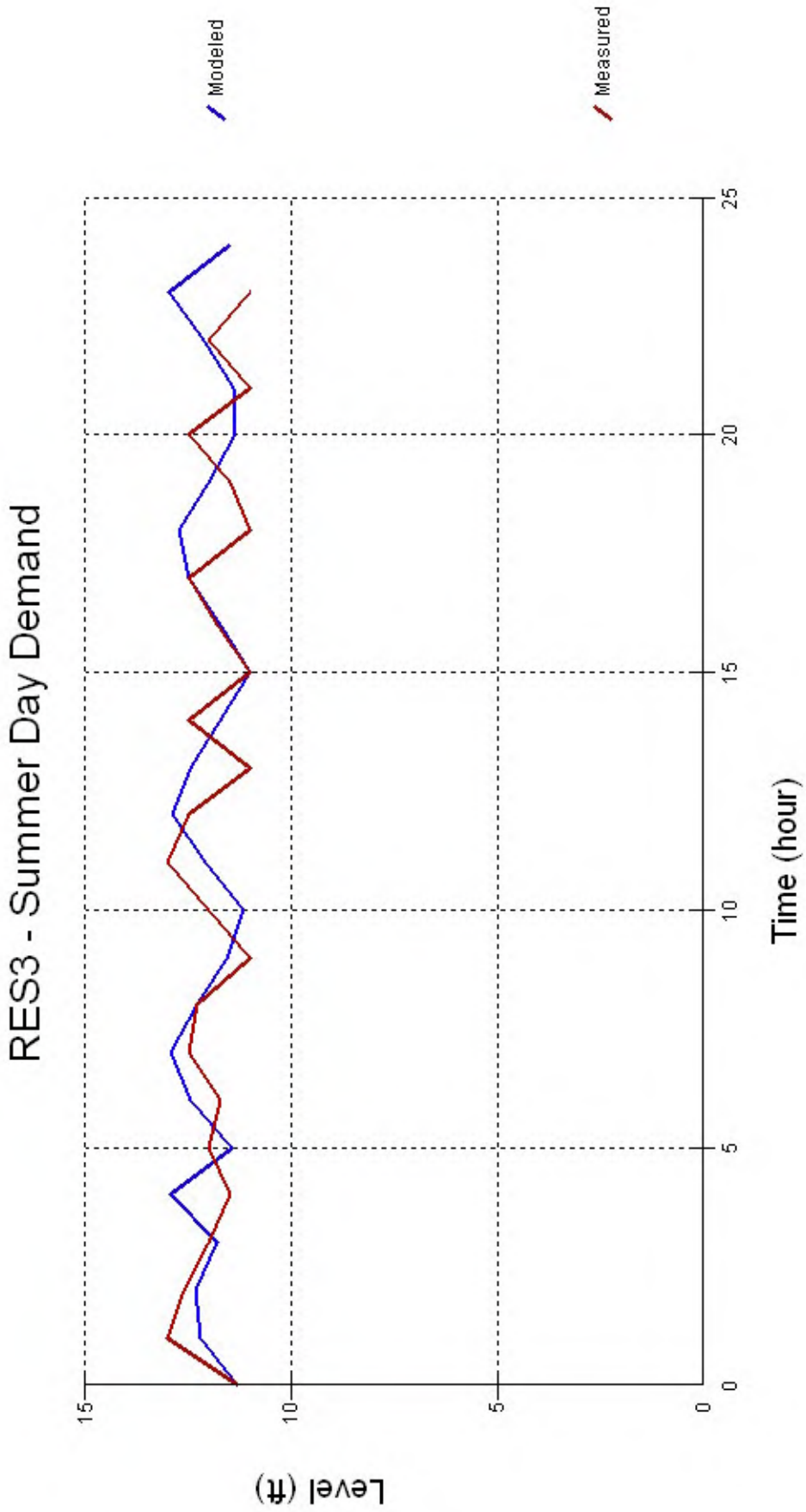

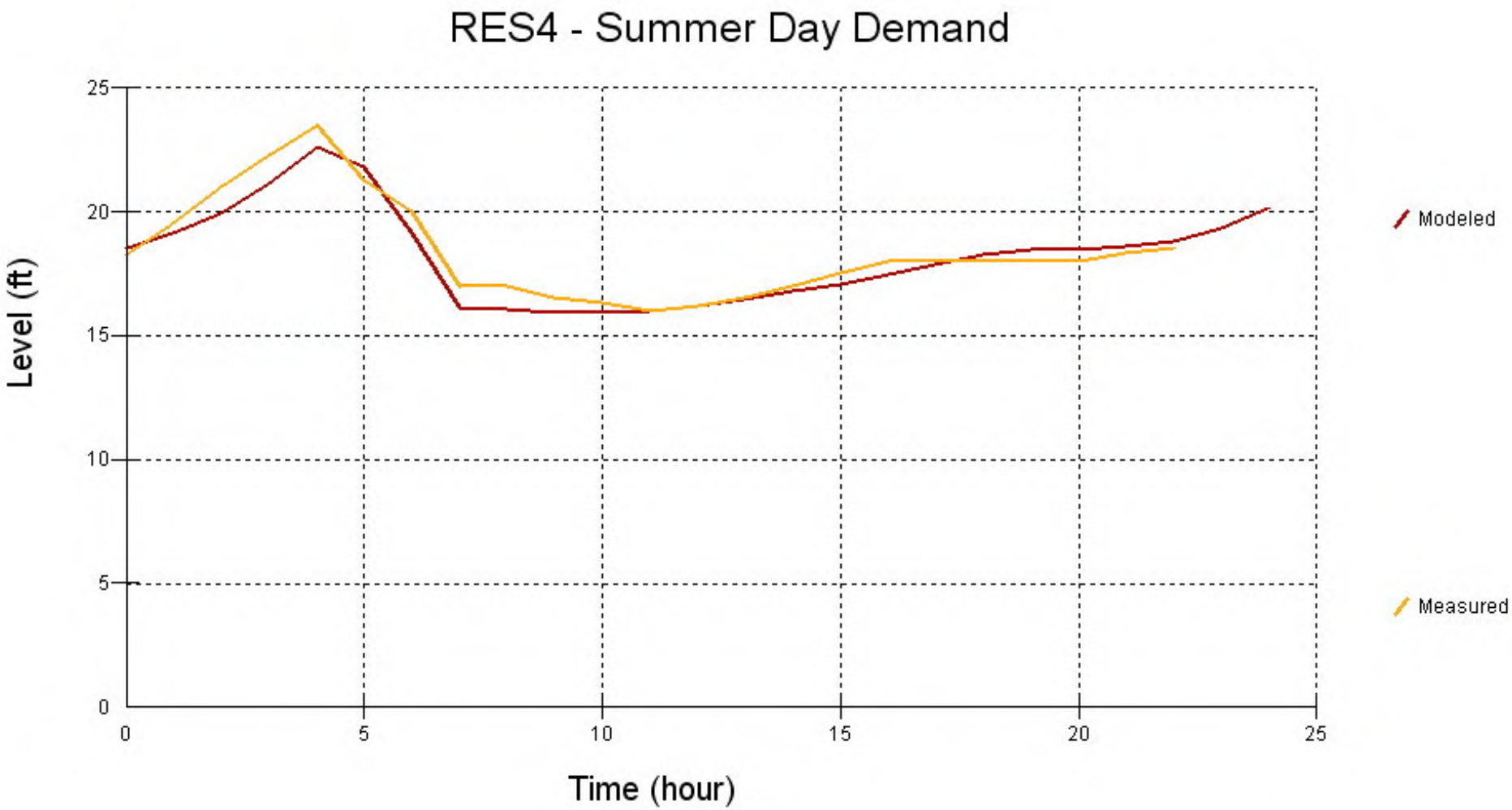

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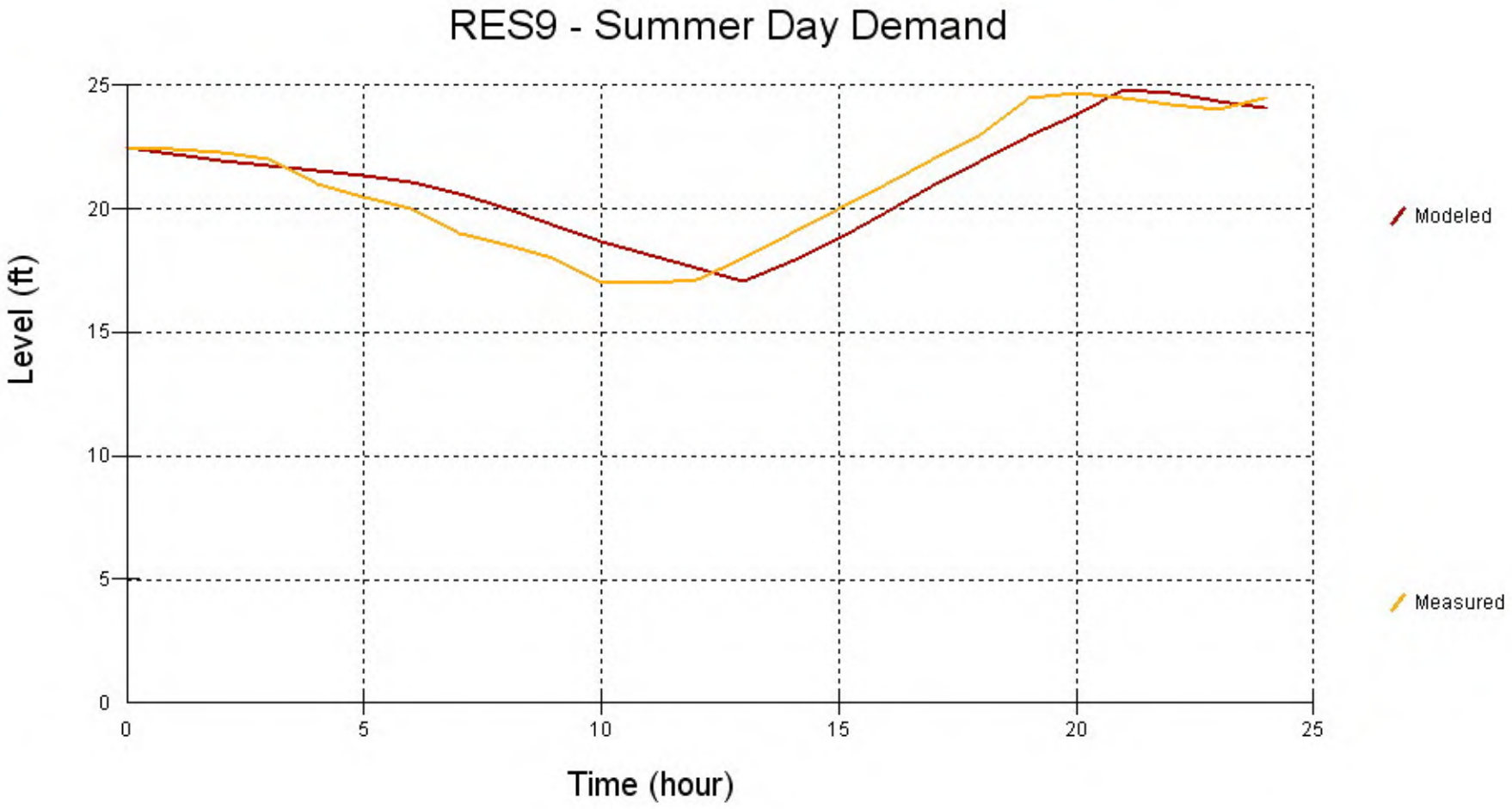

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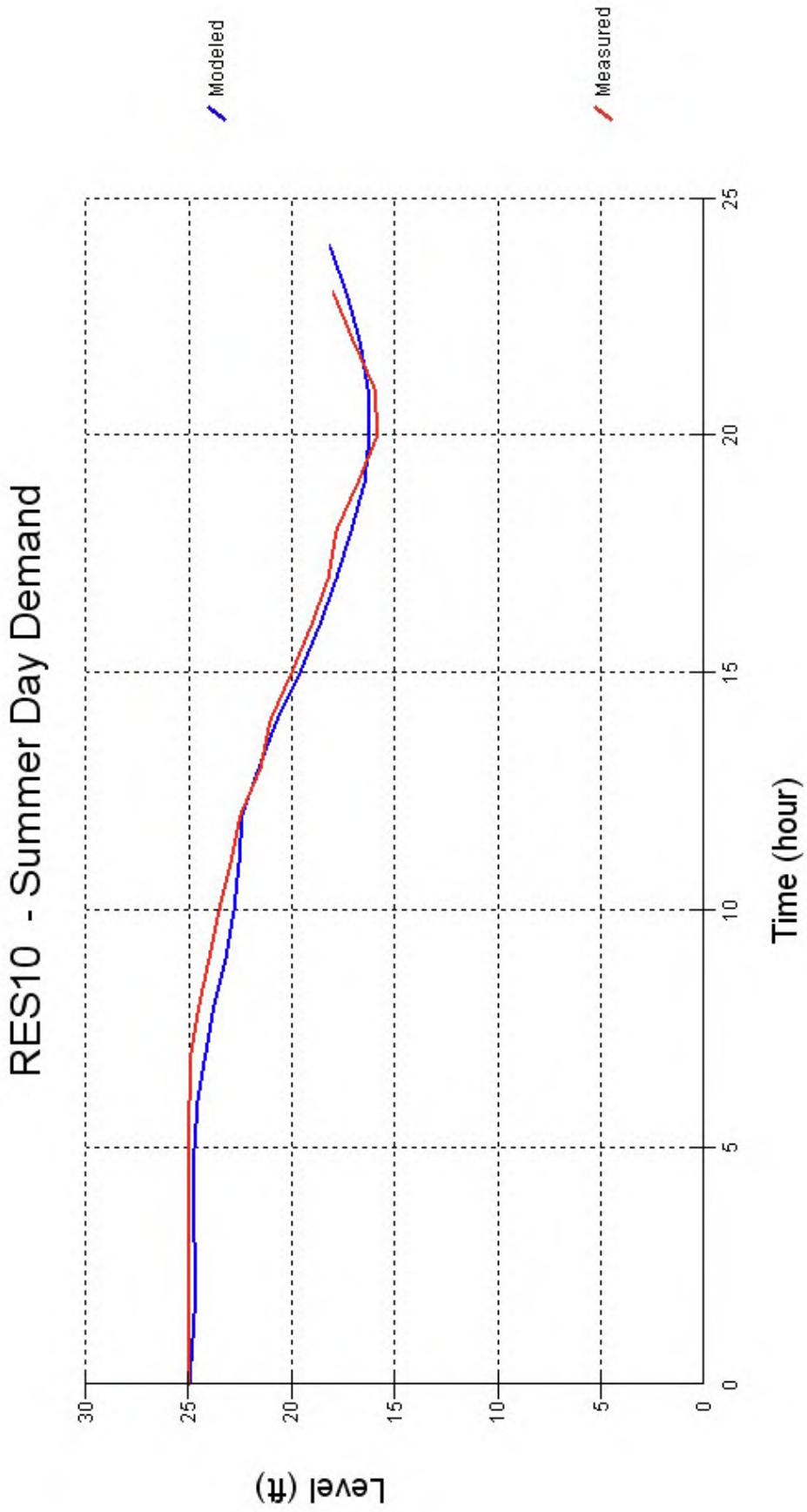

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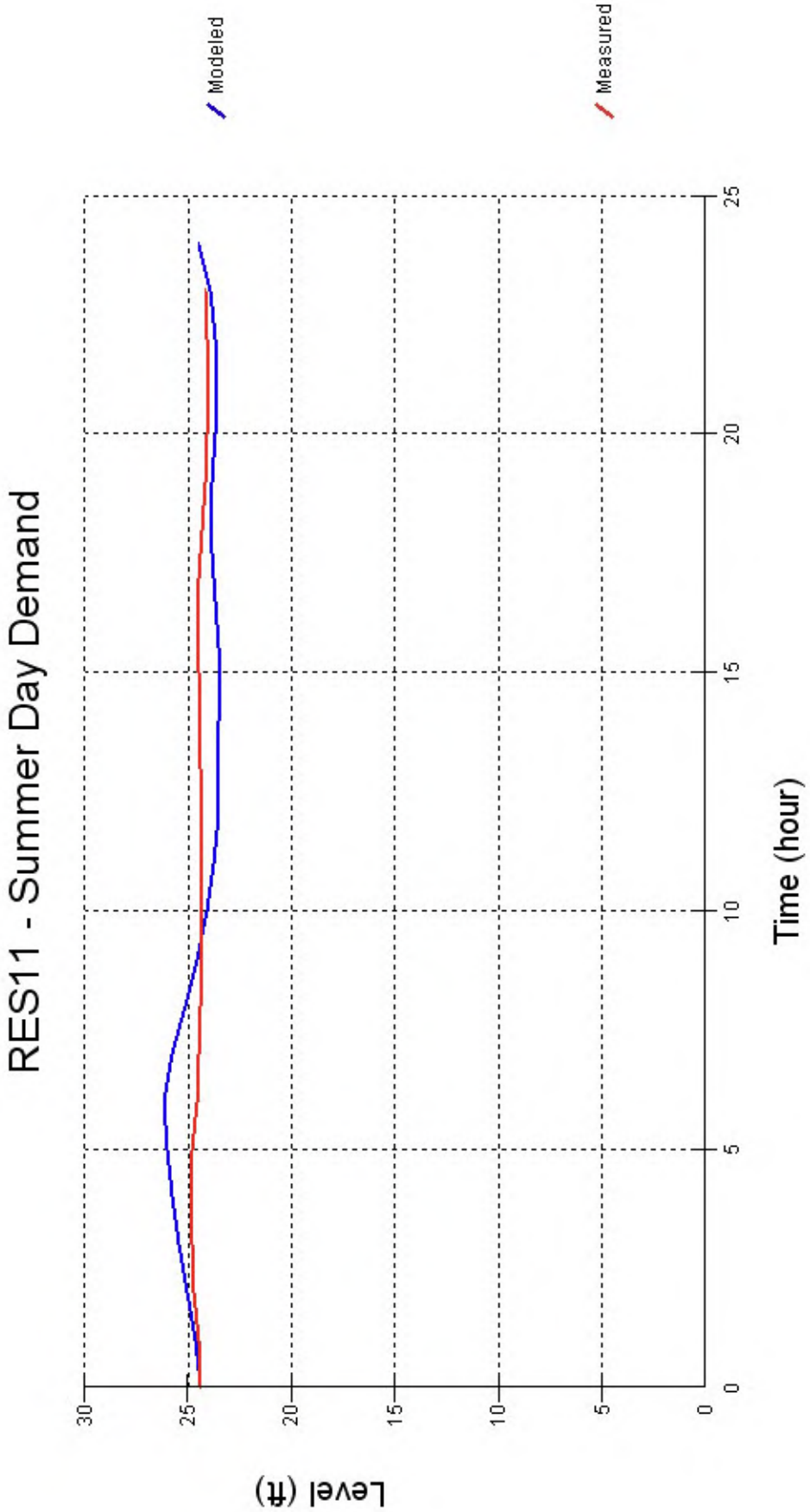

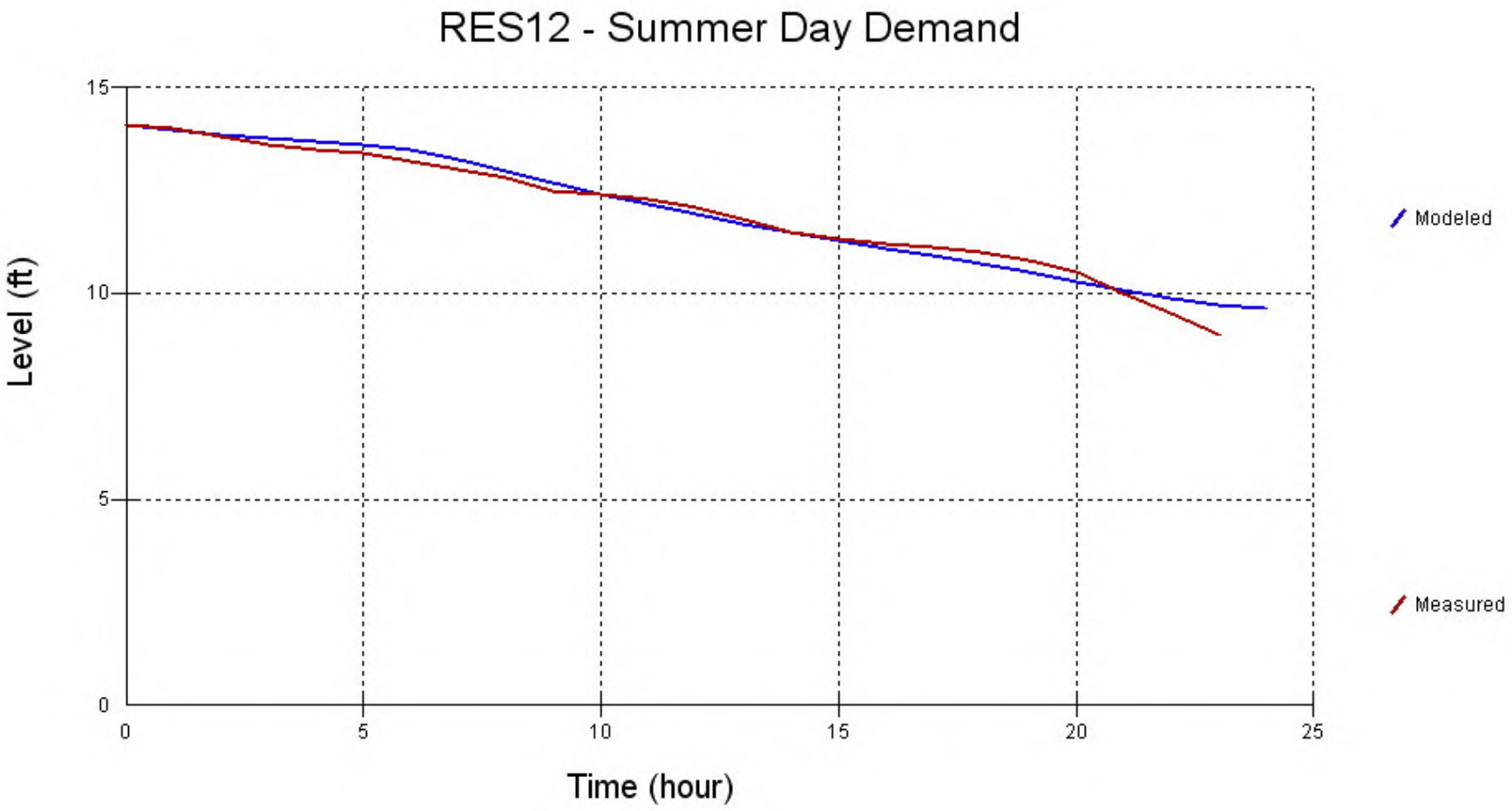

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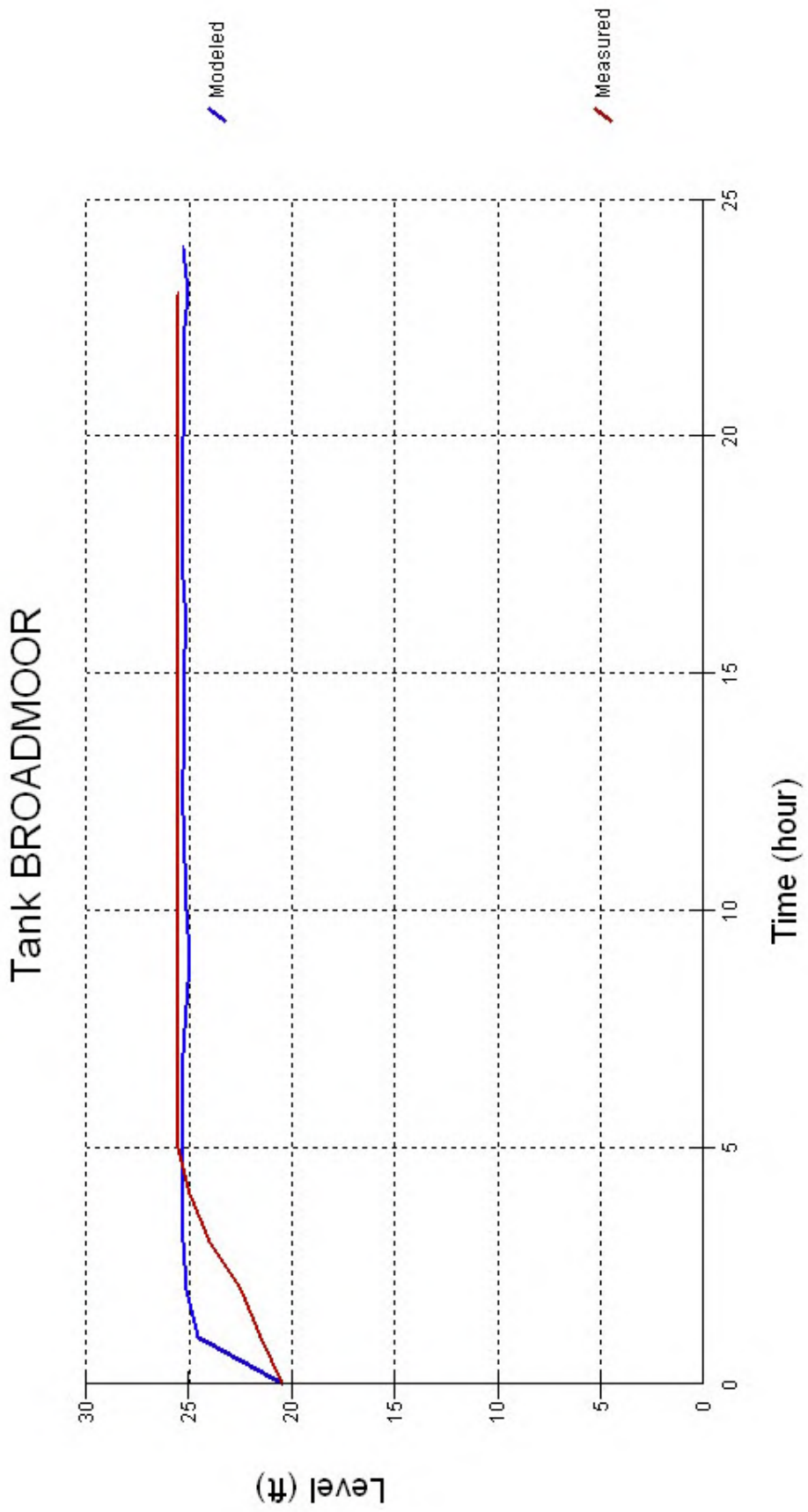

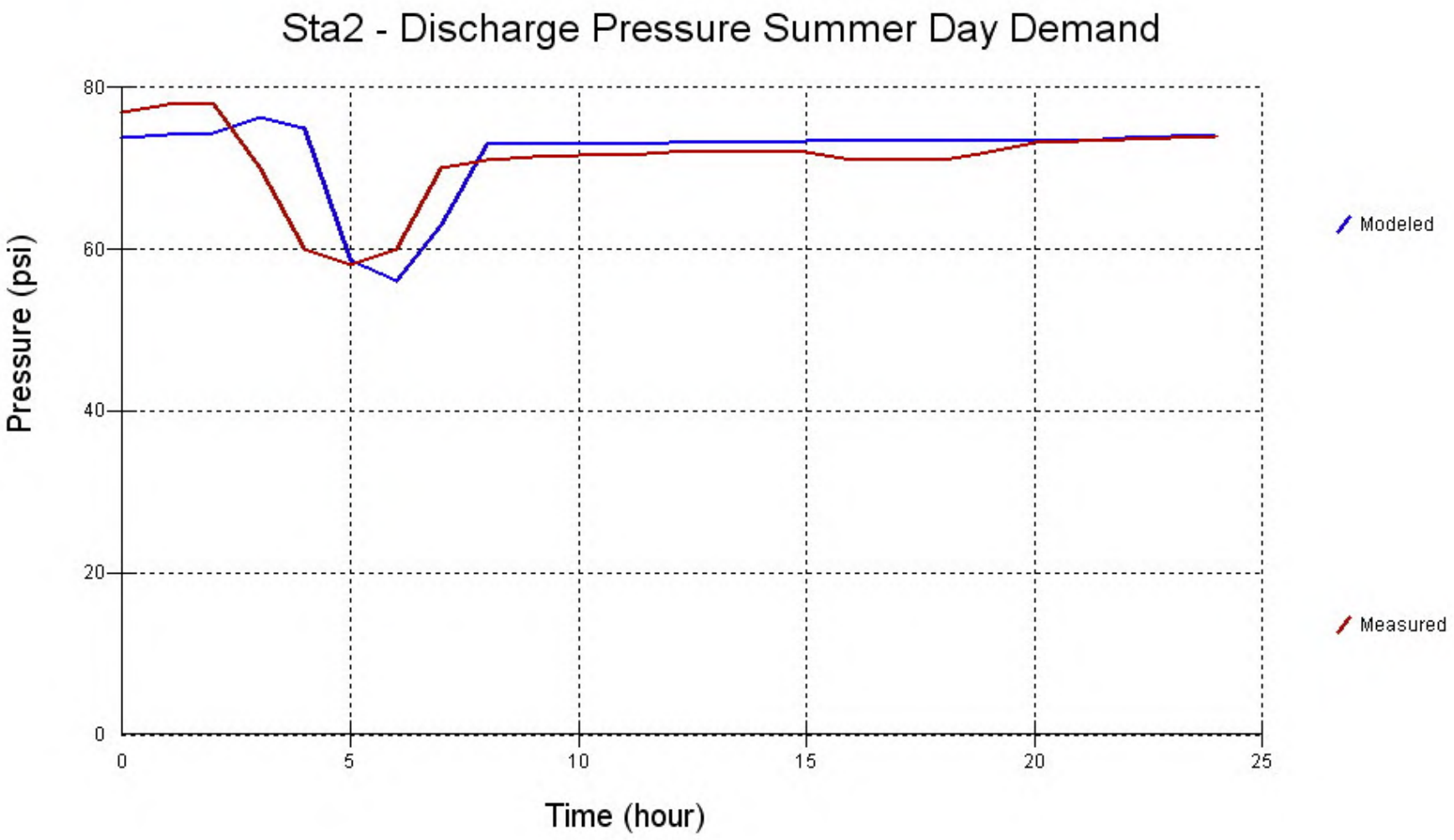

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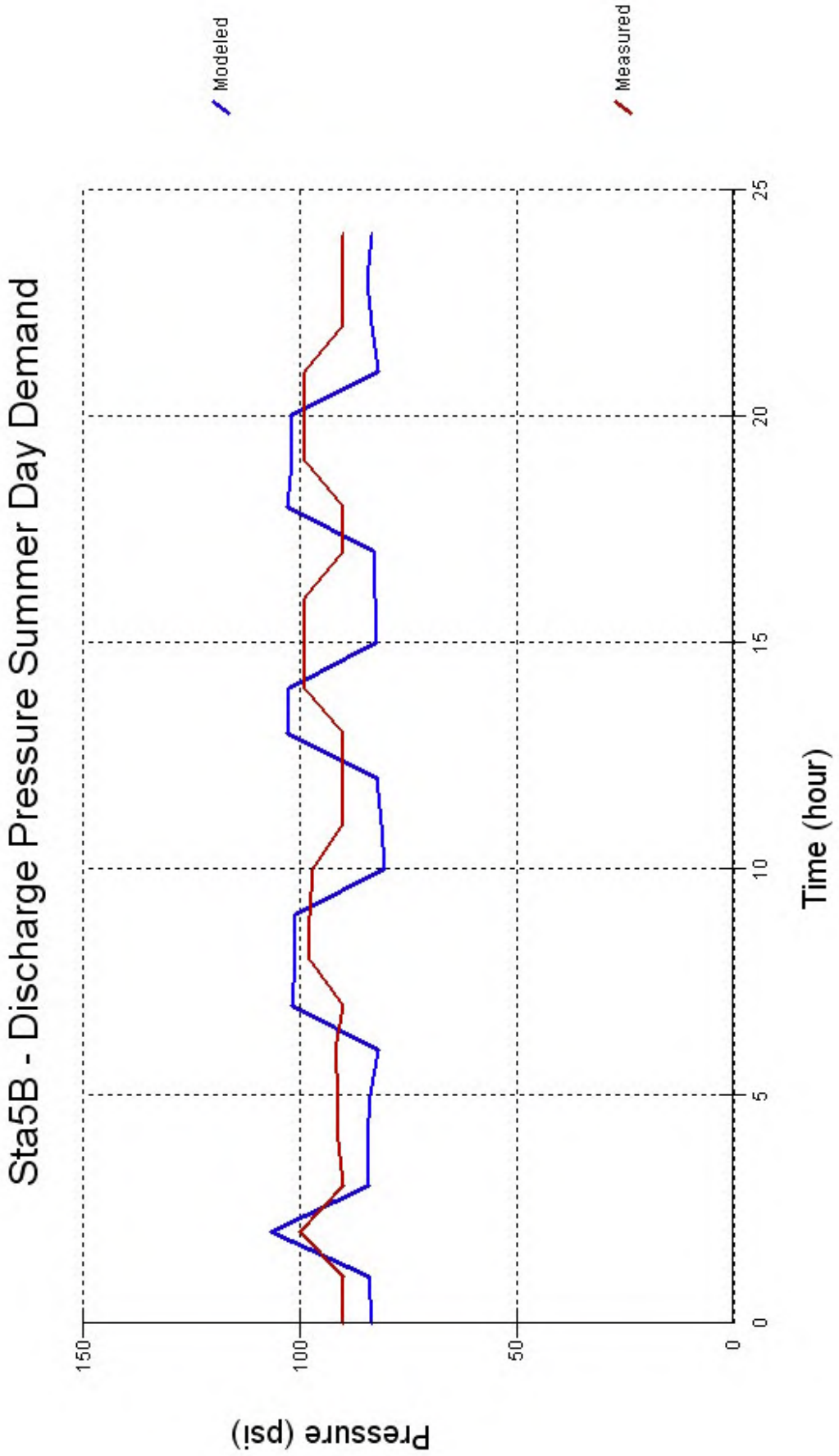

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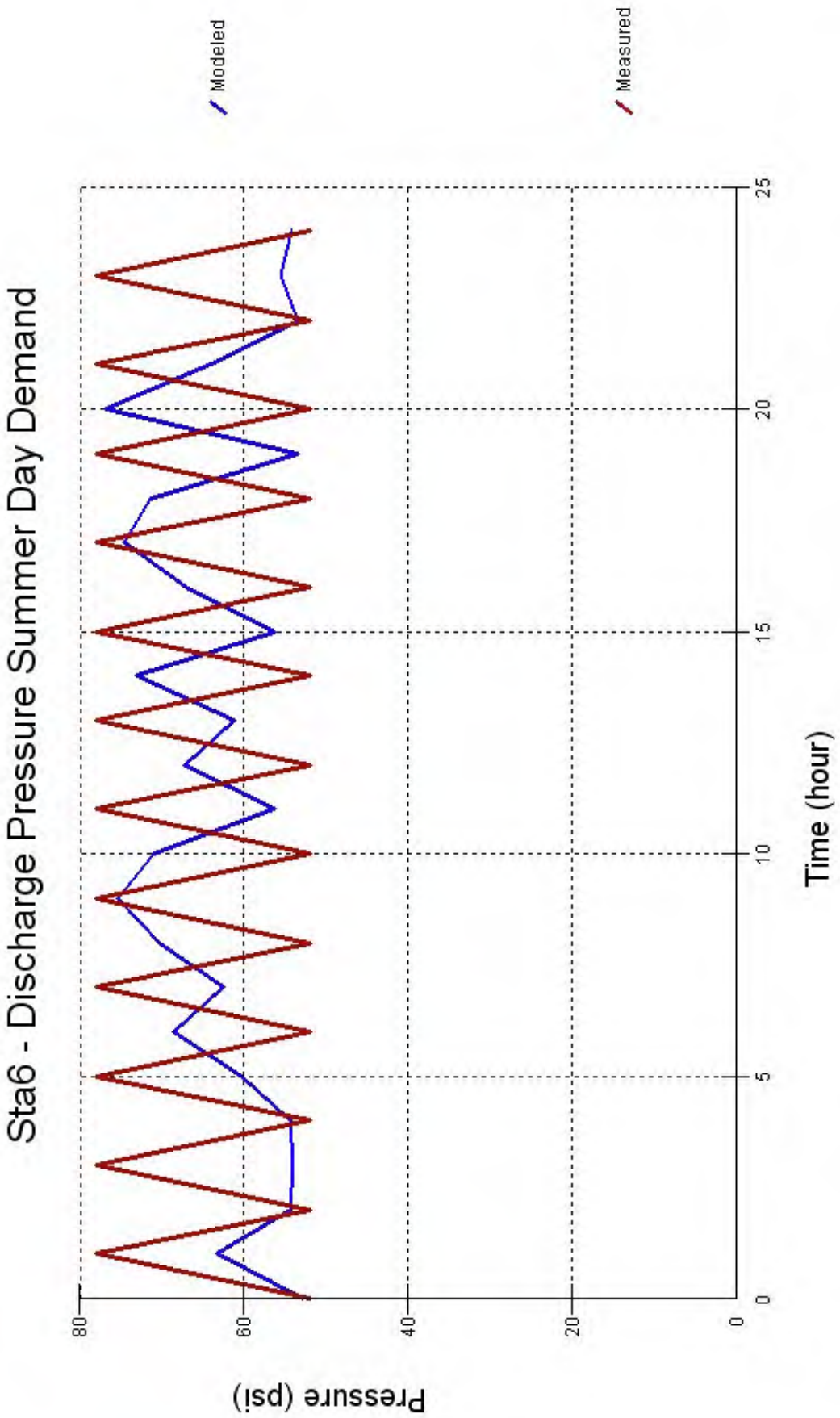

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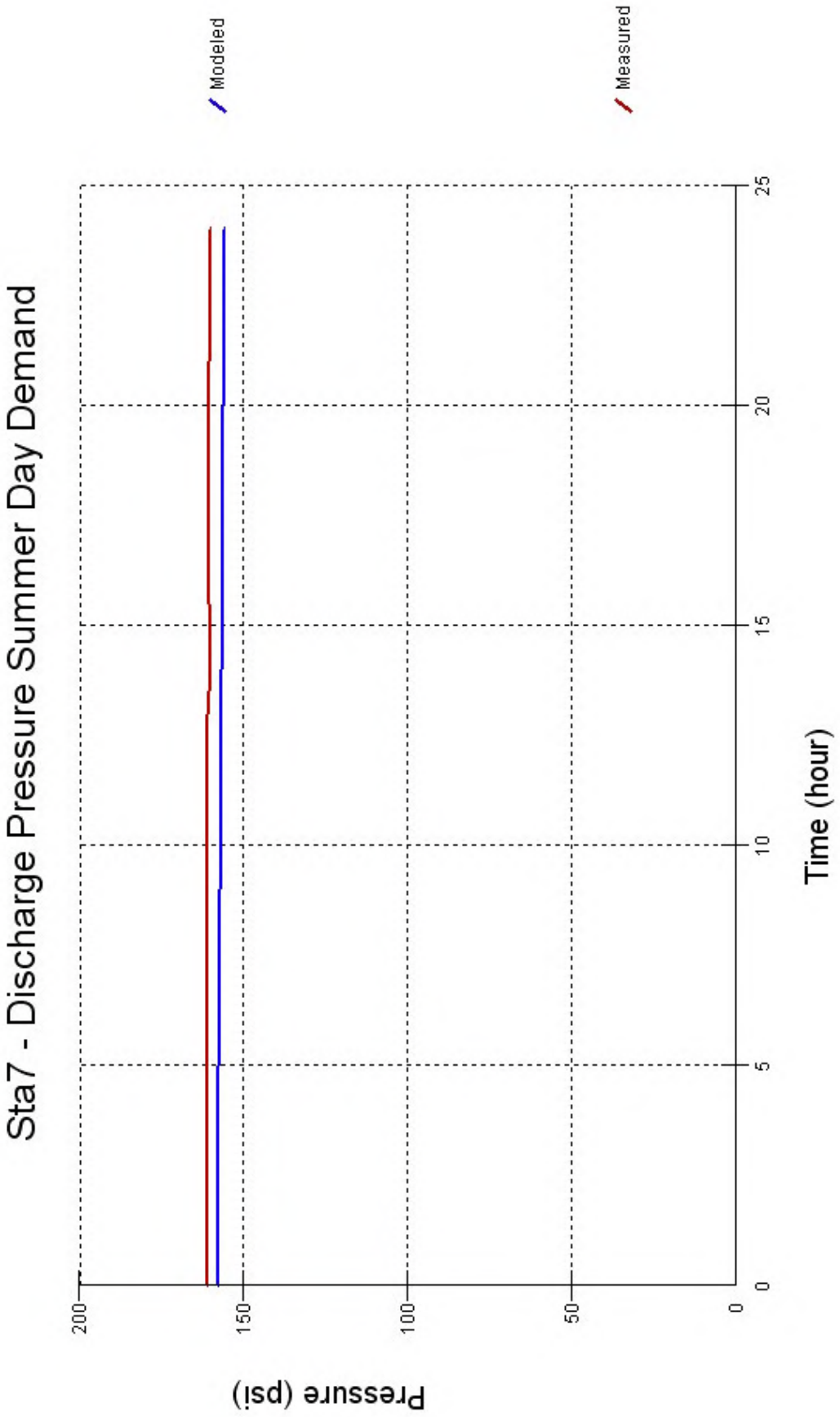

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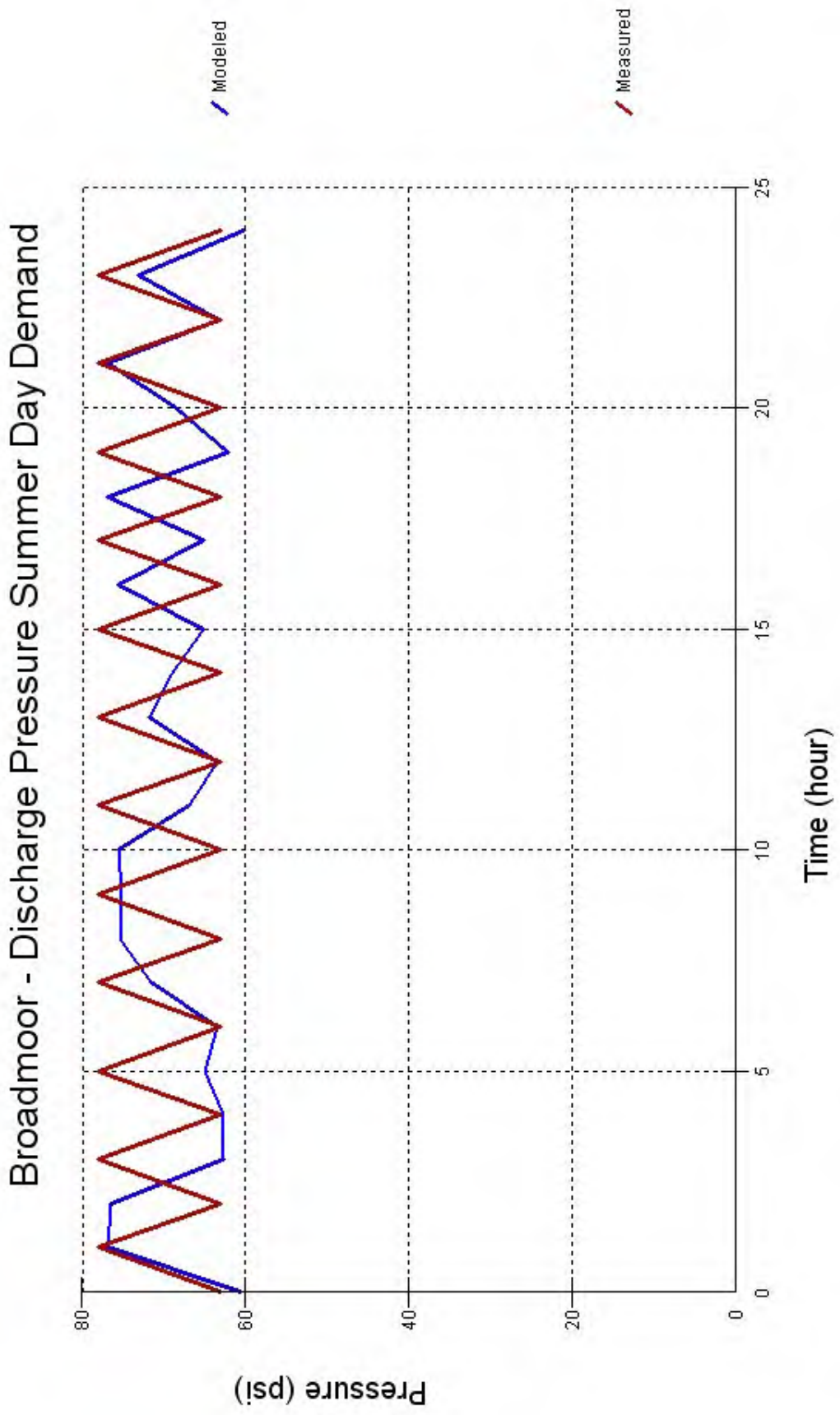
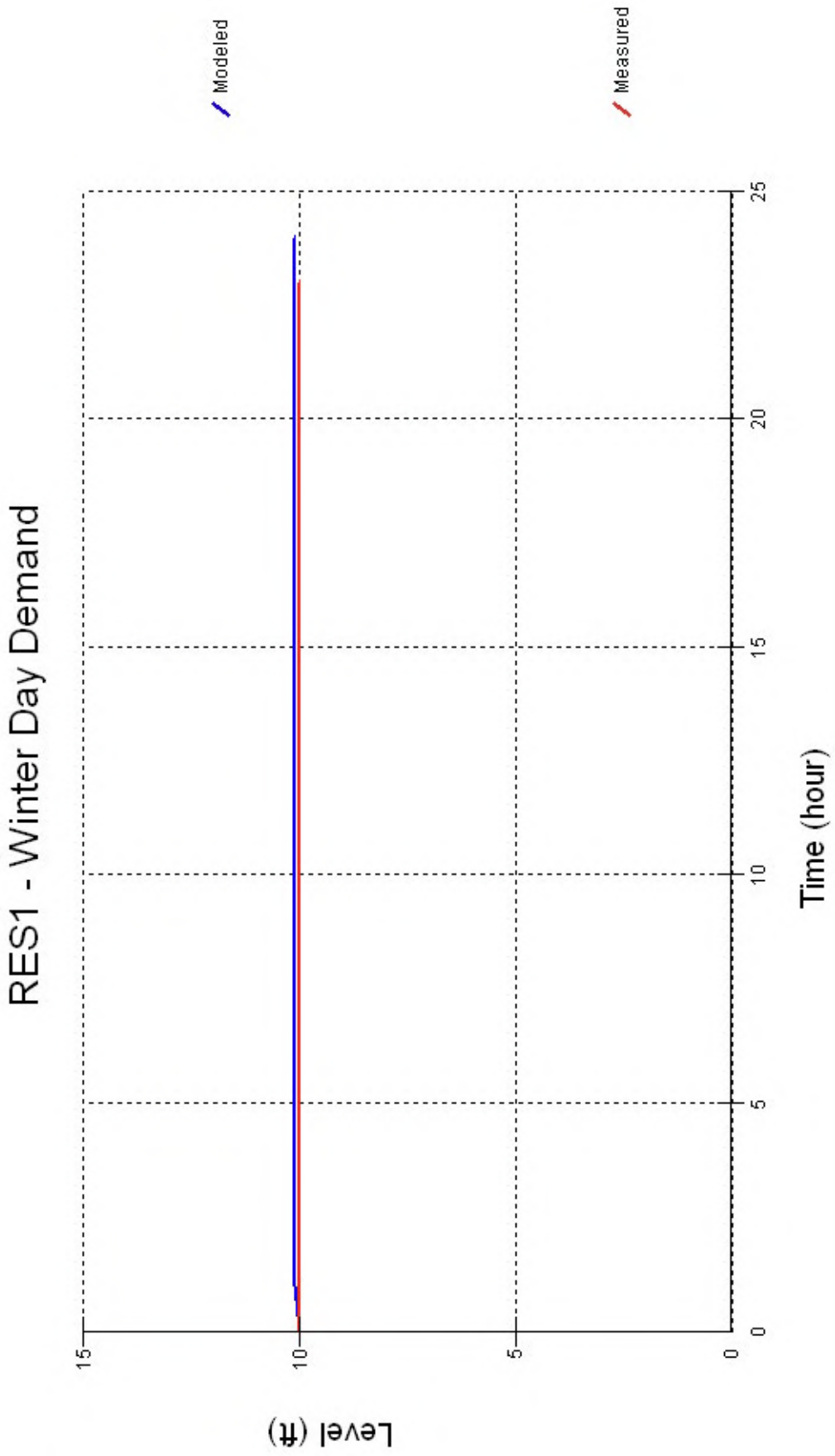


Appendix 3 to Hydraulic Model Tech Memo

Plots of Measured and Modeled Reservoir Levels For Minimum (Winter) Day Verification

Public Version



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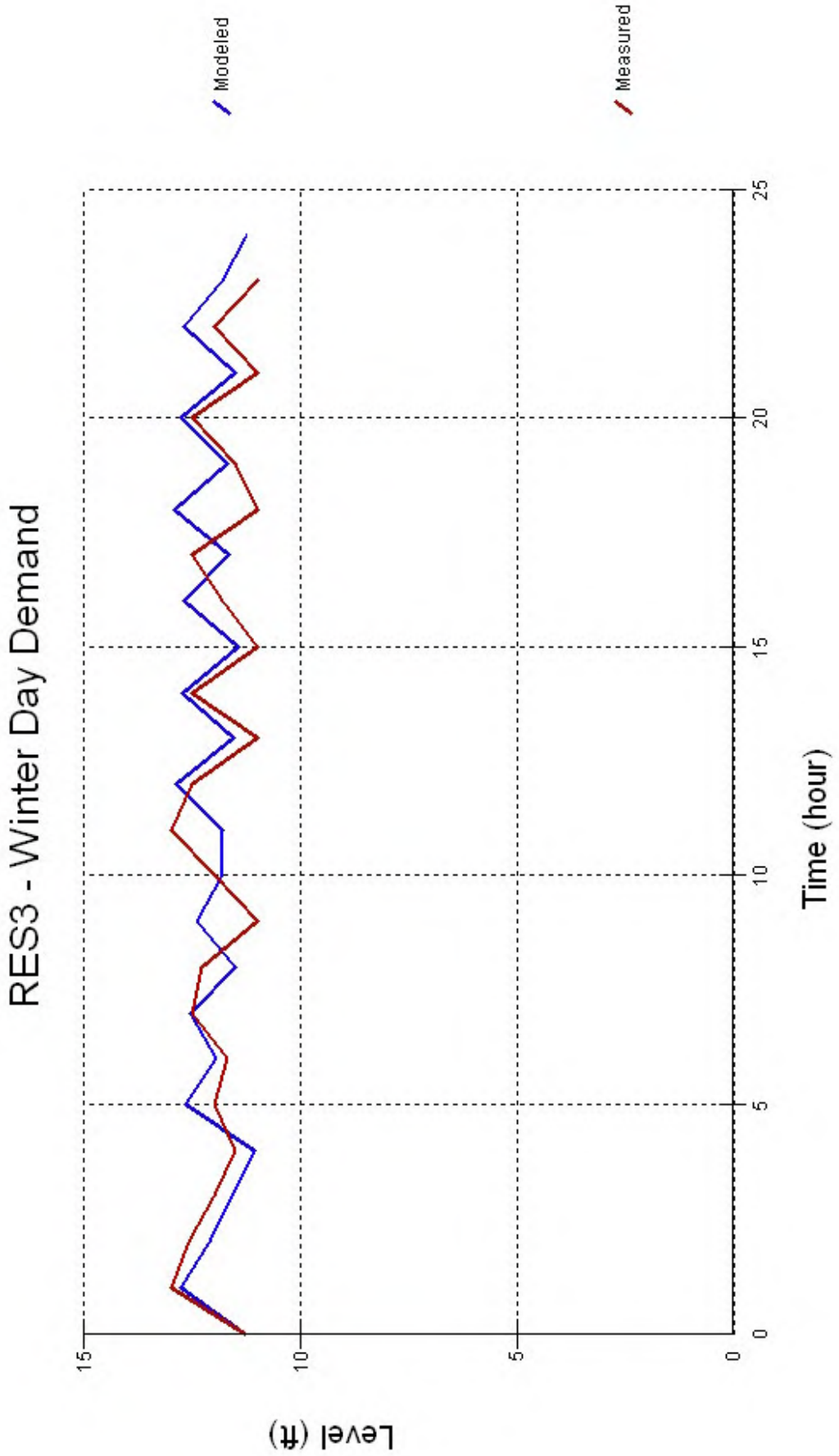

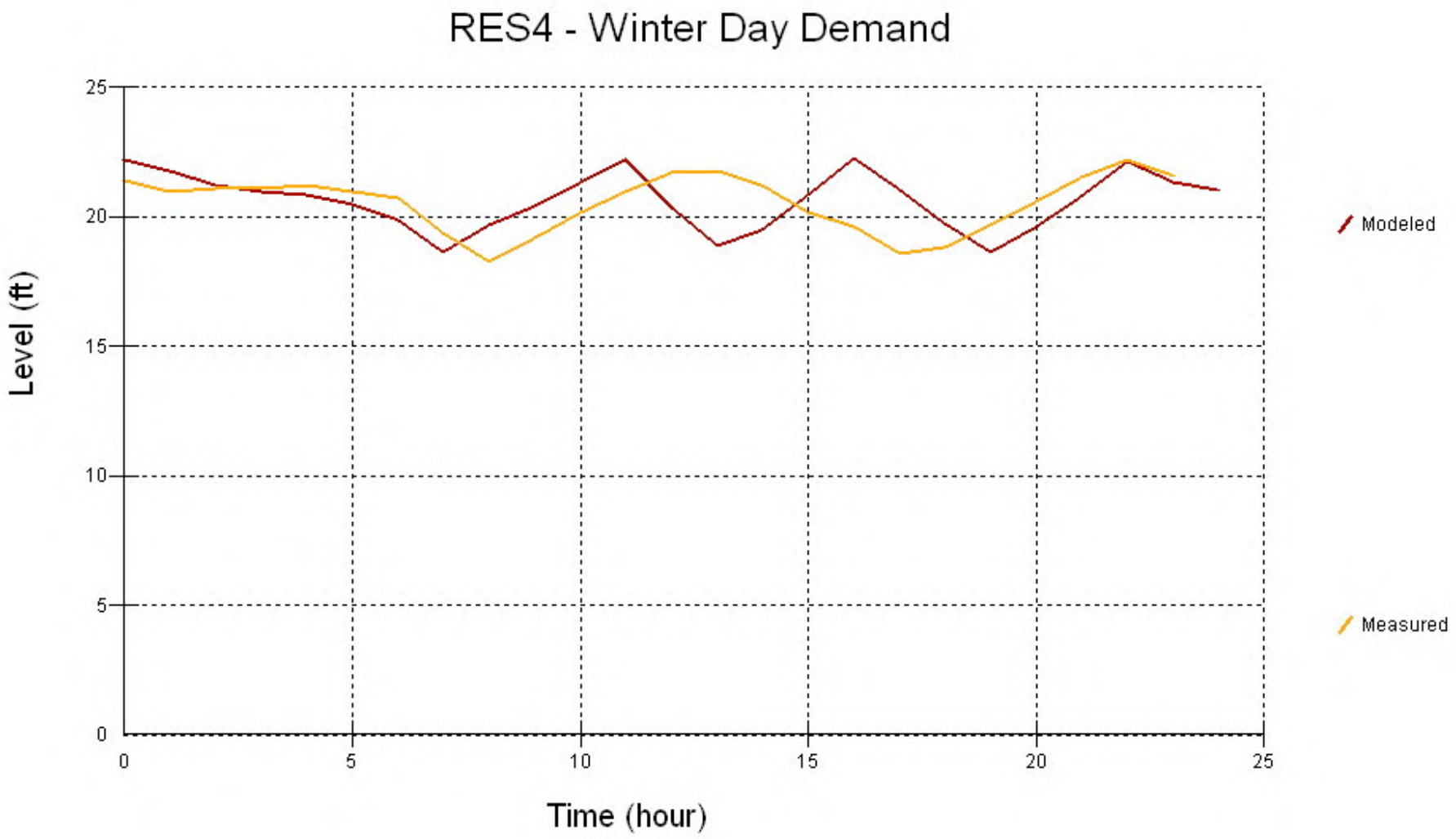

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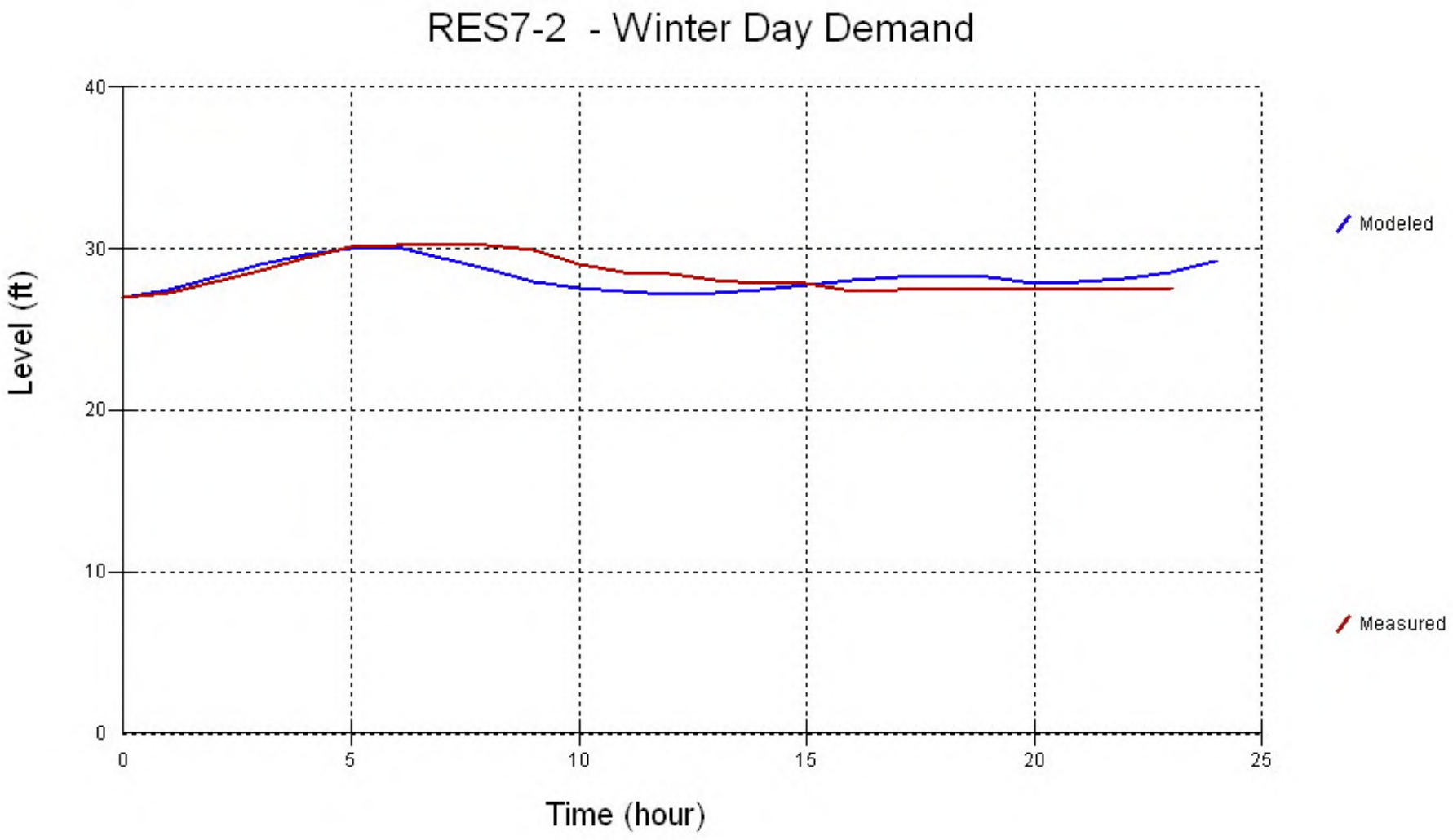

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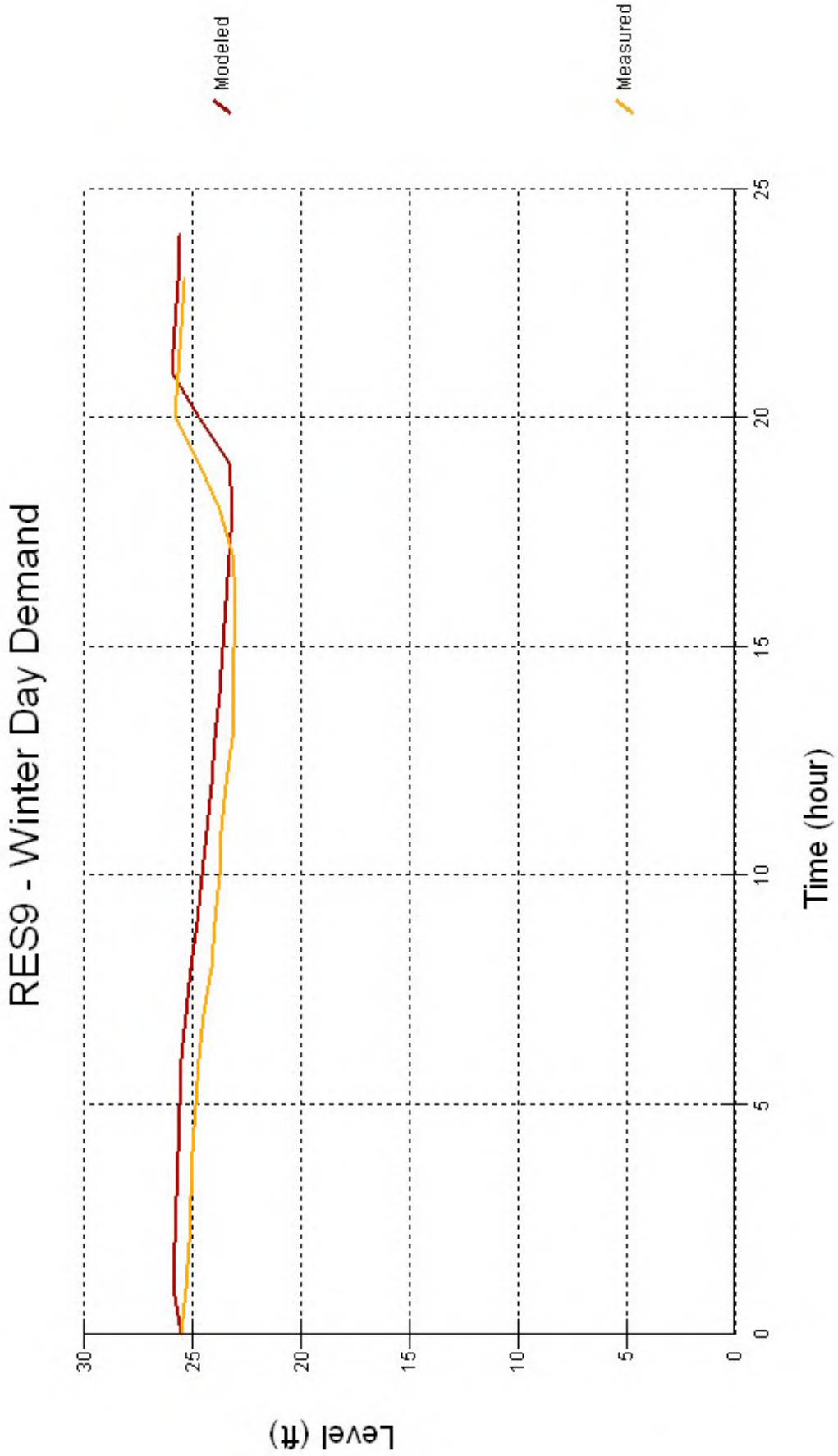

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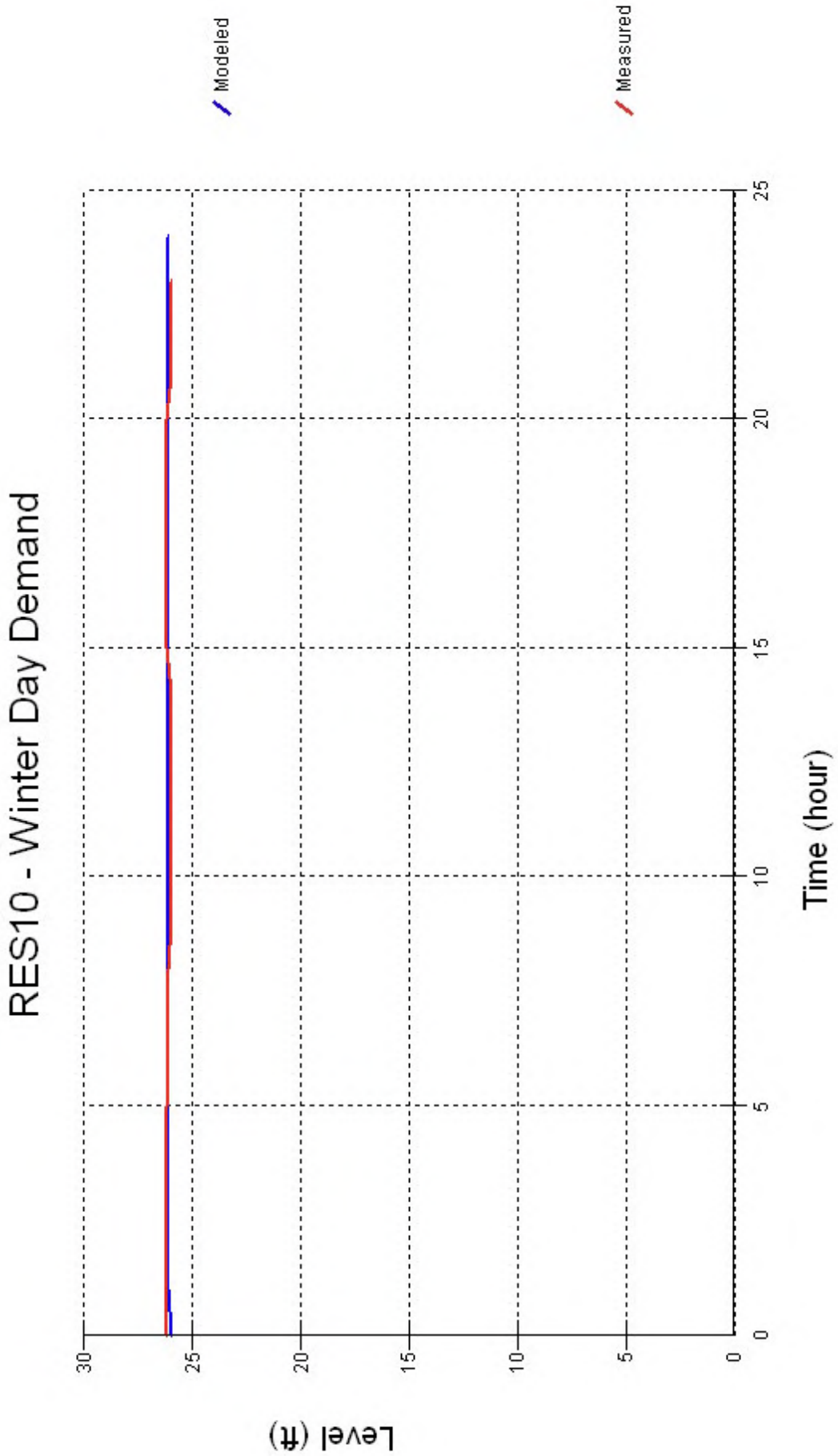

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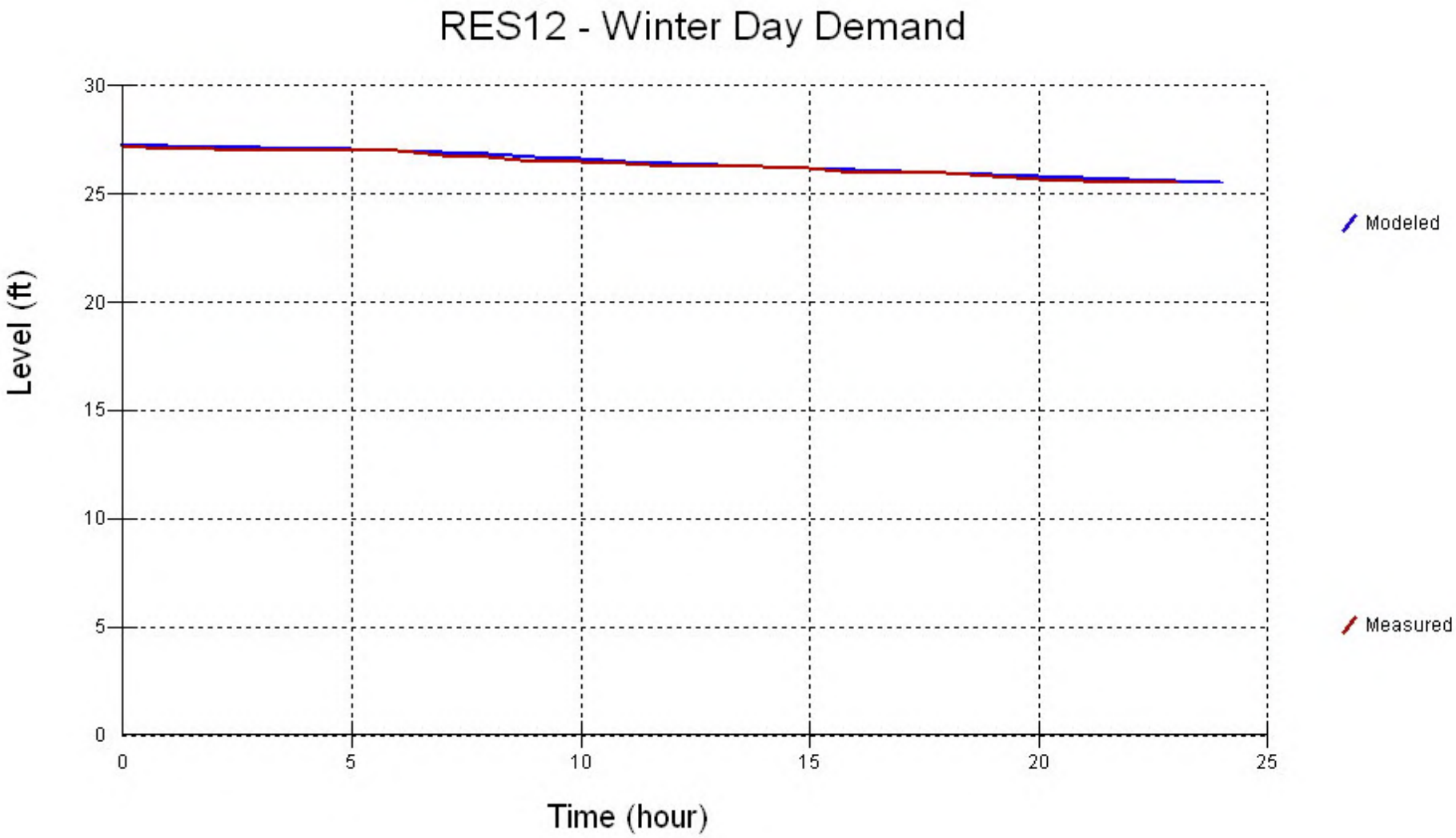

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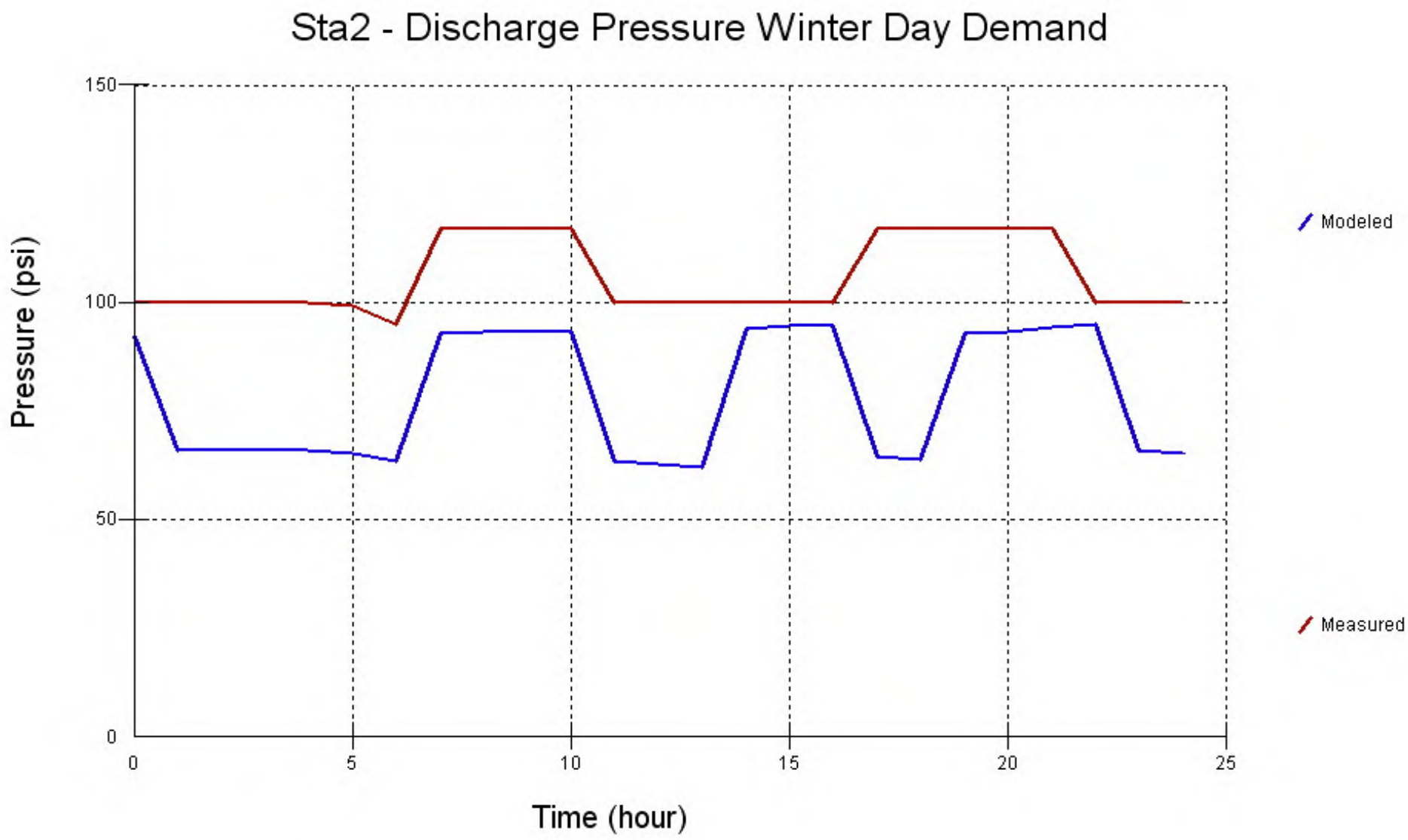

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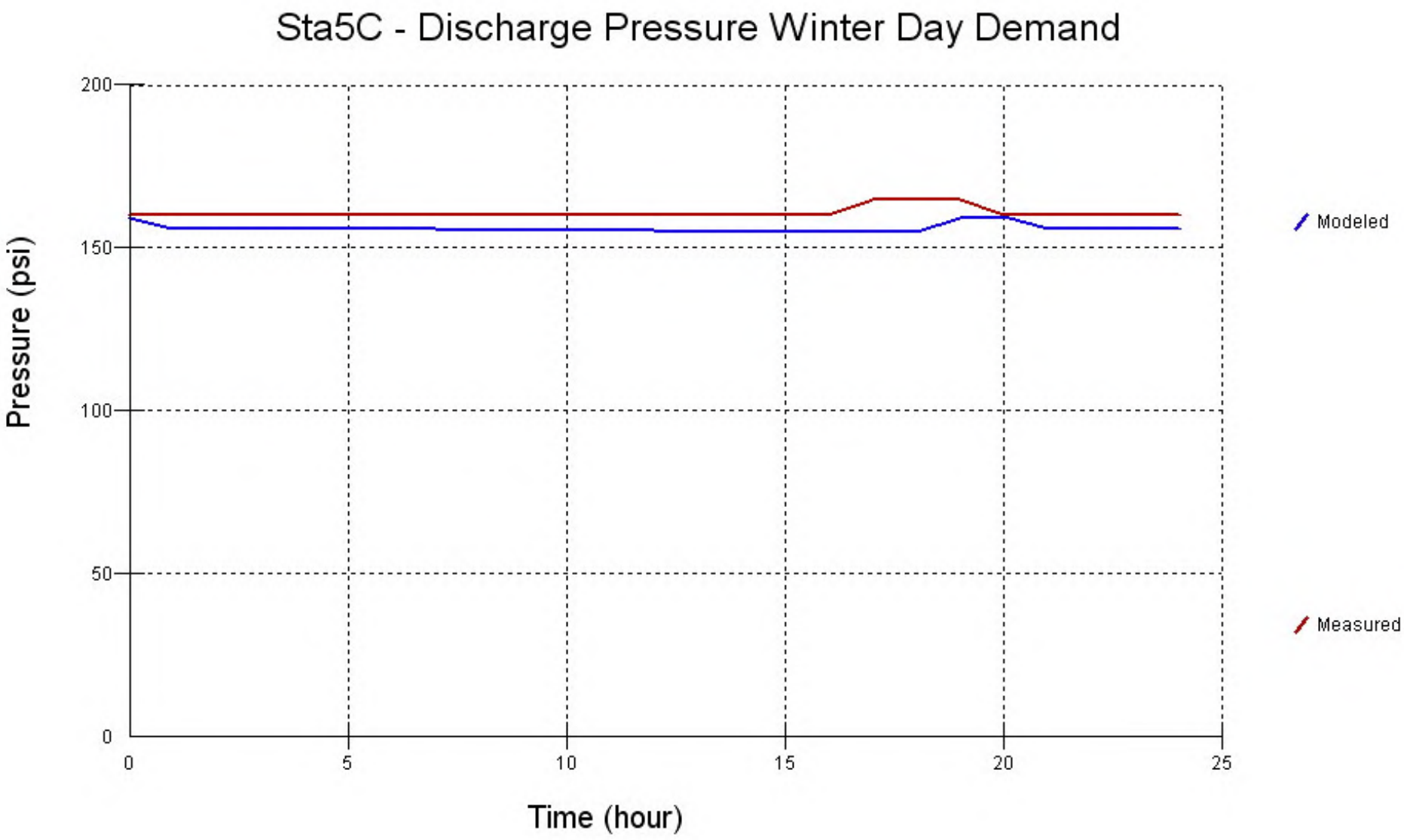

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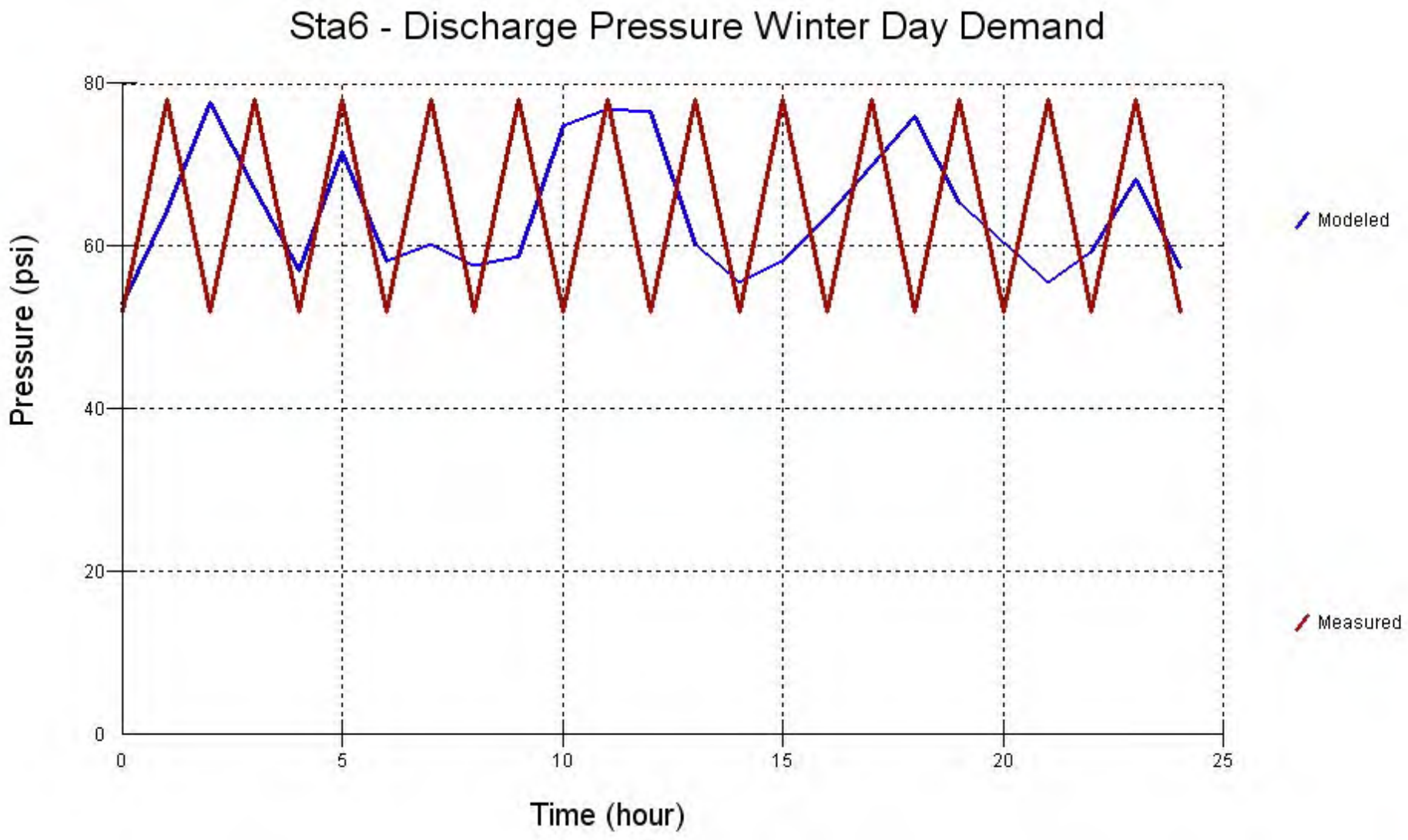

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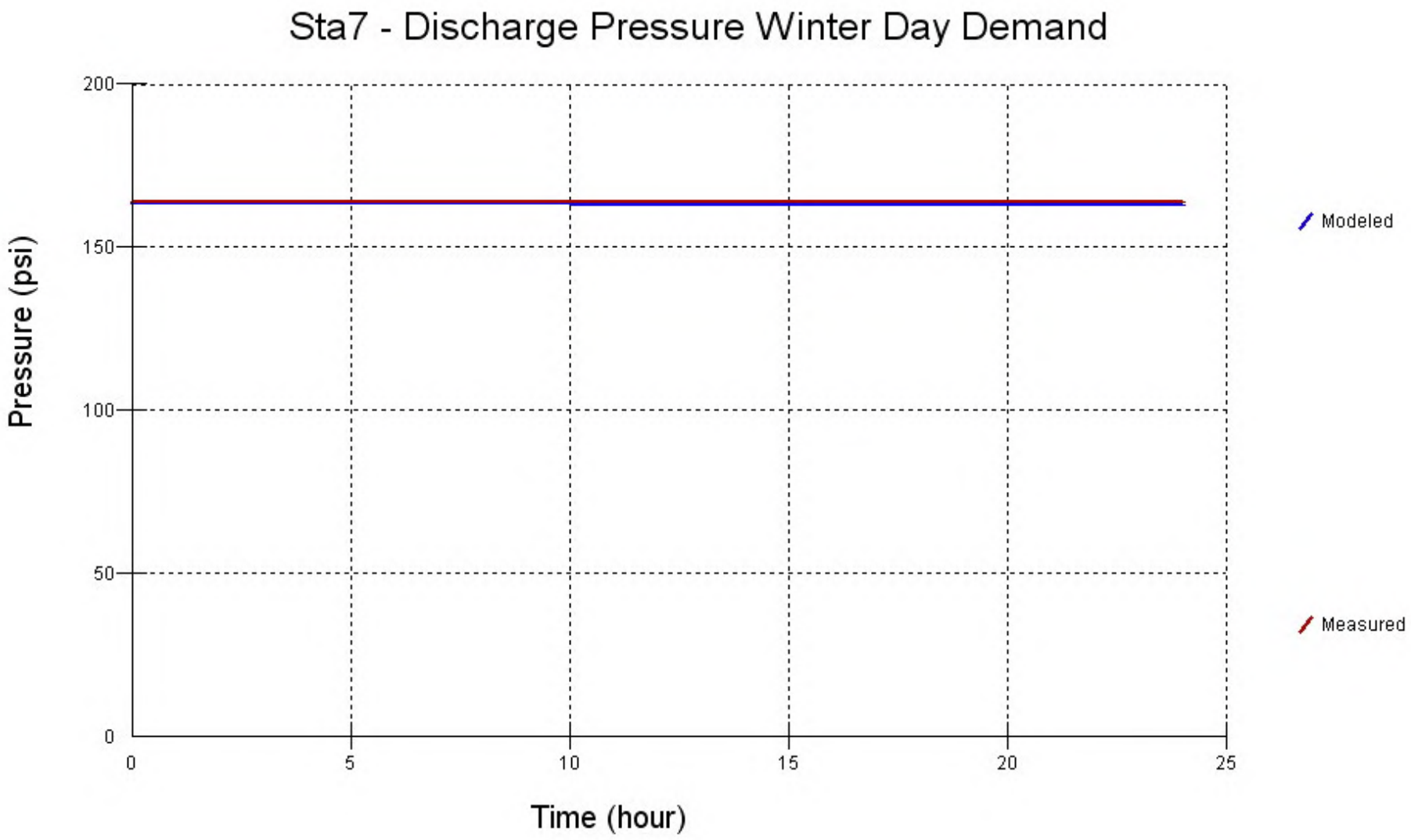

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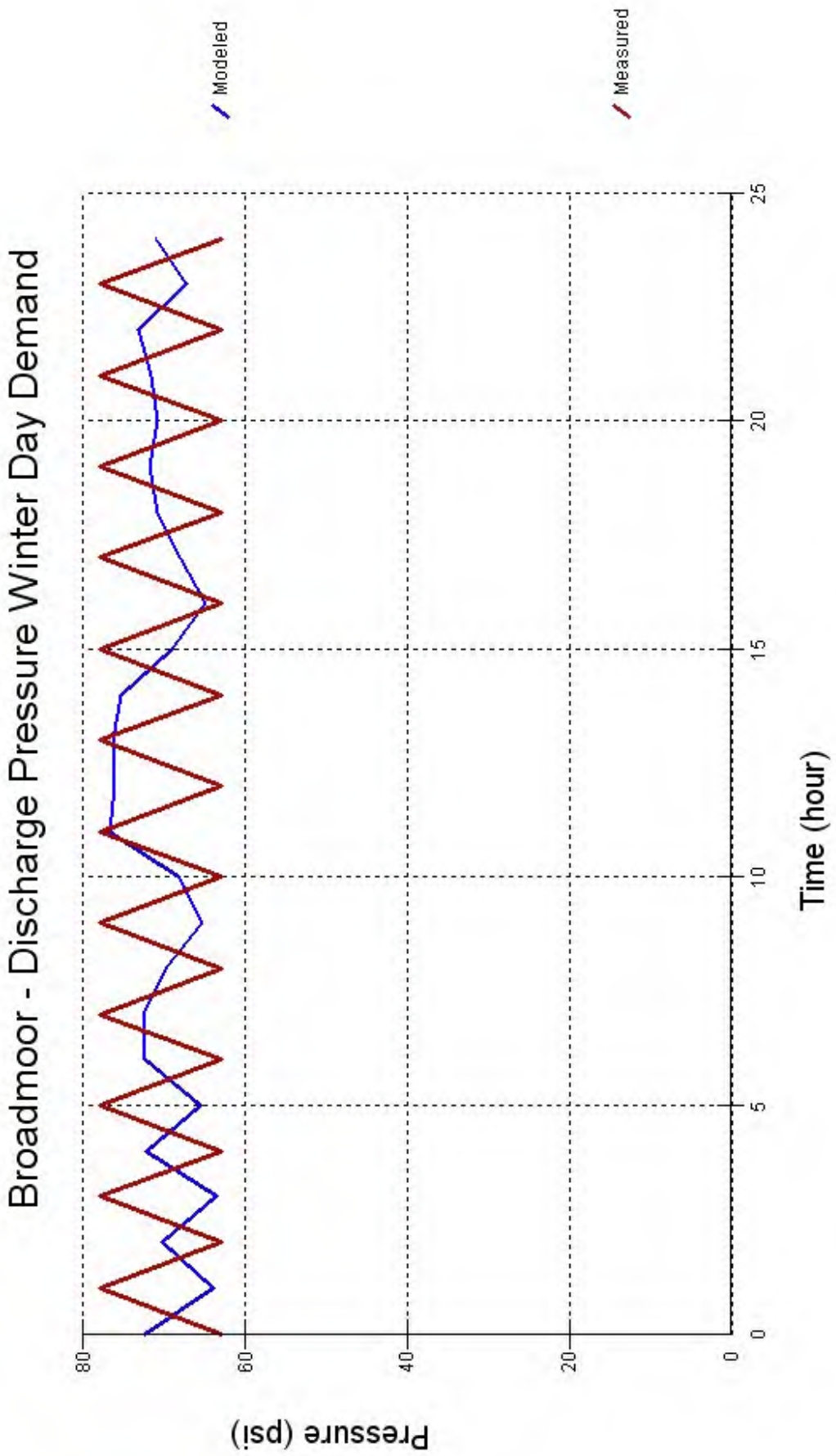

Appendix H

Fire Flow Analysis Results

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
Zone 200				
J-200-1482	88	0.35	46	26
J-200-1858	81	0.13	49	27
J-200-0748	23	0.47	74	30
J-200-1473	17	1.00	77	42
J-200-0336	111	2.64	36	72
J-200-0808	55	1.18	60	101
J-200-1868	42	1.10	66	104
J-200-0255	41	0.65	66	105
J-200-0807	51	0.30	62	137
J-200-0122	71	0.15	57	391
J-200-0125	70	1.95	57	402
J-200-0809	47	0.27	64	439
J-200-0113	43	1.32	65	443
J-200-0676	38	0.95	67	469
J-200-0009	53	1.01	60	481
J-200-1381	33	3.91	75	490
J-200-0678	49	1.05	63	553
J-200-0520	66	0.82	56	736
J-200-0599	45	3.10	67	821
J-200-0687	46	1.95	67	852
J-200-0124	48	0.86	67	971
J-200-1552	23	7.50	74	981
J-200-0126	48	2.80	66	982
J-200-1377	45	4.23	68	1,009
J-200-1469	97	1.66	42	1,026
J-200-0033	56	12.83	62	1,172
J-200-0337	109	1.13	37	1,295
J-200-0499	18	2.82	76	1,331
J-200-0500	20	1.48	75	1,355
J-200-0338	20	0.04	75	1,395
J-200-1931	26	0.43	72	1,430
J-200-0689	45	1.60	68	1,541
J-200-0251	47	0.43	63	1,618
J-200-2260	19	3.33	75	1,651
J-200-0516	58	5.13	60	1,651
J-200-0972	49	1.28	65	1,661
J-200-0768	19	2.06	75	1,694
J-200-0677	49	24.74	63	1,724
J-200-0679	46	10.90	64	1,728
J-200-1472	23	5.20	74	1,728
J-200-1596	36	18.44	69	1,785
J-200-2256	19	1.63	75	1,786
J-200-2257	22	2.84	74	1,792
J-200-2258	22	2.93	74	1,795

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-200-1470	118	0.82	33	1,806
J-200-1926	19	1.00	75	1,867
J-200-2251	19	0.23	75	1,884
J-200-1380	25	3.31	78	1,906
J-200-1550	18	0.91	76	1,934
J-200-1471	22	0.03	75	1,988
J-200-2253	19	2.20	75	1,989
J-200-0766	19	4.60	75	1,998
J-200-0619	22	5.11	75	2,013
J-200-0213	20	3.72	75	2,023
J-200-0602	21	3.96	75	2,031
J-200-0308	57	0.43	59	2,089
J-200-2255	19	0.67	75	2,091
J-200-2262	19	0.93	75	2,098
J-200-0543	20	1.10	76	2,103
J-200-2220	19	1.40	75	2,108
J-200-1935	19	0.22	75	2,156
J-200-1934	19	0.65	75	2,186
J-200-1930	27	5.45	71	2,195
J-200-0598	44	1.61	67	2,217
J-200-0780	23	2.24	74	2,220
J-200-0549	47	4.67	64	2,228
J-200-0083	20	0.34	73	2,256
J-200-2217	26	0.76	72	2,263
J-200-0697	72	1.11	54	2,263
J-200-0696	72	2.15	54	2,273
J-200-0789	35	10.20	69	2,293
J-200-0144	36	13.32	68	2,307
J-200-0673	37	0.98	68	2,312
J-200-0290	48	7.49	63	2,318
J-200-1357	36	1.95	74	2,331
J-200-0542	19	0.14	76	2,348
J-200-2098	27	0.61	71	2,351
J-200-0781	32	1.06	70	2,355
J-200-0784	33	0.18	69	2,369
J-200-1861	16	4.42	77	2,376
J-200-2219	19	0.90	75	2,394
J-200-2193	19	0.93	75	2,402
J-200-1761	24	5.32	73	2,402
J-200-2099	27	2.44	71	2,419
J-200-0971	71	0.56	55	2,420
J-200-1549	22	0.48	74	2,421
J-200-2218	19	8.46	75	2,426
J-200-2265	20	5.55	74	2,453
J-200-2054	15	0.13	74	2,473

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-200-2385	19	39.95	73	2,485
J-200-1427	49	0.82	63	2,516
J-200-0034	39	0.42	70	2,518
J-200-1376	46	0.66	68	2,520
J-200-0541	19	0.59	76	2,521
J-200-1435	47	0.55	64	2,522
J-200-2221	19	1.21	75	2,551
J-200-1928	19	2.50	75	2,553
J-200-1929	19	4.75	75	2,558
J-200-0088	38	1.52	70	2,565
J-200-0094	43	0.38	68	2,567
J-200-2223	24	0.24	73	2,574
J-200-1859	17	0.26	77	2,574
J-200-1760	24	0.55	73	2,588
J-200-0085	38	0.49	70	2,596
J-200-1764	19	7.66	75	2,607
J-200-0089	38	0.14	70	2,630
J-200-2197	20	0.55	74	2,637
J-200-1475	31	0.62	73	2,646
J-200-0093	38	2.88	70	2,656
J-200-2196	21	0.89	74	2,657
J-200-2263	19	0.42	75	2,662
J-200-0092	37	1.97	71	2,666
J-200-0763	19	2.63	75	2,666
J-200-0098	37	0.13	71	2,667
J-200-0099	37	3.29	71	2,673
J-200-1371	68	2.94	57	2,683
J-200-2222	19	4.44	75	2,685
J-200-1372	68	2.65	56	2,701
J-200-1425	45	5.89	65	2,719
J-200-1434	45	1.60	65	2,735
J-200-2202	19	0.68	75	2,767
J-200-0703	79	10.80	50	2,788
J-200-0772	20	7.36	75	2,794
J-200-2392	63	0.78	54	2,801
J-200-1866	39	0.97	68	2,819
J-200-2266	19	7.34	75	2,831
J-200-0744	19	0.76	75	2,836
J-200-0746	19	0.51	75	2,842
J-200-0738	20	4.36	75	2,859
J-200-1480	71	1.06	55	2,880
J-200-1577	55	0.06	68	2,912
J-200-0686	42	6.45	66	2,924
J-200-0764	19	0.46	75	2,937
J-200-0596	40	0.55	66	2,939

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-200-0597	40	3.07	67	2,951
J-200-0765	19	3.01	75	2,952
J-200-0775	21	0.35	74	2,986
J-200-0806	66	7.91	56	3,008
J-200-0833	20	3.70	74	3,009
J-200-0426	18	0.27	76	3,020
J-200-1369	57	3.76	62	3,055
J-200-0825	20	4.36	74	3,062
J-200-0146	21	0.19	76	3,062
J-200-0745	19	1.92	75	3,092
J-200-0777	22	1.43	74	3,094
J-200-0614	32	5.88	74	3,103
J-200-1641	63	3.60	57	3,110
J-200-1772	19	0.84	75	3,111
J-200-0819	21	5.98	75	3,112
J-200-1771	19	1.26	75	3,113
J-200-0962	62	6.67	57	3,139
J-200-0135	21	0.22	75	3,153
J-200-0820	25	3.72	78	3,160
J-200-0130	36	0.31	72	3,172
J-200-1923	19	0.20	75	3,210
J-200-1830	35	0.53	70	3,220
J-200-2224	19	5.10	75	3,243
J-200-0934	66	5.76	55	3,252
J-200-1910	69	8.59	54	3,279
J-200-2391	62	0.78	54	3,318
J-200-1893	81	0.76	49	3,324
J-200-1766	19	2.14	75	3,334
J-200-2204	19	3.85	75	3,334
J-200-2173	19	1.75	75	3,339
J-200-1241	24	0.84	74	3,363
J-200-1411	36	2.42	68	3,366
J-200-1200	36	0.89	68	3,377
J-200-1432	55	0.81	60	3,379
J-200-1365	46	0.09	68	3,381
J-200-2393	63	1.19	54	3,413
J-200-0277	41	0.59	66	3,446
J-200-0568	59	19.75	58	3,464
J-200-0710	51	1.10	62	3,464
J-200-0931	72	8.06	53	3,466
J-200-0008	53	41.78	60	3,468
J-200-0706	50	0.66	62	3,470
J-200-1442	35	0.20	69	3,477
J-200-2127	10	14.81	77	3,508
J-200-0582	34	8.15	69	3,515

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-200-2174	19	1.46	75	3,519
J-200-0584	35	1.13	69	3,522
J-200-1959	25	2.01	70	3,543
J-200-1765	19	0.17	75	3,546
J-200-0007	53	2.02	61	3,569
J-200-0701	85	7.28	49	3,572
J-200-1561	85	3.05	49	3,576
J-200-1773	19	0.32	75	3,587
J-200-1286	44	3.77	65	3,589
J-200-2143	117	133.78	29	3,590
J-200-0166	50	145.20	66	3,592
J-200-0932	67	0.18	55	3,606
J-200-1403	40	0.25	73	3,611
J-200-0811	69	0.37	54	3,642
J-200-0281	58	50.65	55	3,694
J-200-1481	80	1.38	49	3,705
J-200-0424	17	0.24	77	3,706
J-200-0580	34	0.16	69	3,725
J-200-0220	19	0.07	75	3,729
J-200-0279	111	82.83	32	3,764
J-200-0317	19	6.85	75	3,767
J-200-0943	61	0.34	58	3,777
J-200-1358	39	0.60	73	3,807
J-200-1361	38	0.45	73	3,821
J-200-1278	19	5.95	75	3,822
J-200-0945	61	2.31	58	3,829
J-200-1246	37	1.17	73	3,842
J-200-1955	25	0.10	70	3,861
J-200-1419	50	0.34	69	3,882
J-200-1359	42	1.78	72	3,887
J-200-0969	47	1.26	70	3,887
J-200-0801	31	1.90	93	3,889
J-200-1192	41	0.85	72	3,891
J-200-0831	19	0.25	73	3,893
J-200-2362	14	0.34	75	3,909
J-200-1177	33	0.51	73	3,947
J-200-0108	43	78.79	65	3,966
J-200-0224	20	59.50	74	3,976
J-200-0705	56	17.71	60	3,978
J-200-2021	2	4.00	80	4,016
J-200-0292	47	1.08	63	4,028
J-200-0713	56	0.39	60	4,034
J-200-0714	56	2.96	60	4,057
J-200-2022	0	0.60	81	4,067
J-200-1193	69	2.56	62	4,093

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-200-0712	55	0.28	60	4,095
J-200-1418	44	0.44	72	4,104
J-200-0810	67	0.74	55	4,106
J-200-1062	19	1.22	74	4,127
J-200-2189	19	2.28	75	4,133
J-200-1576	44	0.15	72	4,155
J-200-0711	55	0.22	60	4,178
J-200-0387	34	1.14	69	4,196
J-200-2103	19	0.44	75	4,204
J-200-2199	19	6.16	75	4,207
J-200-1572	47	0.27	71	4,211
J-200-0800	32	1.77	87	4,212
J-200-1270	24	0.51	73	4,213
J-200-1573	48	0.13	71	4,219
J-200-1908	78	5.26	50	4,230
J-200-0293	41	5.98	66	4,256
J-200-0115	41	0.42	66	4,256
J-200-1194	54	0.04	68	4,269
J-200-1574	50	0.15	70	4,269
J-200-0693	55	2.49	60	4,278
J-200-0399	41	0.06	66	4,279
J-200-0316	19	3.77	75	4,291
J-200-1409	29	2.76	126	4,292
J-200-2079	10	5.24	77	4,308
J-200-0280	95	9.28	39	4,345
J-200-0397	34	24.12	69	4,405
J-200-1906	77	0.95	51	4,408
J-200-0394	29	7.33	71	4,436
J-200-0260	43	7.05	65	4,436
J-200-0749	33	3.79	70	4,447
J-200-2332	16	8.92	74	4,459
J-200-0393	29	11.54	71	4,468
J-200-0105	42	0.36	65	4,475
J-200-0646	24	3.19	73	4,483
J-200-2144	104	21.67	35	4,524
J-200-0702	65	5.03	56	4,525
J-200-0296	38	4.00	67	4,538
J-200-0700	65	4.91	56	4,542
J-200-2126	10	2.42	77	4,551
J-200-0462	38	19.30	67	4,554
J-200-0694	55	0.08	60	4,571
J-200-1287	46	1.59	64	4,595
J-200-0590	36	0.83	72	4,596
J-200-0699	65	28.89	56	4,620
J-200-0722	57	14.06	59	4,639

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-200-0961	50	2.02	63	4,647
J-200-0683	45	0.87	64	4,649
J-200-0148	19	10.82	75	4,652
J-200-0347	34	2.58	70	4,661
J-200-0214	19	2.87	75	4,675
J-200-0444	32	11.00	70	4,684
J-200-2384	23	6.51	71	4,685
J-200-0226	19	59.62	75	4,686
J-200-1334	0	1.00	82	4,730
J-200-0511	37	0.48	73	4,761
J-200-0723	59	14.07	58	4,764
J-200-0681	46	6.53	64	4,800
J-200-0448	33	20.94	70	4,815
J-200-2276	56	1.26	58	4,833
J-200-0937	56	1.74	60	4,852
J-200-2278	60	7.21	56	4,854
J-200-1915	30	17.44	71	4,862
J-200-0635	18	2.33	75	4,881
J-200-0941	55	1.05	60	4,882
J-200-0634	18	0.35	75	4,884
J-200-0818	19	2.21	75	4,914
J-200-2029	19	32.80	73	4,921
J-200-1954	25	1.39	70	4,926
J-200-0942	35	9.49	69	4,928
J-200-0830	18	1.89	73	4,942
J-200-0816	36	13.19	68	4,973
J-200-1363	35	0.17	72	4,976
J-200-0817	83	28.08	48	4,985
J-200-0975	18	0.10	75	4,989
J-200-1323	0	0.19	82	5,001
J-200-0603	33	3.31	69	5,002
J-200-0136	22	1.04	74	5,003
J-200-0636	18	2.73	75	5,015
J-200-0215	59	20.69	58	5,030
J-200-0518	55	0.75	61	5,030
J-200-0692	55	0.57	61	5,030
J-200-0725	56	2.35	60	5,050
J-200-0588	35	0.12	72	5,061
J-200-1631	41	8.76	66	5,072
J-200-1623	23	7.91	74	5,093
J-200-2049	16	0.72	74	5,107
J-200-0691	47	0.47	64	5,118
J-200-0106	43	0.05	65	5,127
J-200-0729	57	0.36	59	5,136
J-200-0384	18	0.04	75	5,151

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-200-1239	56	7.44	60	5,180
J-200-1624	23	0.37	74	5,183
J-200-1386	25	2.54	74	5,197
J-200-1346	18	1.62	75	5,201
J-200-1057	24	0.61	72	5,217
J-200-0726	57	4.08	59	5,236
J-200-2369	15	7.53	74	5,248
J-200-2176	22	44.08	73	5,261
J-200-1158	23	4.40	71	5,269
J-200-1249	12	5.82	75	5,292
J-200-0938	34	13.71	69	5,312
J-200-0790	21	1.45	74	5,325
J-200-0950	26	9.67	73	5,334
J-200-0791	21	7.04	74	5,340
J-200-2293	21	0.11	72	5,356
J-200-0145	34	8.53	69	5,372
J-200-0986	34	0.34	69	5,378
J-200-2295	19	0.64	73	5,378
J-200-0022	19	9.86	75	5,381
J-200-0771	21	0.99	74	5,391
J-200-0685	42	0.21	66	5,396
J-200-1898	43	0.73	66	5,406
J-200-2076	14	1.66	75	5,411
J-200-0770	21	0.87	74	5,414
J-200-1384	26	5.57	74	5,460
J-200-1810	17	7.95	75	5,462
J-200-0151	30	0.43	71	5,481
J-200-0318	19	0.26	75	5,487
J-200-1081	19	0.11	74	5,488
J-200-0719	25	12.30	73	5,506
J-200-1648	41	2.68	66	5,518
J-200-2048	16	3.99	74	5,531
J-200-1869	43	13.33	65	5,538
J-200-2342	19	1.09	73	5,544
J-200-0045	24	0.15	71	5,551
J-200-2207	19	10.89	73	5,556
J-200-0004	41	18.97	66	5,561
J-200-0567	59	2.06	58	5,581
J-200-0668	19	2.88	75	5,587
J-200-1330	-1	0.57	83	5,596
J-200-1410	28	4.31	73	5,601
J-200-2044	14	0.46	75	5,606
J-200-0959	49	0.65	63	5,623
J-200-2358	18	7.91	73	5,638
J-200-0044	22	2.47	72	5,650

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-200-0753	19	2.20	75	5,652
J-200-0043	24	4.50	73	5,670
J-200-1437	28	46.63	73	5,671
J-200-0754	19	0.50	75	5,672
J-200-0907	94	18.91	40	5,677
J-200-2360	18	0.18	73	5,683
J-200-0319	19	5.91	75	5,710
J-200-0201	20	2.81	72	5,718
J-200-1947	15	39.86	74	5,729
J-200-1266	100	8.96	37	5,744
J-200-0792	23	2.66	74	5,748
J-200-1077	18	2.64	73	5,751
J-200-1609	7	7.18	79	5,761
J-200-0670	19	0.22	75	5,770
J-200-0918	45	4.29	65	5,813
J-200-2386	13	3.08	75	5,814
J-200-2366	16	6.45	74	5,840
J-200-1500	31	3.40	68	5,869
J-200-0665	19	1.20	75	5,873
J-200-0935	33	7.61	70	5,876
J-200-2206	20	3.76	72	5,879
J-200-1082	18	0.18	73	5,899
J-200-0523	19	0.98	75	5,908
J-200-0525	19	0.22	75	5,914
J-200-1083	18	0.09	73	5,923
J-200-0672	34	0.08	69	5,925
J-200-1415	39	2.95	71	5,935
J-200-0936	35	2.58	69	5,954
J-200-0742	19	1.04	75	5,964
J-200-0353	43	1.87	65	5,984
J-200-0579	21	8.16	74	5,987
J-200-1966	20	13.78	72	5,998
J-200-0174	19	1.77	76	6,000
J-200-2101	19	0.35	75	6,019
J-200-1546	15	0.92	74	6,033
J-200-0352	43	0.40	65	6,033
J-200-2185	16	24.31	74	6,047
J-200-0003	41	1.07	66	6,048
J-200-0001	42	0.38	65	6,070
J-200-0916	46	1.08	64	6,072
J-200-0569	36	0.43	68	6,078
J-200-1513	22	1.69	75	6,079
J-200-1514	23	3.17	74	6,079
J-200-1613	14	0.69	76	6,096
J-200-0524	19	2.71	75	6,098

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-200-0365	20	0.24	73	6,126
J-200-0571	35	1.63	69	6,128
J-200-2100	19	0.98	75	6,151
J-200-0920	32	8.65	70	6,156
J-200-0570	35	7.61	69	6,158
J-200-0202	18	4.76	73	6,164
J-200-1636	32	1.87	70	6,168
J-200-0203	18	1.86	73	6,170
J-200-2154	25	0.50	70	6,174
J-200-0479	22	4.91	73	6,178
J-200-0752	19	2.04	75	6,185
J-200-0216	83	9.40	48	6,198
J-200-0940	30	3.62	71	6,201
J-200-0704	34	14.52	69	6,209
J-200-1515	24	1.10	74	6,213
J-200-0751	19	1.85	75	6,223
J-200-0824	19	0.14	74	6,229
J-200-1521	30	0.23	71	6,260
J-200-2167	76	18.46	49	6,264
J-200-2394	69	0.58	52	6,275
J-200-0928	55	1.44	60	6,277
J-200-1414	38	4.08	71	6,280
J-200-1634	31	0.14	71	6,296
J-200-0573	19	7.04	75	6,313
J-200-0480	23	0.25	73	6,322
J-200-1671	48	2.34	64	6,330
J-200-1417	38	1.33	71	6,344
J-200-1637	31	0.25	71	6,346
J-200-1783	15	0.63	75	6,370
J-200-1544	15	72.36	74	6,373
J-200-2056	16	21.89	74	6,450
J-200-1525	30	2.23	71	6,474
J-200-0869	25	7.31	71	6,479
J-200-0431	16	6.97	77	6,487
J-200-2350	15	0.42	74	6,492
J-200-0577	20	1.07	75	6,503
J-200-1808	12	2.84	77	6,510
J-200-0951	46	0.04	64	6,527
J-200-1536	16	0.08	74	6,528
J-200-0322	23	0.27	73	6,530
J-200-0841	36	17.54	67	6,542
J-200-0747	28	0.68	72	6,549
J-200-0823	19	2.56	74	6,609
J-200-2390	69	9.84	52	6,644
J-200-0574	21	1.32	74	6,664

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-200-0642	22	0.02	73	6,673
J-200-1453	120	0.63	32	6,673
J-200-1946	15	5.97	75	6,679
J-200-0865	33	0.60	68	6,691
J-200-1838	32	1.59	68	6,723
J-200-1782	14	4.40	75	6,725
J-200-0080	18	3.00	73	6,733
J-200-0066	34	2.59	67	6,740
J-200-0079	18	32.62	73	6,743
J-200-1896	49	2.35	63	6,760
J-200-1115	6	15.21	80	6,763
J-200-2322	20	2.97	72	6,767
J-200-1905	60	1.67	58	6,793
J-200-1260	2	12.33	80	6,810
J-200-2016	14	0.43	75	6,810
J-200-0607	20	0.09	75	6,818
J-200-2009	16	23.41	74	6,833
J-200-0204	18	137.29	73	6,836
J-200-1903	57	10.61	59	6,859
J-200-1364	35	0.40	71	6,865
J-200-1436	58	1.84	59	6,875
J-200-2273	25	0.26	72	6,908
J-200-2339	18	0.58	73	6,941
J-200-2357	19	0.11	73	6,981
J-200-0666	19	24.37	75	6,998
J-200-0593	36	0.22	72	7,011
J-200-0467	28	0.14	71	7,065
J-200-0617	16	1.19	77	7,073
J-200-1847	25	1.01	72	7,091
J-200-2117	28	1.89	72	7,097
J-200-2274	25	1.97	72	7,111
J-200-0924	54	1.15	61	7,111
J-200-1904	59	0.93	59	7,123
J-200-1846	25	2.15	72	7,123
J-200-1973	18	17.15	73	7,127
J-200-2335	20	1.36	73	7,143
J-200-2115	27	1.43	72	7,156
J-200-1114	6	15.34	80	7,190
J-200-2348	19	3.32	73	7,207
J-200-1650	40	0.45	67	7,225
J-200-2397	61	10.28	55	7,274
J-200-2146	23	36.19	71	7,278
J-200-0247	29	0.10	69	7,284
J-200-0073	29	0.80	69	7,290
J-200-1652	39	1.02	67	7,309

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-200-0236	23	0.78	72	7,309
J-200-0239	22	5.38	73	7,341
J-200-0074	23	3.73	72	7,374
J-200-1806	27	8.04	70	7,491
J-200-2153	25	6.99	70	7,502
J-200-0233	24	90.90	72	7,521
J-200-2370	16	0.74	74	7,535
J-200-2107	24	7.95	73	7,579
J-200-2106	24	34.65	73	7,596
J-200-0077	17	0.87	74	7,610
J-200-1562	80	3.10	51	7,624
J-200-2313	24	1.35	70	7,630
J-200-0838	19	2.60	73	7,635
J-200-0078	17	3.84	74	7,652
J-200-0051	19	3.04	74	7,655
J-200-2314	24	1.95	70	7,666
J-200-0060	17	1.00	74	7,685
J-200-0161	33	0.22	69	7,698
J-200-0235	25	9.43	71	7,715
J-200-1617	11	27.56	77	7,750
J-200-1911	23	13.53	72	7,780
J-200-0926	55	4.21	60	7,873
J-200-1817	17	0.30	77	7,894
J-200-2309	22	18.13	71	7,905
J-200-1146	23	11.26	73	7,909
J-200-0192	56	47.45	58	7,911
J-200-0326	113	1.50	36	7,920
J-200-0522	24	0.17	73	7,949
J-200-0193	54	2.82	58	7,955
J-200-1965	20	0.17	72	7,988
J-200-0929	54	1.77	61	7,994
J-200-2164	16	20.80	74	8,016
J-200-2092	21	1.88	74	8,041
J-200-1344	19	4.40	74	8,065
J-200-1456	106	2.10	38	8,071
J-200-1345	19	5.97	74	8,072
J-200-2136	17	1.64	73	8,072
J-200-2382	53	5.04	58	8,079
J-200-2137	17	9.03	73	8,079
J-200-2307	20	1.84	72	8,080
J-200-2489	19	0.39	75	8,083
J-200-2140	27	0.06	68	8,083
J-200-1964	20	1.13	72	8,100
J-200-1238	31	8.94	71	8,113
J-200-1339	19	1.45	74	8,116

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-200-2344	17	1.12	73	8,146
J-200-1457	105	6.31	39	8,201
J-200-0812	19	5.18	75	8,223
J-200-0813	19	2.46	75	8,235
J-200-2345	15	2.39	74	8,248
J-200-2162	16	0.53	74	8,249
J-200-1999	16	3.01	74	8,253
J-200-0993	86	0.35	47	8,253
J-200-0822	19	0.93	74	8,272
J-200-1272	85	0.11	47	8,277
J-200-1008	85	1.05	47	8,331
J-200-2000	16	1.73	74	8,343
J-200-1343	19	1.22	74	8,346
J-200-2284	19	18.15	81	8,381
J-200-2104	19	0.24	75	8,446
J-200-0767	19	3.48	75	8,453
J-200-0432	28	1.15	72	8,462
J-200-2323	15	1.10	74	8,548
J-200-2228	6	11.40	78	8,574
J-200-0769	19	1.79	75	8,580
J-200-0987	33	0.39	70	8,593
J-200-2004	15	0.44	74	8,654
J-200-2346	15	1.02	74	8,674
J-200-1342	19	0.55	74	8,686
J-200-2230	5	47.29	78	8,686
J-200-1465	54	2.29	57	8,696
J-200-2377	54	3.89	58	8,727
J-200-2347	15	1.65	74	8,732
J-200-1768	19	18.67	75	8,732
J-200-1759	19	0.32	75	8,754
J-200-1352	77	1.88	53	8,770
J-200-1757	19	4.53	75	8,775
J-200-0227	19	0.68	75	8,880
J-200-0606	33	86.83	69	8,936
J-200-1144	22	4.98	74	8,943
J-200-0551	36	6.99	69	8,955
J-200-0973	19	10.25	74	8,986
J-200-0954	48	2.36	63	8,991
J-200-1969	17	3.27	73	8,991
J-200-2138	4	366.66	79	8,994
J-200-1979	11	7.44	76	9,065
J-200-2231	7	308.17	77	9,083
J-200-1228	35	0.19	69	9,114
J-200-1941	19	23.63	75	9,198
J-200-0952	48	2.85	64	9,217

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-200-1789	36	8.62	66	9,242
J-200-1997	3	1.80	79	9,313
J-200-1466	63	3.20	54	9,346
J-200-2388	11	4.08	76	9,376
J-200-1310	3	13.35	79	9,384
J-200-2387	11	18.25	76	9,411
J-200-1998	13	2.10	75	9,423
J-200-1502	62	1.98	54	9,434
J-200-2234	12	8.08	76	9,444
J-200-2304	15	2.37	74	9,450
J-200-1216	64	5.23	53	9,454
J-200-1353	81	1.49	51	9,502
J-200-0600	51	0.56	64	9,528
J-200-0968	80	1.79	51	9,535
J-200-1788	36	0.26	67	9,558
J-200-0661	21	3.43	74	9,571
J-200-1939	19	59.50	75	9,573
J-200-0027	21	3.16	74	9,599
J-200-0179	35	7.47	67	9,616
J-200-1229	21	3.56	75	9,638
J-200-1109	11	31.91	78	9,639
J-200-2285	19	16.48	81	9,702
J-200-1739	61	21.24	56	9,814
J-200-2301	14	9.89	75	9,831
J-200-2085	19	1.37	75	9,906
J-200-0555	25	1.66	73	9,911
J-200-2214	8	2.32	77	9,920
J-200-2378	40	8.68	64	9,960
J-200-1803	32	9.20	68	9,980
J-200-2082	19	8.57	75	9,988
J-200-1993	8	8.46	77	10,002
J-200-2321	14	3.74	75	10,032
J-200-1096	25	35.57	72	10,043
J-200-0026	19	0.92	75	10,046
J-200-1099	35	4.85	67	10,052
J-200-0888	38	2.21	66	10,069
J-200-2212	10	13.63	77	10,118
J-200-1724	25	18.01	71	10,130
J-200-1744	60	5.84	56	10,172
J-200-1740	62	21.69	55	10,173
J-200-0660	19	0.14	75	10,179
J-200-1097	29	2.09	70	10,195
J-200-0616	25	1.60	73	10,230
J-200-1987	8	1.52	77	10,232
J-200-0333	20	33.13	75	10,245

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-200-1309	14	0.56	75	10,249
J-200-1968	14	1.29	75	10,287
J-200-1984	8	16.28	77	10,291
J-200-2298	14	1.34	75	10,319
J-200-0889	38	31.34	66	10,338
J-200-2303	14	0.05	75	10,358
J-200-1071	22	0.73	72	10,393
J-200-1988	7	2.63	78	10,467
J-200-1273	34	0.76	69	10,506
J-200-1726	25	16.82	71	10,512
J-200-1967	12	2.91	75	10,576
J-200-0054	19	0.23	75	10,615
J-200-1510	25	22.35	71	10,621
J-200-1277	19	0.03	75	10,627
J-200-1212	47	26.47	61	10,663
J-200-1110	15	22.65	77	10,680
J-200-1290	5	9.50	78	10,681
J-200-0154	29	2.98	71	10,690
J-200-1962	11	0.26	76	10,738
J-200-1274	19	2.21	75	10,769
J-200-1629	22	2.07	75	10,864
J-200-1963	9	1.72	77	10,893
J-200-1647	39	0.86	67	10,913
J-200-1989	6	2.42	78	10,956
J-200-0650	19	3.36	75	11,004
J-200-0615	30	26.47	71	11,069
J-200-1961	10	0.70	77	11,076
J-200-0484	19	0.58	75	11,088
J-200-1237	30	1.97	71	11,094
J-200-0482	19	59.50	75	11,110
J-200-1027	15	13.34	74	11,150
J-200-2475	17	38.59	81	11,181
J-200-1592	34	8.53	71	11,191
J-200-0887	35	4.46	68	11,205
J-200-2396	14	10.04	75	11,279
J-200-2242	14	2.72	75	11,305
J-200-0325	110	0.49	38	11,348
J-200-2379	39	87.52	64	11,415
J-200-2241	37	12.09	65	11,440
J-200-1128	16	16.78	76	11,536
J-200-0194	54	15.77	59	11,587
J-200-0733	126	1.49	35	11,777
J-200-0195	52	12.49	60	11,780
J-200-2211	11	1.37	76	11,792
J-200-2208	12	3.41	76	11,807

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-200-1992	6	7.57	78	11,811
J-200-1227	36	2.51	69	11,825
J-200-0996	36	0.27	69	11,863
J-200-1508	13	23.10	76	11,873
J-200-1990	6	2.93	78	11,876
J-200-1919	63	64.32	62	11,944
J-200-1950	11	0.38	76	11,965
J-200-1951	10	0.45	77	11,976
J-200-1952	10	0.07	77	11,981
J-200-1995	6	6.16	78	12,004
J-200-1213	48	8.32	60	12,030
J-200-2184	10	0.17	77	12,045
J-200-1126	47	0.38	62	12,229
J-200-1994	8	4.19	77	12,299
J-200-0116	110	0.13	38	12,325
J-200-1684	10	9.49	77	12,580
J-200-1683	10	55.16	77	12,688
J-200-1235	11	3.67	79	12,804
J-200-0997	37	0.35	68	12,862
J-200-1047	9	2.56	77	12,867
J-200-1399	38	0.72	68	12,950
J-200-1394	39	2.23	67	12,979
J-200-1422	16	0.56	77	12,991
J-200-1421	16	0.09	77	13,011
J-200-1314	38	1.85	64	13,014
J-200-1049	6	17.32	78	13,032
J-200-1395	38	0.35	68	13,049
J-200-1460	37	1.31	68	13,091
J-200-1659	20	0.23	75	13,239
J-200-1397	14	4.90	75	13,342
J-200-1458	22	0.36	75	13,369
J-200-1698	18	16.51	73	13,499
J-200-1051	13	7.74	75	13,663
J-200-2472	15	0.33	82	13,672
J-200-1255	14	0.44	75	13,715
J-200-2473	17	4.24	82	13,781
J-200-1693	18	8.06	73	14,106
J-200-0876	26	38.59	71	14,107
J-200-1996	5	1.32	79	14,331
J-200-1981	5	13.21	78	14,342
J-200-1312	27	17.58	69	14,589
J-200-0734	125	1.71	36	14,597
J-200-1132	20	21.54	74	14,950
J-200-1311	25	0.43	70	14,965
J-200-0375	10	6.21	76	15,267

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-200-0883	20	0.09	74	15,292
J-200-2464	16	1.06	82	15,853
J-200-0373	13	2.17	75	16,142
J-200-1702	14	0.95	75	16,357
J-200-0418	7	12.63	78	16,954
J-200-1493	10	2.67	77	16,986
J-200-1703	13	15.79	76	17,388
J-200-1489	14	6.91	75	17,567
J-200-0875	17	32.06	76	18,054
J-200-1120	16	20.14	77	18,451
J-200-1024	15	5.49	74	18,549
J-200-1030	13	8.52	75	18,624
J-200-1031	11	6.05	76	18,900
J-200-1688	10	0.01	77	19,120
J-200-1020	10	18.17	77	19,136
J-200-1483	10	52.08	77	19,547
J-200-1044	11	5.21	80	19,653
J-200-1038	11	12.43	80	20,161
J-200-0526	11	134.59	80	20,270
J-200-0406	18	5.64	73	20,383
J-200-0404	18	0.22	73	20,398
J-200-0533	9	38.59	82	20,790
J-200-0407	15	0.03	74	21,780
J-200-0735	110	0.47	42	21,876
J-200-0410	16	9.92	74	22,063
J-200-0413	16	0.42	74	22,445
J-200-0498	16	1.01	74	22,609
J-200-0298	18	13.23	73	23,274
J-200-0299	14	0.74	75	25,943
J-200-2450	14	38.59	83	33,453
Zone 260				
J-260-375	95	0.16	74	125
J-260-022	64	0.52	82	130
J-260-021	63	0.61	82	223
J-260-289	80	0.13	81	308
J-260-174	43	0.33	95	382
J-260-140	78	1.30	82	454
J-260-031	62	0.82	82	492
J-260-180	52	1.62	92	537
J-260-358	159	0.56	41	737
J-260-046	85	4.61	72	751
J-260-356	152	2.52	44	918
J-260-357	160	0.58	52	1032
J-260-047	75	4.07	77	1232
J-260-353	140	5.17	49	1243

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-260-017	74	1.08	77	1280
J-260-268	70	2.12	79	1322
J-260-320	86	1.95	72	1333
J-260-053	56	3.05	85	1360
J-260-359	88	0.58	75	1398
J-260-181	90	8.86	74	1401
J-260-258	73	1.19	78	1412
J-260-150	25	7.62	98	1420
J-260-323	84	1.92	73	1452
J-260-239	73	7.24	78	1520
J-260-250	28	2.90	97	1528
J-260-081	31	1.58	96	1533
J-260-292	28	6.91	97	1545
J-260-223	88	0.38	71	1550
J-260-083	25	7.85	98	1571
J-260-317	71	0.22	79	1586
J-260-299	100	1.84	66	1592
J-260-231	85	3.40	73	1593
J-260-273	70	2.91	79	1602
J-260-230	79	0.43	75	1606
J-260-161	82	2.13	74	1611
J-260-200	82	2.65	74	1615
J-260-217	82	4.16	74	1621
J-260-165	72	0.76	78	1633
J-260-354	74	1.89	79	1637
J-260-300	96	2.41	68	1638
J-260-164	70	0.26	79	1640
J-260-129	74	4.83	79	1644
J-260-080	25	3.34	98	1645
J-260-158	72	3.04	78	1646
J-260-318	71	0.13	79	1647
J-260-147	25	0.14	98	1659
J-260-216	83	1.74	74	1671
J-260-319	71	0.22	79	1671
J-260-241	94	2.10	69	1681
J-260-148	25	0.18	98	1689
J-260-089	84	25.63	73	1690
J-260-025	65	1.04	81	1693
J-260-267	73	0.61	78	1694
J-260-394	25	1.08	98	1697
J-260-240	93	2.07	69	1709
J-260-366	80	4.37	80	1713
J-260-157	71	0.54	79	1715
J-260-222	72	0.97	78	1722
J-260-168	98	2.93	67	1726

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-260-079	26	4.11	98	1727
J-260-220	73	3.36	78	1733
J-260-139	39	0.10	92	1742
J-260-337	39	2.46	92	1757
J-260-243	44	0.21	90	1761
J-260-087	45	0.58	90	1765
J-260-242	87	1.23	72	1772
J-260-135	94	0.03	69	1776
J-260-391	25	5.99	98	1777
J-260-386	25	1.42	98	1789
J-260-045	66	0.82	81	1790
J-260-302	86	1.61	72	1796
J-260-301	85	1.07	73	1802
J-260-314	85	0.73	73	1802
J-260-086	46	1.36	89	1807
J-260-196	95	12.16	68	1811
J-260-303	85	1.25	73	1814
J-260-085	46	3.95	89	1814
J-260-166	84	1.44	73	1827
J-260-221	75	1.14	77	1840
J-260-151	27	13.52	97	1843
J-260-076	94	0.27	69	1855
J-260-381	28	34.82	97	1863
J-260-131	85	1.26	73	1869
J-260-167	80	0.45	75	1870
J-260-172	46	0.96	94	1873
J-260-092	88	0.74	71	1876
J-260-091	87	0.88	72	1880
J-260-209	79	0.45	76	1886
J-260-128	51	0.09	87	1892
J-260-313	74	0.45	77	1903
J-260-308	79	0.25	76	1920
J-260-309	79	12.34	76	1925
J-260-093	90	4.36	70	1939
J-260-371	94	0.22	75	2015
J-260-039	67	5.80	80	2018
J-260-009	63	14.45	82	2036
J-260-034	90	0.43	70	2042
J-260-324	72	1.38	78	2061
J-260-229	59	4.09	84	2086
J-260-005	57	3.44	85	2086
J-260-255	72	0.91	78	2086
J-260-012	76	5.93	76	2087
J-260-007	61	0.57	83	2106
J-260-003	56	4.18	85	2119

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-260-094	90	0.65	71	2130
J-260-010	58	2.77	84	2138
J-260-401	71	0.36	79	2150
J-260-257	76	0.89	77	2156
J-260-018	73	2.17	78	2172
J-260-014	89	7.39	71	2177
J-260-043	75	10.46	77	2185
J-260-145	92	8.16	76	2224
J-260-127	25	0.61	99	2226
J-260-274	79	2.08	75	2227
J-260-130	58	2.25	86	2228
J-260-069	79	0.38	75	2228
J-260-126	25	0.12	99	2231
J-260-144	91	0.54	76	2236
J-260-097	90	0.22	70	2237
J-260-296	50	1.10	88	2238
J-260-066	71	0.49	79	2242
J-260-202	58	0.11	86	2244
J-260-011	50	1.35	88	2255
J-260-013	69	0.55	79	2261
J-260-331	25	1.72	99	2278
J-260-002	75	0.56	77	2299
J-260-015	73	3.18	78	2300
J-260-214	61	7.58	88	2320
J-260-234	50	0.53	88	2327
J-260-001	72	0.81	78	2334
J-260-179	58	3.17	89	2344
J-260-321	51	0.24	87	2348
J-260-233	55	0.47	86	2357
J-260-270	53	0.52	86	2360
J-260-062	72	0.26	78	2362
J-260-235	50	0.38	88	2375
J-260-396	61	1.57	88	2377
J-260-284	64	0.80	87	2395
J-260-059	71	0.55	78	2396
J-260-232	50	0.39	88	2401
J-260-237	50	0.46	88	2403
J-260-191	70	0.66	79	2406
J-260-236	50	0.96	88	2411
J-260-322	53	0.63	87	2419
J-260-192	69	0.36	80	2426
J-260-207	33	0.54	95	2428
J-260-247	31	10.68	96	2476
J-260-042	71	0.41	79	2478
J-260-290	50	18.43	88	2486

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-260-188	66	3.58	81	2502
J-260-330	26	1.28	98	2519
J-260-203	60	0.26	86	2523
J-260-189	63	3.45	82	2536
J-260-186	63	2.01	82	2541
J-260-246	26	0.24	98	2580
J-260-340	41	9.36	92	2602
J-260-194	65	4.84	81	2740
J-260-056	67	3.84	80	2774
J-260-030	65	0.30	81	2782
J-260-215	55	5.34	91	2797
J-260-055	67	0.50	80	2810
J-260-175	46	1.13	94	2829
J-260-178	53	1.85	91	2844
J-260-294	56	3.45	87	2855
J-260-190	55	7.09	88	2871
J-260-400	55	0.72	91	2874
J-260-177	59	1.73	89	2890
J-260-379	55	0.76	91	2908
J-260-173	48	0.28	93	2915
J-260-078	56	12.84	87	2922
J-260-283	65	5.30	86	2961
J-260-349	41	2.49	96	3005
J-260-170	49	0.95	93	3058
J-260-171	48	6.38	93	3074
J-260-182	46	4.36	93	3166
J-260-113	55	2.03	91	3238
J-260-176	55	1.40	91	3259
J-260-342	39	0.80	97	3391
J-260-077	45	5.72	94	3452
J-260-374	81	1.08	80	3488
J-260-347	41	0.17	95	3542
J-260-405	43	5.68	95	3573
J-260-398	41	0.33	96	3639
J-260-395	43	0.03	95	3663
J-260-380	43	12.83	95	3696
J-260-345	38	4.41	97	3770
J-260-143	79	6.96	81	4003
J-260-142	80	0.35	81	4075
J-260-117	77	0.94	82	4658
J-260-112	64	2.02	88	5592
J-260-110	65	0.09	88	6685
J-260-282	66	0.33	87	6952
J-260-281	70	0.80	86	9189
Zone 265				

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-265-377	114	1.80	59	32
J-265-614	170	0.99	27	53
J-265-376	109	0.76	62	71
J-265-226	152	0.03	46	80
J-265-673	186	0.20	31	173
J-265-613	159	0.49	32	216
J-265-114	141	1.91	51	409
J-265-084	162	3.17	42	410
J-265-083	161	0.49	42	411
J-265-180	145	0.97	49	469
J-265-117	141	4.74	116	480
J-265-118	142	0.93	51	483
J-265-442	104	0.36	67	496
J-265-116	139	1.42	52	519
J-265-643	120	2.47	59	521
J-265-030	139	0.22	52	521
J-265-562	107	1.01	66	537
J-265-561	116	1.58	62	573
J-265-525	167	2.00	27	608
J-265-305	165	8.55	28	621
J-265-427	97	1.71	56	630
J-265-139	113	2.37	63	640
J-265-306	165	0.33	28	658
J-265-304	164	0.20	29	700
J-265-266	68	0.26	82	727
J-265-617	158	1.38	32	734
J-265-034	117	3.46	61	746
J-265-311	163	0.56	29	776
J-265-032	117	0.74	62	795
J-265-147	119	1.37	61	807
J-265-140	104	5.44	67	818
J-265-033	116	0.81	62	823
J-265-315	167	0.24	30	838
J-265-310	161	0.45	30	842
J-265-313	167	1.54	30	842
J-265-502	84	0.95	64	847
J-265-322	166	1.96	30	861
J-265-245	179	0.17	35	896
J-265-307	163	1.67	29	899
J-265-309	162	0.21	30	900
J-265-192	102	5.29	68	914
J-265-390	120	3.69	59	930
J-265-197	111	0.62	64	963
J-265-672	163	0.21	41	989
J-265-349	104	0.09	66	1023

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SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-265-424	70	2.81	68	1026
J-265-411	88	0.88	59	1032
J-265-194	168	0.44	39	1041
J-265-578	150	1.73	36	1059
J-265-577	150	4.86	36	1060
J-265-452	188	0.27	31	1070
J-265-110	119	3.92	61	1072
J-265-196	94	2.00	72	1163
J-265-025	92	0.90	72	1189
J-265-026	91	0.29	73	1191
J-265-027	91	0.29	73	1193
J-265-028	88	1.90	74	1204
J-265-041	163	0.20	42	1214
J-265-022	90	1.16	73	1215
J-265-564	140	1.89	51	1229
J-265-131	70	3.30	82	1238
J-265-265	70	1.39	81	1238
J-265-021	86	1.50	75	1244
J-265-020	86	1.04	75	1248
J-265-029	77	3.35	79	1259
J-265-019	84	0.36	76	1260
J-265-172	94	2.25	71	1271
J-265-493	70	1.01	81	1296
J-265-088	109	5.21	65	1351
J-265-423	91	3.60	59	1351
J-265-486	51	5.98	90	1400
J-265-575	135	7.00	42	1401
J-265-484	72	2.19	81	1403
J-265-319	156	3.32	37	1405
J-265-321	156	0.87	37	1416
J-265-320	156	0.39	37	1416
J-265-138	108	1.03	65	1433
J-265-109	137	2.86	53	1441
J-265-079	94	5.73	71	1448
J-265-316	152	1.50	39	1455
J-265-451	177	0.27	35	1466
J-265-419	106	1.30	39	1475
J-265-082	127	0.16	57	1483
J-265-441	137	0.20	53	1489
J-265-171	104	10.44	66	1491
J-265-436	130	0.14	56	1510
J-265-616	79	0.85	50	1511
J-265-080	127	2.04	57	1523
J-265-168	157	1.15	39	1529
J-265-301	136	6.74	40	1568

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-265-489	92	0.34	72	1594
J-265-706	103	0.56	40	1598
J-265-146	100	5.91	69	1606
J-265-299	137	0.64	39	1609
J-265-422	70	0.77	76	1614
J-265-596	113	1.72	63	1631
J-265-634	113	2.04	63	1638
J-265-579	123	0.83	48	1645
J-265-069	162	0.74	42	1645
J-265-145	75	8.78	80	1675
J-265-491	92	0.94	73	1684
J-265-398	117	4.32	50	1688
J-265-582	122	3.28	48	1689
J-265-127	93	1.25	72	1697
J-265-621	124	0.49	47	1697
J-265-126	93	1.77	72	1698
J-265-167	159	0.47	38	1699
J-265-173	136	0.13	53	1720
J-265-169	159	0.13	39	1734
J-265-592	120	2.03	60	1736
J-265-576	124	3.67	47	1749
J-265-136	71	0.07	82	1758
J-265-152	168	2.54	37	1765
J-265-165	150	5.03	42	1771
J-265-134	71	2.41	81	1773
J-265-159	89	0.25	65	1773
J-265-294	126	5.59	43	1786
J-265-633	116	1.09	62	1791
J-265-191	92	4.03	72	1797
J-265-402	115	0.19	51	1798
J-265-009	75	0.16	80	1803
J-265-644	114	0.52	62	1814
J-265-373	110	0.50	43	1816
J-265-642	120	1.47	59	1818
J-265-293	126	1.31	44	1829
J-265-064	131	2.64	55	1839
J-265-324	166	0.14	38	1851
J-265-606	107	3.96	65	1866
J-265-610	70	0.14	81	1870
J-265-513	104	0.64	56	1871
J-265-504	101	0.15	52	1872
J-265-302	136	2.44	40	1878
J-265-175	128	0.46	57	1883
J-265-707	96	0.33	57	1885
J-265-300	130	3.14	42	1892

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SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-265-636	129	4.79	56	1906
J-265-345	117	2.72	54	1913
J-265-420	74	7.29	74	1931
J-265-704	114	0.24	62	1935
J-265-193	152	3.17	46	1937
J-265-120	112	1.29	64	1940
J-265-347	116	0.23	54	1943
J-265-641	136	2.46	53	1950
J-265-162	115	1.91	54	1957
J-265-062	123	1.67	59	1963
J-265-040	140	0.89	52	1966
J-265-591	129	1.18	56	1967
J-265-401	134	2.53	40	1968
J-265-071	122	1.12	59	1981
J-265-323	164	0.25	39	1986
J-265-595	118	2.13	61	2004
J-265-511	115	4.10	51	2011
J-265-176	121	0.27	60	2025
J-265-184	118	3.40	61	2036
J-265-070	121	1.30	60	2043
J-265-035	120	1.82	60	2053
J-265-099	117	0.91	61	2053
J-265-170	160	0.22	40	2065
J-265-686	91	1.47	72	2072
J-265-003	108	0.79	66	2099
J-265-178	117	0.30	62	2104
J-265-001	116	0.73	62	2109
J-265-004	107	1.71	66	2113
J-265-098	116	0.12	62	2117
J-265-585	112	1.36	52	2118
J-265-335	119	0.09	49	2131
J-265-680	69	1.52	82	2144
J-265-569	116	0.46	50	2153
J-265-568	115	2.67	51	2181
J-265-006	101	1.59	69	2191
J-265-336	119	0.80	49	2205
J-265-153	161	2.51	41	2209
J-265-216	73	3.34	53	2215
J-265-007	100	2.49	69	2218
J-265-341	118	1.60	50	2231
J-265-329	121	4.88	50	2253
J-265-450	150	0.71	47	2256
J-265-257	100	8.10	66	2259
J-265-328	121	0.36	50	2287
J-265-449	149	2.25	48	2291

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-265-448	148	0.80	48	2313
J-265-291	117	2.71	46	2320
J-265-570	111	4.01	53	2321
J-265-410	101	1.04	52	2351
J-265-698	104	1.03	67	2360
J-265-665	87	1.08	74	2370
J-265-520	110	7.18	53	2373
J-265-695	102	1.74	68	2392
J-265-160	89	0.34	66	2392
J-265-540	85	0.55	75	2393
J-265-542	84	0.60	75	2399
J-265-008	91	3.15	73	2417
J-265-166	95	4.23	64	2422
J-265-332	118	0.37	50	2444
J-265-534	91	0.17	72	2457
J-265-537	82	1.58	76	2461
J-265-701	96	0.39	70	2462
J-265-123	115	0.35	63	2462
J-265-338	117	0.68	52	2471
J-265-586	101	0.43	57	2490
J-265-038	117	0.25	62	2506
J-265-121	113	0.49	63	2507
J-265-531	92	1.29	72	2507
J-265-533	92	0.18	72	2516
J-265-624	101	0.39	57	2529
J-265-512	105	0.90	56	2536
J-265-296	119	0.37	47	2542
J-265-297	119	0.89	47	2573
J-265-475	106	0.46	66	2590
J-265-039	115	1.37	63	2597
J-265-456	142	2.82	51	2599
J-265-286	108	4.74	51	2606
J-265-295	119	0.48	47	2613
J-265-453	141	0.20	51	2623
J-265-290	120	1.98	45	2624
J-265-663	70	2.33	81	2652
J-265-406	78	0.76	65	2679
J-265-697	112	0.78	64	2688
J-265-209	87	0.04	75	2691
J-265-457	138	0.18	53	2701
J-265-285	107	0.54	52	2705
J-265-662	70	0.30	81	2710
J-265-460	138	2.88	53	2713
J-265-638	71	0.27	81	2734
J-265-482	143	0.52	50	2787

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SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-265-655	74	0.09	80	2832
J-265-272	145	3.92	49	2837
J-265-283	110	3.93	46	2845
J-265-010	73	1.14	80	2860
J-265-682	109	1.25	65	2878
J-265-195	130	0.85	56	2880
J-265-656	74	2.99	80	2898
J-265-163	96	1.36	62	2903
J-265-417	86	3.55	61	2953
J-265-415	79	0.19	64	2956
J-265-461	127	4.84	57	2997
J-265-363	95	0.23	63	3013
J-265-364	95	0.72	63	3037
J-265-426	91	0.14	59	3062
J-265-418	86	6.87	61	3085
J-265-425	89	0.10	60	3144
J-265-141	110	5.12	65	3161
J-265-683	110	0.40	65	3200
J-265-674	146	0.98	48	3211
J-265-358	105	6.36	50	3225
J-265-156	96	0.41	57	3288
J-265-684	110	0.64	65	3296
J-265-355	93	3.25	62	3342
J-265-289	107	0.41	52	3343
J-265-282	113	0.97	45	3345
J-265-359	105	5.18	50	3350
J-265-381	115	0.14	62	3383
J-265-387	122	2.47	59	3392
J-265-619	112	7.06	44	3420
J-265-142	91	5.52	73	3530
J-265-343	104	0.48	53	3569
J-265-273	164	5.65	41	3652
J-265-073	101	1.54	69	3758
J-265-011	65	0.45	84	3771
J-265-233	65	1.06	84	3853
J-265-605	69	0.92	83	3884
J-265-236	59	25.45	87	3921
J-265-274	69	0.76	85	4018
J-265-551	62	6.84	85	4059
J-265-046	131	6.62	56	4115
J-265-462	71	2.21	81	4155
J-265-221	168	2.31	40	4279
J-265-689	166	0.21	41	4417
J-265-124	125	1.55	58	4754
J-265-223	87	0.19	74	4987

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SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-265-705	107	0.04	39	5544
J-265-072	100	0.55	69	5759
J-265-051	125	0.06	58	5784
J-265-224	72	0.41	81	6224
Zone 280				
J-280-016	108	16.87	70	2302
J-280-015	126	16.87	62	2340
J-280-013	132	16.87	59	2354
J-280-012	138	16.87	57	2414
J-280-011	136	16.87	58	2599
J-280-009	143	16.87	55	2739
J-280-007	138	16.87	57	3201
Zone 285				
J-285-011	232	0.74	21	161
J-285-010	232	2.86	21	164
J-285-012	230	0.86	22	291
J-285-136	224	0.30	24	388
J-285-131	226	0.37	23	399
J-285-051	217	0.30	27	519
J-285-053	217	0.30	27	542
J-285-050	212	0.30	29	626
J-285-015	219	2.63	26	658
J-285-013	219	2.20	26	660
J-285-213	138	0.69	61	680
J-285-052	208	0.24	31	693
J-285-139	207	0.98	32	722
J-285-140	206	3.00	32	731
J-285-236	124	0.12	68	734
J-285-180	130	0.54	66	742
J-285-179	116	0.58	72	743
J-285-178	109	1.00	75	754
J-285-110	133	0.86	64	767
J-285-249	104	2.31	77	773
J-285-063	197	1.50	36	774
J-285-014	213	0.96	29	830
J-285-009	202	0.82	34	925
J-285-007	200	0.56	34	965
J-285-250	96	2.77	81	968
J-285-084	91	0.71	82	970
J-285-137	167	1.80	49	977
J-285-150	85	1.21	85	978
J-285-006	199	1.89	35	986
J-285-034	205	2.65	33	1008
J-285-082	103	1.27	77	1012
J-285-083	103	0.21	77	1012

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SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-285-066	103	0.48	76	1018
J-285-147	205	1.04	32	1032
J-285-024	190	2.67	39	1060
J-285-005	186	4.46	41	1066
J-285-027	194	1.75	37	1082
J-285-028	194	1.13	37	1090
J-285-042	201	1.30	34	1116
J-285-048	184	0.29	42	1123
J-285-191	169	0.39	48	1128
J-285-004	182	0.78	42	1132
J-285-008	184	4.88	42	1133
J-285-127	168	4.33	49	1150
J-285-026	191	0.74	39	1179
J-285-065	128	1.99	66	1211
J-285-025	191	1.68	38	1213
J-285-062	154	2.46	55	1294
J-285-001	160	4.55	52	1296
J-285-217	165	1.96	50	1299
J-285-142	143	0.29	59	1339
J-285-243	188	0.80	40	1351
J-285-068	151	0.38	57	1354
J-285-046	188	2.09	40	1382
J-285-141	146	0.49	58	1401
J-285-130	146	0.30	58	1406
J-285-129	145	0.17	58	1414
J-285-044	187	0.39	40	1424
J-285-069	140	9.27	61	1426
J-285-023	187	0.26	40	1427
J-285-190	170	0.76	47	1447
J-285-022	185	1.08	41	1461
J-285-111	92	0.45	82	1480
J-285-234	187	1.05	40	1484
J-285-040	171	4.09	47	1500
J-285-059	120	5.87	69	1560
J-285-039	166	0.43	49	1589
J-285-064	119	0.48	70	1594
J-285-144	158	4.20	53	1623
J-285-118	124	0.06	67	1624
J-285-060	161	4.15	52	1631
J-285-055	160	3.09	52	1648
J-285-239	108	5.78	75	1659
J-285-189	171	1.70	47	1722
J-285-214	164	0.23	50	1724
J-285-238	98	5.37	80	1738
J-285-134	139	1.65	62	1755

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RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-285-232	184	0.74	42	1783
J-285-076	108	0.10	75	1784
J-285-247	181	0.62	43	1796
J-285-020	156	1.26	54	1798
J-285-146	154	2.65	54	1805
J-285-125	158	0.90	53	1826
J-285-216	163	2.19	51	1848
J-285-235	183	0.62	42	1849
J-285-074	97	0.36	80	1866
J-285-135	134	2.78	64	1868
J-285-078	136	0.81	63	1872
J-285-079	131	0.69	65	1878
J-285-124	155	0.38	54	1879
J-285-109	142	0.95	60	1887
J-285-080	127	1.53	67	1900
J-285-033	140	5.42	61	1903
J-285-186	111	3.13	73	1906
J-285-071	98	3.05	80	1918
J-285-061	96	4.99	80	1933
J-285-029	161	2.43	51	1938
J-285-215	168	0.24	49	1942
J-285-032	159	1.26	52	1950
J-285-031	166	1.21	49	1956
J-285-185	111	1.08	73	1974
J-285-218	119	2.41	70	1984
J-285-193	183	0.45	42	2003
J-285-105	173	1.13	46	2022
J-285-088	72	1.66	90	2028
J-285-086	72	0.23	90	2036
J-285-117	136	2.46	62	2052
J-285-081	110	1.30	74	2077
J-285-208	148	0.46	57	2082
J-285-021	137	0.86	62	2095
J-285-242	104	4.40	76	2097
J-285-151	86	4.02	84	2110
J-285-089	163	3.28	51	2119
J-285-077	108	3.53	76	2121
J-285-200	129	0.24	65	2127
J-285-122	146	2.51	58	2131
J-285-197	134	0.47	63	2133
J-285-199	126	0.70	67	2145
J-285-123	147	0.38	58	2149
J-285-198	122	1.19	68	2175
J-285-177	105	2.05	77	2182
J-285-085	86	0.82	84	2184

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RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-285-210	156	7.05	54	2197
J-285-184	119	0.61	70	2237
J-285-121	119	0.82	70	2274
J-285-035	124	3.18	67	2316
J-285-120	122	0.60	69	2347
J-285-075	97	1.05	80	2349
J-285-119	122	0.72	68	2352
J-285-224	95	0.90	81	2394
J-285-173	94	0.34	81	2453
J-285-222	94	0.23	82	2490
J-285-219	88	2.70	84	2502
J-285-220	88	0.24	84	2514
J-285-107	143	3.33	60	2528
J-285-169	94	6.43	82	2564
J-285-098	142	0.91	61	2567
J-285-132	91	0.78	82	2768
J-285-113	89	1.22	84	3105
J-285-090	75	9.28	90	3290
J-285-211	74	0.56	90	3417
J-285-133	89	0.70	84	3498
J-285-091	74	0.62	90	3595
J-285-099	92	7.78	82	3958
J-285-102	74	2.25	90	4705
J-285-095	72	0.53	91	5303
J-285-094	72	0.82	91	5804
J-285-154	70	1.74	92	8226
J-285-158	70	0.18	92	8790
J-285-155	70	0.04	92	9488
Zone 330				
J-330-0164	48	2.89	117	141
J-330-0231	45	1.76	119	188
J-330-0499	121	5.53	89	206
J-330-0498	126	1.52	87	240
J-330-0390	168	3.79	69	268
J-330-0630	98	3.10	99	296
J-330-0627	109	0.72	94	387
J-330-0389	172	1.52	67	540
J-330-0496	128	0.46	86	545
J-330-0230	43	1.65	120	695
J-330-0480	219	6.06	42	782
J-330-0902	71	7.08	111	884
J-330-0043	151	6.11	70	891
J-330-0119	237	0.91	39	1002
J-330-0848	237	0.06	34	1004
J-330-0734	219	24.90	43	1043

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RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-330-0689	80	0.59	103	1043
J-330-0382	236	1.32	39	1051
J-330-0337	230	0.73	42	1054
J-330-0117	236	2.46	39	1065
J-330-0385	235	2.11	39	1066
J-330-0811	241	1.17	32	1102
J-330-0863	238	0.68	33	1144
J-330-0505	227	4.79	43	1147
J-330-0378	230	1.03	42	1167
J-330-0381	231	3.87	41	1168
J-330-0329	228	0.65	43	1240
J-330-0330	227	2.02	43	1298
J-330-0463	139	4.86	93	1318
J-330-0338	215	1.32	48	1334
J-330-0808	182	5.01	57	1370
J-330-0379	218	0.71	47	1386
J-330-0809	186	0.42	56	1388
J-330-0093	61	1.46	115	1430
J-330-0120	216	2.99	48	1431
J-330-0092	61	3.09	115	1443
J-330-0864	217	0.23	43	1468
J-330-0334	214	2.25	49	1470
J-330-0333	213	0.80	49	1487
J-330-0335	213	0.53	49	1488
J-330-0076	56	2.76	117	1497
J-330-0815	214	0.85	44	1497
J-330-0504	211	2.41	50	1503
J-330-0340	209	6.12	51	1505
J-330-0339	212	1.27	50	1512
J-330-0626	213	1.08	49	1517
J-330-0143	213	0.82	49	1518
J-330-0813	211	1.47	45	1526
J-330-0075	49	0.61	120	1543
J-330-0816	207	1.58	47	1545
J-330-0669	171	0.49	67	1549
J-330-0121	211	1.76	50	1558
J-330-0308	209	2.24	51	1562
J-330-0309	208	3.50	51	1573
J-330-0084	45	0.01	122	1594
J-330-0673	175	0.57	66	1612
J-330-0083	45	0.23	122	1613
J-330-0786	203	2.18	49	1626
J-330-0115	209	0.15	51	1630
J-330-0882	172	1.16	62	1635
J-330-0082	44	0.71	122	1641

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-330-0614	205	2.68	49	1693
J-330-0770	164	3.80	66	1728
J-330-0645	130	5.09	85	1744
J-330-0068	46	1.76	121	1746
J-330-0279	85	1.28	100	1761
J-330-0668	166	0.51	69	1761
J-330-0678	185	0.96	56	1818
J-330-0636	114	4.15	92	1819
J-330-0732	185	2.58	57	1823
J-330-0679	185	1.94	56	1828
J-330-0562	155	1.99	69	1842
J-330-0452	139	11.49	81	1861
J-330-0042	144	5.64	73	1866
J-330-0029	41	4.60	124	1869
J-330-0311	168	0.36	68	1909
J-330-0312	170	1.08	68	1915
J-330-0310	170	3.46	68	1917
J-330-0181	106	0.15	74	1923
J-330-0638	146	0.55	78	1948
J-330-0503	146	5.09	78	1972
J-330-0643	112	1.42	93	2003
J-330-0388	173	0.75	67	2016
J-330-0178	108	0.32	73	2017
J-330-0449	186	0.76	61	2024
J-330-0602	184	0.21	62	2039
J-330-0031	40	0.15	124	2042
J-330-0641	146	0.52	78	2042
J-330-0342	223	1.05	40	2046
J-330-0446	178	0.78	64	2047
J-330-0622	167	0.35	65	2051
J-330-0714	81	1.10	102	2104
J-330-0667	157	2.71	74	2118
J-330-0666	156	0.97	74	2132
J-330-0644	128	0.71	86	2158
J-330-0183	105	5.70	74	2163
J-330-0651	128	0.65	86	2179
J-330-0444	176	0.72	65	2186
J-330-0021	42	2.00	123	2186
J-330-0637	110	0.23	94	2198
J-330-0635	109	3.46	94	2207
J-330-0613	167	3.55	65	2208
J-330-0510	152	3.60	76	2223
J-330-0972	60	1.24	116	2251
J-330-0294	101	1.44	76	2257
J-330-0442	171	0.67	67	2259

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-330-0582	139	4.67	77	2266
J-330-0664	153	0.17	75	2272
J-330-0648	138	1.95	82	2273
J-330-0650	134	1.73	83	2282
J-330-0511	153	0.21	75	2285
J-330-0647	138	0.53	82	2287
J-330-0646	138	0.60	82	2296
J-330-0494	127	3.39	86	2299
J-330-0105	75	3.02	87	2313
J-330-0929	108	6.09	95	2331
J-330-0293	102	1.62	75	2376
J-330-0617	172	3.13	62	2384
J-330-0292	102	0.69	75	2392
J-330-0047	143	1.05	74	2401
J-330-0623	167	0.55	65	2427
J-330-0462	139	2.29	81	2449
J-330-0750	104	8.34	97	2482
J-330-0495	127	1.64	86	2524
J-330-0110	104	7.19	90	2563
J-330-0365	128	1.21	80	2580
J-330-0515	137	0.36	81	2591
J-330-0426	147	1.29	78	2593
J-330-0947	64	2.74	114	2599
J-330-0410	137	1.09	81	2608
J-330-0736	219	35.83	43	2617
J-330-0051	156	1.85	69	2630
J-330-0493	128	0.92	86	2642
J-330-0375	114	1.09	86	2653
J-330-0771	170	3.68	64	2654
J-330-0050	156	1.54	69	2657
J-330-0098	44	0.21	122	2659
J-330-0291	86	6.86	82	2676
J-330-0290	88	0.56	82	2684
J-330-0032	46	0.06	122	2749
J-330-0461	131	1.66	85	2795
J-330-0024	42	1.06	123	2803
J-330-0783	172	2.41	62	2811
J-330-0963	48	39.27	121	2816
J-330-0525	132	2.07	82	2816
J-330-0670	121	9.98	89	2830
J-330-0427	129	0.63	86	2844
J-330-0940	112	4.30	92	2862
J-330-0653	131	2.88	85	2862
J-330-0475	168	4.91	64	2864
J-330-0392	120	0.74	89	2876

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-330-0306	120	3.21	89	2877
J-330-0386	120	2.28	90	2888
J-330-0141	133	4.75	79	2893
J-330-0655	129	0.22	86	2904
J-330-0662	129	0.42	86	2922
J-330-0780	210	1.99	45	2932
J-330-0719	172	1.35	62	2940
J-330-0772	169	24.99	64	2941
J-330-0657	113	5.72	93	2954
J-330-0001	98	0.30	95	2991
J-330-0718	187	0.65	56	2995
J-330-0633	111	2.66	94	2999
J-330-0788	107	6.06	95	2999
J-330-0387	113	1.13	92	3026
J-330-0421	106	0.07	96	3038
J-330-0420	105	1.39	96	3042
J-330-0343	202	1.53	49	3044
J-330-0460	130	0.42	85	3049
J-330-0625	169	1.52	64	3058
J-330-0501	97	1.70	99	3088
J-330-0527	136	0.56	80	3098
J-330-0490	123	0.62	88	3098
J-330-0327	108	5.67	95	3100
J-330-0526	136	0.78	80	3105
J-330-0568	204	0.92	48	3108
J-330-0579	137	1.15	79	3113
J-330-0317	136	4.28	80	3120
J-330-0632	113	0.65	93	3122
J-330-0299	69	0.81	90	3135
J-330-0328	108	2.29	95	3139
J-330-0223	115	5.85	90	3149
J-330-0781	203	1.95	49	3151
J-330-0712	66	1.87	108	3161
J-330-0162	57	1.41	95	3161
J-330-0721	192	0.19	54	3164
J-330-0006	87	0.44	100	3169
J-330-0220	132	3.15	83	3170
J-330-0002	87	0.15	100	3170
J-330-0005	87	0.10	100	3174
J-330-0422	110	0.57	94	3191
J-330-0512	114	1.97	91	3199
J-330-0578	139	1.05	78	3203
J-330-0720	192	0.33	53	3204
J-330-0746	185	0.60	57	3211
J-330-0733	209	1.72	47	3224

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-330-0577	139	0.30	78	3228
J-330-0785	176	0.12	61	3242
J-330-0486	123	0.54	88	3263
J-330-0161	64	0.04	92	3282
J-330-0158	63	26.69	92	3293
J-330-0763	175	2.28	61	3307
J-330-0367	128	10.29	80	3322
J-330-0287	63	0.60	92	3327
J-330-0768	164	4.93	66	3345
J-330-0142	119	2.23	85	3366
J-330-0433	129	4.04	80	3380
J-330-0588	136	5.62	78	3386
J-330-0782	166	2.36	65	3391
J-330-0314	136	3.67	80	3393
J-330-0057	92	0.17	97	3397
J-330-0488	122	0.49	89	3414
J-330-0453	167	3.34	65	3415
J-330-0188	43	16.94	120	3421
J-330-0456	165	3.25	66	3434
J-330-0044	141	17.54	74	3438
J-330-0571	136	1.32	80	3441
J-330-0587	94	0.22	96	3445
J-330-0219	126	0.14	86	3457
J-330-0572	138	0.38	79	3472
J-330-0056	90	5.69	98	3474
J-330-0315	138	0.69	79	3478
J-330-0615	186	2.22	57	3492
J-330-0616	203	1.38	49	3497
J-330-0129	166	0.61	66	3499
J-330-0013	95	3.68	96	3513
J-330-0850	129	0.80	85	3515
J-330-0216	126	1.52	86	3518
J-330-0928	121	2.38	89	3560
J-330-0618	164	1.37	65	3568
J-330-0764	175	3.74	61	3569
J-330-0533	99	0.58	94	3580
J-330-0524	119	1.67	87	3597
J-330-0766	176	0.87	61	3604
J-330-0016	95	3.15	96	3614
J-330-0828	62	11.24	115	3615
J-330-0930	113	1.67	92	3618
J-330-0752	129	6.32	85	3624
J-330-0887	129	0.29	85	3624
J-330-0769	165	0.35	66	3627
J-330-0939	107	1.78	94	3633

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SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-330-0747	122	5.05	89	3637
J-330-0213	123	1.43	87	3651
J-330-0374	128	4.01	81	3659
J-330-0779	198	2.23	51	3674
J-330-0225	110	1.32	93	3677
J-330-0789	105	0.19	96	3695
J-330-0130	165	3.19	66	3701
J-330-0936	167	0.22	65	3710
J-330-0218	109	8.19	93	3716
J-330-0723	164	1.70	65	3716
J-330-0745	199	1.19	51	3724
J-330-0429	118	0.78	85	3728
J-330-0323	118	0.37	88	3731
J-330-0518	110	0.43	92	3737
J-330-0247	77	1.19	103	3741
J-330-0933	104	7.53	97	3743
J-330-0520	108	0.63	93	3752
J-330-0521	107	0.49	94	3773
J-330-0938	106	2.00	95	3780
J-330-0765	167	0.42	65	3781
J-330-0942	105	0.26	95	3783
J-330-0542	78	5.51	103	3787
J-330-0851	123	0.93	88	3788
J-330-0761	81	5.04	106	3790
J-330-0514	111	12.32	91	3797
J-330-0522	108	0.12	94	3807
J-330-0224	109	0.88	93	3817
J-330-0778	197	1.19	51	3825
J-330-0478	167	0.40	65	3827
J-330-0713	77	3.73	104	3833
J-330-0059	94	0.49	97	3837
J-330-0937	108	1.47	94	3853
J-330-0048	146	0.98	73	3869
J-330-0934	105	0.68	96	3882
J-330-0150	94	2.95	95	3946
J-330-0932	104	0.64	96	3950
J-330-0534	136	6.40	78	3951
J-330-0916	73	0.26	110	3952
J-330-0045	137	1.97	76	3962
J-330-0124	136	1.85	77	3972
J-330-0886	128	0.33	86	3981
J-330-0561	77	1.77	104	3984
J-330-0039	137	4.35	76	3991
J-330-0837	73	1.28	110	4009
J-330-0914	62	2.53	115	4033

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RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-330-0438	110	1.17	92	4035
J-330-0599	101	40.20	95	4038
J-330-0566	169	2.23	63	4041
J-330-0592	115	40.20	89	4044
J-330-0869	128	1.83	83	4053
J-330-0415	128	1.40	83	4067
J-330-0125	128	7.83	80	4069
J-330-0313	104	3.74	93	4080
J-330-0128	165	0.16	66	4097
J-330-0956	60	4.20	116	4100
J-330-0878	70	5.83	111	4111
J-330-0368	129	1.73	80	4134
J-330-0399	106	2.49	93	4144
J-330-0412	130	4.39	82	4147
J-330-0454	157	4.83	69	4150
J-330-0758	55	1.32	118	4154
J-330-0318	131	0.35	82	4161
J-330-0604	127	18.98	83	4169
J-330-0605	128	1.11	83	4177
J-330-0212	88	2.96	98	4190
J-330-0899	89	5.22	103	4195
J-330-0790	103	0.44	97	4214
J-330-0807	152	2.86	71	4216
J-330-0693	106	0.89	93	4231
J-330-0694	105	0.59	94	4238
J-330-0629	71	2.43	111	4249
J-330-0885	128	0.13	86	4254
J-330-0699	105	0.19	93	4260
J-330-0484	94	9.73	98	4265
J-330-0762	88	0.68	104	4269
J-330-0418	106	70.75	93	4275
J-330-0535	100	0.51	94	4276
J-330-0952	61	2.07	115	4276
J-330-0725	153	1.07	70	4281
J-330-0879	61	1.62	115	4281
J-330-0700	105	0.13	93	4283
J-330-0884	127	0.96	86	4284
J-330-0704	104	1.78	94	4284
J-330-0131	157	0.60	69	4292
J-330-0621	154	0.86	70	4301
J-330-0532	99	1.39	94	4310
J-330-0113	98	2.20	90	4313
J-330-0362	116	2.48	85	4323
J-330-0320	130	0.94	82	4345
J-330-0364	116	1.36	85	4361

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-330-0726	159	0.80	68	4365
J-330-0729	207	0.19	48	4365
J-330-0430	115	0.56	86	4366
J-330-0951	96	4.35	100	4369
J-330-0556	87	0.08	100	4392
J-330-0036	129	16.08	80	4394
J-330-0565	162	0.73	66	4394
J-330-0061	90	6.79	98	4414
J-330-0949	107	7.37	95	4425
J-330-0620	155	0.52	69	4441
J-330-0038	137	3.64	76	4455
J-330-0316	124	1.16	85	4458
J-330-0467	207	1.26	48	4458
J-330-0303	156	2.05	69	4466
J-330-0727	206	0.85	48	4480
J-330-0688	88	0.23	99	4481
J-330-0530	103	0.29	93	4490
J-330-0702	102	0.54	95	4490
J-330-0373	157	5.35	69	4499
J-330-0035	136	11.26	77	4505
J-330-0428	126	0.54	82	4509
J-330-0037	137	1.48	76	4514
J-330-0269	33	5.20	124	4528
J-330-0555	76	0.42	104	4536
J-330-0703	93	2.80	99	4551
J-330-0041	143	3.88	74	4560
J-330-0724	155	0.90	69	4562
J-330-0403	94	0.32	97	4563
J-330-0539	91	0.69	98	4578
J-330-0455	139	5.09	77	4587
J-330-0537	92	4.92	97	4596
J-330-0136	213	0.43	45	4612
J-330-0273	100	1.76	89	4615
J-330-0612	91	0.71	97	4617
J-330-0744	220	17.29	42	4627
J-330-0759	58	2.15	116	4627
J-330-0544	74	4.64	105	4639
J-330-0185	35	16.08	123	4642
J-330-0404	102	1.42	93	4673
J-330-0536	91	0.09	98	4674
J-330-0730	204	3.02	49	4682
J-330-0272	101	3.76	89	4685
J-330-0169	114	1.04	87	4686
J-330-0707	102	0.78	94	4708
J-330-0705	102	0.59	94	4724

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-330-0451	205	0.24	49	4727
J-330-0246	77	3.12	103	4735
J-330-0049	145	3.12	73	4743
J-330-0787	166	0.35	66	4751
J-330-0423	70	7.34	111	4755
J-330-0361	116	7.76	85	4800
J-330-0126	212	0.50	46	4802
J-330-0546	89	0.19	98	4810
J-330-0144	126	0.38	82	4814
J-330-0402	93	1.12	97	4834
J-330-0358	116	16.43	85	4857
J-330-0806	198	1.15	51	4875
J-330-0738	164	4.15	66	4880
J-330-0283	63	1.61	102	4930
J-330-0543	76	1.43	104	4953
J-330-0740	166	2.27	65	4955
J-330-0276	82	12.33	97	4962
J-330-0468	207	1.17	48	4965
J-330-0370	92	3.38	97	4971
J-330-0174	139	0.17	76	4996
J-330-0109	111	1.38	87	4998
J-330-0053	136	1.65	77	5002
J-330-0465	207	0.72	48	5086
J-330-0541	74	0.83	105	5101
J-330-0531	137	4.88	78	5106
J-330-0431	131	4.83	79	5120
J-330-0148	139	0.87	76	5162
J-330-0167	135	0.50	78	5191
J-330-0052	135	0.32	77	5193
J-330-0280	68	2.16	101	5213
J-330-0127	201	0.28	50	5232
J-330-0540	74	0.32	105	5258
J-330-0345	234	0.11	36	5276
J-330-0538	132	4.12	80	5299
J-330-0354	66	2.22	102	5376
J-330-0600	65	0.66	114	5414
J-330-0760	65	0.57	114	5432
J-330-0408	136	0.43	78	5458
J-330-0409	136	1.13	78	5464
J-330-0585	126	4.65	82	5494
J-330-0286	68	6.40	102	5497
J-330-0946	70	2.12	111	5511
J-330-0652	65	1.58	114	5552
J-330-0583	137	0.19	78	5563
J-330-0737	135	4.50	79	5565

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-330-0581	137	1.03	78	5605
J-330-0405	133	3.95	80	5628
J-330-0406	129	0.21	81	5668
J-330-0731	132	0.07	80	5703
J-330-0138	217	0.72	44	5706
J-330-0748	92	3.80	102	5716
J-330-0609	74	65.93	106	5719
J-330-0586	134	1.05	79	5732
J-330-0591	131	2.84	80	5742
J-330-0584	137	0.85	78	5755
J-330-0151	107	1.84	89	5775
J-330-0722	132	0.73	80	5809
J-330-0589	89	0.20	99	5826
J-330-0407	127	0.39	82	5880
J-330-0062	66	1.23	109	5886
J-330-0397	69	6.62	109	5893
J-330-0690	66	0.03	109	5929
J-330-0691	67	0.02	109	5940
J-330-0155	107	7.40	89	5961
J-330-0945	91	0.74	102	5968
J-330-0227	67	0.23	109	5969
J-330-0153	107	0.21	89	5991
J-330-0344	217	1.19	43	5998
J-330-0369	123	2.80	83	6032
J-330-0923	92	0.35	102	6051
J-330-0590	90	1.89	98	6078
J-330-0559	77	0.75	104	6085
J-330-0560	88	0.54	99	6137
J-330-0152	107	1.90	89	6166
J-330-0371	124	0.74	83	6183
J-330-0226	67	19.92	108	6302
J-330-0394	75	19.30	106	6310
J-330-0228	67	2.78	108	6385
J-330-0168	124	0.22	83	6391
J-330-0145	124	0.72	83	6416
J-330-0377	107	4.42	90	6531
J-330-0550	60	16.84	112	6607
J-330-0172	106	0.48	90	6610
J-330-0184	38	0.55	122	6656
J-330-0170	110	1.18	89	6667
J-330-0253	80	2.45	101	7042
J-330-0393	67	18.20	110	7066
J-330-0249	77	0.70	103	7324
J-330-0251	75	1.32	103	7452
J-330-0171	103	1.39	91	7481

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-330-0558	66	2.27	109	7507
J-330-0252	78	1.26	102	7629
J-330-0107	60	10.48	110	7645
J-330-0553	64	0.37	110	7757
J-330-0106	61	0.55	109	7955
J-330-0551	62	1.21	111	7991
J-330-0256	62	0.69	109	8116
J-330-0254	59	0.34	110	8258
J-330-0237	59	4.49	111	8286
J-330-0854	67	13.74	110	8573
J-330-0401	58	7.51	113	9247
J-330-0400	50	5.32	116	10332
J-330-0794	59	40.20	113	10410
J-330-0979	56	50.54	114	10503
J-330-0195	37	3.94	122	10642
J-330-0876	39	16.08	122	10684
J-330-0259	48	1.14	117	10889
J-330-0791	66	2.79	111	10920
J-330-0260	48	4.85	117	11043
J-330-0261	47	4.13	118	11138
J-330-0792	104	3.13	97	11355
Zone 360				
J-360-308	116	1.13	104	209
J-360-575	150	1.65	88	841
J-360-307	113	2.83	105	1215
J-360-369	113	1.04	105	1241
J-360-595	226	1.32	56	1477
J-360-649	151	2.34	88	1597
J-360-525	150	1.04	89	1620
J-360-561	141	5.21	92	1632
J-360-474	209	1.14	63	1643
J-360-447	109	5.57	107	1662
J-360-398	163	2.36	83	1679
J-360-170	213	3.95	61	1741
J-360-562	141	1.65	92	1744
J-360-483	190	1.72	71	1778
J-360-336	166	0.98	81	1840
J-360-178	227	1.46	55	1858
J-360-399	166	2.19	81	1862
J-360-123	197	6.69	68	1865
J-360-518	210	2.67	62	1870
J-360-486	216	0.43	60	1886
J-360-179	216	1.41	60	1900
J-360-485	191	2.66	71	1924
J-360-488	184	4.57	73	1928

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-360-563	141	1.04	92	1929
J-360-482	189	0.83	71	1934
J-360-423	185	8.62	73	1963
J-360-481	188	1.41	72	1964
J-360-446	106	0.72	108	1965
J-360-424	183	2.43	74	1965
J-360-323	229	0.63	54	1966
J-360-171	216	1.17	60	2011
J-360-396	178	1.11	76	2017
J-360-397	177	4.98	77	2036
J-360-536	226	2.12	55	2038
J-360-174	212	0.37	61	2041
J-360-634	226	1.34	55	2052
J-360-445	106	1.31	108	2089
J-360-358	192	2.49	70	2108
J-360-175	204	3.62	65	2111
J-360-332	145	2.08	91	2153
J-360-314	144	4.36	91	2181
J-360-327	216	0.49	59	2183
J-360-325	218	0.22	59	2184
J-360-444	106	0.71	108	2185
J-360-564	141	1.33	92	2186
J-360-519	218	0.82	59	2187
J-360-601	215	1.73	60	2196
J-360-559	163	1.76	83	2197
J-360-502	193	1.48	71	2236
J-360-443	107	0.63	108	2239
J-360-439	132	2.71	97	2243
J-360-417	206	0.22	64	2249
J-360-121	181	1.89	75	2259
J-360-299	206	0.26	64	2263
J-360-392	212	0.14	61	2269
J-360-490	172	5.57	79	2278
J-360-356	191	2.77	70	2281
J-360-440	110	0.77	106	2285
J-360-614	155	2.76	86	2289
J-360-172	183	3.62	74	2299
J-360-480	179	0.28	76	2302
J-360-173	182	0.37	74	2306
J-360-339	194	3.95	69	2316
J-360-122	180	1.51	75	2317
J-360-418	209	3.44	63	2325
J-360-442	115	0.75	104	2334
J-360-328	186	1.78	73	2343
J-360-300	198	1.08	68	2352

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-360-487	173	3.52	78	2354
J-360-331	152	2.62	87	2363
J-360-639	197	4.36	68	2365
J-360-479	174	0.15	78	2373
J-360-476	173	0.34	78	2399
J-360-381	217	1.36	59	2405
J-360-387	152	2.18	87	2405
J-360-346	159	4.89	84	2414
J-360-436	116	0.25	103	2415
J-360-379	216	0.30	59	2425
J-360-386	146	3.58	90	2435
J-360-660	211	2.31	62	2444
J-360-455	213	1.85	61	2445
J-360-295	194	2.92	69	2459
J-360-380	216	0.78	60	2460
J-360-668	211	2.13	62	2463
J-360-388	160	1.76	84	2463
J-360-384	146	0.70	90	2463
J-360-377	224	1.68	56	2480
J-360-296	194	0.98	69	2484
J-360-640	180	1.85	75	2487
J-360-435	123	1.80	101	2490
J-360-373	216	0.54	59	2491
J-360-489	159	1.63	84	2506
J-360-292	181	3.68	75	2507
J-360-477	155	0.36	86	2512
J-360-186	169	1.17	81	2537
J-360-263	181	2.96	75	2537
J-360-273	169	3.62	81	2541
J-360-552	212	0.89	61	2546
J-360-478	158	0.87	85	2549
J-360-031	163	1.02	84	2556
J-360-029	161	0.32	85	2571
J-360-028	161	3.72	85	2581
J-360-676	144	12.84	91	2593
J-360-260	173	3.42	78	2601
J-360-580	201	0.38	66	2604
J-360-329	185	2.44	73	2610
J-360-551	211	0.52	62	2623
J-360-259	173	1.54	78	2623
J-360-661	208	0.57	63	2650
J-360-641	171	1.78	79	2669
J-360-456	208	0.94	63	2671
J-360-390	185	5.35	73	2671
J-360-338	174	1.27	78	2675

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-360-293	163	3.65	83	2690
J-360-250	168	7.41	80	2705
J-360-374	215	0.33	60	2715
J-360-294	163	2.15	83	2734
J-360-256	167	4.27	81	2738
J-360-650	137	3.82	94	2739
J-360-405	143	3.43	92	2744
J-360-550	208	0.20	63	2757
J-360-276	194	1.82	70	2758
J-360-255	167	1.32	81	2761
J-360-261	156	5.04	86	2762
J-360-262	156	2.20	86	2802
J-360-606	186	1.90	73	2821
J-360-419	174	3.20	78	2823
J-360-636	212	0.20	61	2834
J-360-432	172	0.63	79	2837
J-360-457	204	0.15	65	2840
J-360-642	165	4.70	82	2842
J-360-391	172	2.77	79	2849
J-360-378	210	0.47	62	2856
J-360-434	172	2.08	79	2861
J-360-257	150	5.17	88	2862
J-360-382	215	2.51	60	2873
J-360-298	164	0.28	82	2889
J-360-433	172	0.46	79	2892
J-360-375	212	0.46	61	2893
J-360-422	166	4.81	81	2894
J-360-337	172	0.25	79	2899
J-360-258	150	1.52	88	2916
J-360-534	127	2.01	99	2921
J-360-528	155	0.30	86	2971
J-360-333	164	1.19	82	2971
J-360-330	164	2.69	82	2977
J-360-438	133	1.98	96	2978
J-360-185	101	15.75	111	2989
J-360-573	156	0.65	86	3001
J-360-254	160	1.10	84	3008
J-360-545	171	1.71	79	3053
J-360-577	201	0.87	66	3095
J-360-354	146	0.41	90	3096
J-360-162	154	3.83	88	3101
J-360-184	103	1.75	110	3125
J-360-421	159	0.89	85	3148
J-360-277	196	0.53	69	3171
J-360-410	140	0.24	93	3190

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SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-360-448	146	0.69	91	3206
J-360-318	145	3.42	90	3216
J-360-368	146	0.21	91	3216
J-360-367	146	0.30	91	3227
J-360-522	158	0.77	85	3245
J-360-449	148	0.26	90	3246
J-360-352	143	5.29	91	3258
J-360-492	161	1.64	84	3262
J-360-347	142	0.85	92	3262
J-360-572	154	0.80	87	3276
J-360-403	164	0.91	82	3278
J-360-353	142	0.91	92	3279
J-360-527	154	0.76	87	3283
J-360-402	164	0.59	82	3285
J-360-252	159	0.48	84	3286
J-360-546	170	1.26	79	3290
J-360-251	158	3.24	85	3292
J-360-253	145	4.30	90	3296
J-360-024	109	0.81	107	3326
J-360-665	155	0.72	86	3327
J-360-164	132	19.71	97	3379
J-360-107	137	2.06	95	3383
J-360-495	158	0.90	85	3403
J-360-427	159	0.20	84	3406
J-360-026	121	3.10	102	3415
J-360-287	184	2.26	75	3419
J-360-429	159	0.54	85	3426
J-360-027	122	2.35	101	3434
J-360-165	131	1.57	98	3436
J-360-453	147	0.09	90	3462
J-360-272	185	0.25	75	3468
J-360-602	153	5.32	88	3494
J-360-428	152	0.52	88	3554
J-360-498	156	5.60	86	3566
J-360-430	151	0.50	88	3573
J-360-034	161	1.94	85	3575
J-360-035	161	0.14	85	3629
J-360-675	150	0.24	88	3660
J-360-180	134	4.91	96	3662
J-360-578	195	0.44	69	3690
J-360-163	154	1.56	88	3710
J-360-407	143	0.52	92	3716
J-360-658	153	0.88	87	3734
J-360-183	115	1.37	105	3772
J-360-161	135	2.08	96	3780

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SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-360-167	164	0.58	84	3783
J-360-416	154	0.13	87	3821
J-360-033	136	2.53	96	3863
J-360-166	132	1.55	97	3880
J-360-615	147	1.45	90	3894
J-360-431	145	0.71	91	3939
J-360-270	185	1.58	74	3946
J-360-317	145	1.50	90	3954
J-360-278	195	0.43	70	3957
J-360-409	148	0.22	89	4084
J-360-182	132	1.64	97	4096
J-360-032	132	33.04	97	4139
J-360-039	167	5.81	82	4202
J-360-412	151	0.91	88	4241
J-360-038	166	0.34	82	4273
J-360-623	193	0.63	69	4276
J-360-040	166	0.38	83	4277
J-360-413	160	2.99	84	4280
J-360-321	151	0.22	88	4281
J-360-567	148	3.77	89	4338
J-360-319	150	0.67	88	4345
J-360-335	151	3.04	88	4353
J-360-322	151	0.30	88	4358
J-360-100	119	4.51	103	4392
J-360-585	156	1.11	86	4407
J-360-105	150	0.82	89	4456
J-360-303	114	0.44	104	4463
J-360-666	191	0.81	70	4537
J-360-002	186	1.90	77	4595
J-360-104	150	0.09	89	4606
J-360-279	194	0.32	70	4733
J-360-414	154	0.10	87	4733
J-360-370	154	0.17	87	4739
J-360-341	151	0.53	88	4751
J-360-411	151	0.03	88	4755
J-360-568	141	0.79	92	4758
J-360-553	240	2.72	50	4775
J-360-605	152	5.08	87	4804
J-360-168	180	2.14	79	4839
J-360-543	169	5.08	80	4962
J-360-468	191	1.63	70	4970
J-360-313	122	0.34	101	4996
J-360-583	147	1.42	90	5061
J-360-565	148	1.17	89	5094
J-360-542	161	0.30	83	5115

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RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-360-557	209	0.27	62	5182
J-360-547	146	10.09	90	5245
J-360-638	143	9.56	91	5292
J-360-541	151	2.09	88	5342
J-360-469	193	1.92	69	5366
J-360-540	147	0.91	89	5404
J-360-539	146	0.74	90	5494
J-360-366	93	12.88	113	5568
J-360-574	145	0.24	90	5570
J-360-051	121	42.97	105	5667
J-360-587	143	0.78	92	5673
J-360-363	97	76.86	112	5673
J-360-576	145	0.50	91	5685
J-360-126	231	1.60	56	5707
J-360-131	229	0.63	57	5722
J-360-470	211	0.90	62	5725
J-360-588	137	0.60	94	5747
J-360-124	232	0.32	56	5757
J-360-533	123	4.36	100	5856
J-360-592	223	0.93	57	5989
J-360-508	220	2.52	58	6009
J-360-647	134	1.02	95	6023
J-360-611	215	3.71	60	6032
J-360-246	224	0.12	59	6092
J-360-612	142	1.32	92	6112
J-360-517	167	2.62	81	6134
J-360-549	142	3.60	92	6154
J-360-516	162	0.29	83	6233
J-360-646	138	0.24	94	6251
J-360-362	93	2.64	114	6253
J-360-306	113	1.12	105	6259
J-360-644	143	1.45	91	6343
J-360-007	98	12.32	115	6367
J-360-507	218	1.17	59	6371
J-360-643	143	0.17	92	6414
J-360-664	144	0.37	91	6429
J-360-268	190	10.58	72	6567
J-360-267	191	2.17	72	6646
J-360-510	214	1.06	60	6662
J-360-515	146	0.85	90	6664
J-360-555	144	0.45	91	6682
J-360-010	88	1.39	119	6707
J-360-309	119	0.43	102	6722
J-360-617	141	2.34	92	6768
J-360-153	94	5.37	113	6771

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RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-360-052	119	15.64	106	6800
J-360-055	138	0.93	98	6816
J-360-310	120	0.30	102	6873
J-360-151	96	0.28	112	6880
J-360-621	142	0.64	92	6939
J-360-244	136	2.17	99	6940
J-360-301	160	2.28	85	7028
J-360-371	122	0.67	101	7081
J-360-619	141	0.55	92	7085
J-360-011	160	1.39	85	7204
J-360-056	111	1.15	109	7244
J-360-210	128	0.53	102	7333
J-360-067	144	0.04	95	7349
J-360-215	172	1.70	82	7421
J-360-211	128	1.20	102	7462
J-360-109	124	0.35	104	7589
J-360-086	155	0.94	87	7663
J-360-092	115	18.53	104	7719
J-360-264	155	1.74	87	7793
J-360-009	108	1.18	111	7869
J-360-202	103	4.55	113	7899
J-360-275	193	2.55	71	7928
J-360-196	108	5.84	110	7931
J-360-269	192	0.19	72	7938
J-360-145	152	8.05	89	7974
J-360-265	153	0.73	88	7988
J-360-108	120	5.58	106	8008
J-360-113	120	2.19	106	8021
J-360-677	129	0.26	98	8052
J-360-281	198	0.29	69	8081
J-360-194	118	1.04	106	8124
J-360-190	118	0.09	106	8315
J-360-041	157	0.21	86	8448
J-360-042	157	0.13	87	8574
J-360-238	132	6.22	100	8715
J-360-231	122	1.03	105	9610
J-360-018	155	2.81	87	10270
J-360-043	156	0.27	87	10898
Zone 380				
J-380-601	254	1.78	68	360
J-380-294	127	1.18	123	424
J-380-600	235	1.48	76	457
J-380-599	233	2.58	77	476
J-380-076	127	3.25	123	539
J-380-592	127	3.43	127	588

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RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-380-514	134	0.59	113	604
J-380-523	155	0.14	104	607
J-380-352	176	1.94	112	660
J-380-263	219	0.06	91	677
J-380-347	228	0.54	87	685
J-380-174	166	3.93	99	700
J-380-118	147	1.56	107	723
J-380-117	147	2.15	107	733
J-380-468	161	1.55	113	743
J-380-356	174	0.18	113	743
J-380-598	190	2.83	96	801
J-380-348	221	2.42	90	810
J-380-359	173	2.41	114	825
J-380-513	129	0.48	115	826
J-380-597	186	0.91	98	867
J-380-308	200	0.71	102	879
J-380-078	127	1.31	123	900
J-380-286	173	0.39	108	910
J-380-285	174	3.16	108	925
J-380-173	129	2.43	115	928
J-380-340	197	0.06	103	979
J-380-251	150	0.06	118	1019
J-380-467	156	0.93	116	1026
J-380-341	155	0.84	116	1044
J-380-469	155	0.46	116	1051
J-380-171	125	1.77	116	1067
J-380-527	261	0.41	41	1088
J-380-470	149	0.82	118	1164
J-380-515	129	3.44	115	1171
J-380-250	147	0.70	119	1200
J-380-502	173	3.27	103	1206
J-380-152	221	0.99	93	1218
J-380-147	184	7.62	109	1218
J-380-146	183	0.81	109	1271
J-380-144	183	2.45	109	1286
J-380-387	217	2.60	95	1344
J-380-337	193	0.70	105	1381
J-380-382	217	1.09	95	1457
J-380-151	218	1.90	94	1467
J-380-001	182	1.60	104	1483
J-380-110	175	0.12	107	1508
J-380-109	176	0.63	107	1509
J-380-121	181	0.21	105	1512
J-380-267	207	0.42	96	1513
J-380-524	174	4.88	108	1514

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-380-123	185	0.97	103	1516
J-380-528	125	0.26	116	1516
J-380-609	195	5.84	99	1527
J-380-439	170	4.40	115	1570
J-380-172	125	1.17	116	1577
J-380-392	214	0.03	96	1586
J-380-395	214	1.33	96	1596
J-380-441	170	5.46	115	1629
J-380-486	188	0.53	91	1666
J-380-193	168	0.25	116	1691
J-380-170	125	1.97	116	1694
J-380-192	169	0.56	116	1698
J-380-194	171	4.57	115	1718
J-380-362	175	2.04	113	1734
J-380-367	147	1.04	125	1752
J-380-408	177	0.56	112	1782
J-380-235	176	2.96	113	1791
J-380-366	144	0.38	126	1807
J-380-394	207	7.84	99	1823
J-380-393	207	0.11	99	1826
J-380-353	177	2.02	112	1827
J-380-401	193	2.67	105	1829
J-380-402	191	2.36	106	1834
J-380-232	143	0.18	127	1846
J-380-614	177	56.28	112	1853
J-380-374	144	0.69	126	1856
J-380-372	144	0.13	126	1859
J-380-375	174	4.54	113	1869
J-380-231	143	0.07	127	1885
J-380-391	207	2.98	99	1887
J-380-304	158	15.34	121	1889
J-380-365	206	3.39	99	1898
J-380-373	158	4.07	120	1901
J-380-155	173	1.72	114	1905
J-380-381	205	4.67	100	1914
J-380-368	143	0.93	127	1931
J-380-386	199	1.61	102	1936
J-380-344	177	3.01	109	1944
J-380-380	204	3.78	100	1971
J-380-406	199	0.73	103	1987
J-380-351	145	0.18	126	2000
J-380-438	197	6.21	103	2001
J-380-217	197	0.16	103	2007
J-380-440	192	5.09	106	2030
J-380-216	192	0.40	105	2032

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SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-380-215	192	0.50	106	2048
J-380-154	146	2.65	125	2090
J-380-153	145	0.95	126	2091
J-380-433	187	0.20	108	2092
J-380-220	189	0.27	107	2096
J-380-310	176	3.03	112	2100
J-380-466	140	0.72	121	2107
J-380-225	185	0.95	109	2108
J-380-115	125	0.61	116	2112
J-380-580	175	0.13	112	2123
J-380-223	186	1.09	108	2136
J-380-114	125	0.16	116	2145
J-380-236	145	57.21	126	2148
J-380-169	125	1.19	116	2171
J-380-207	131	2.38	114	2173
J-380-268	204	0.88	97	2177
J-380-343	184	0.65	106	2194
J-380-058	266	0.58	74	2201
J-380-529	132	2.89	114	2228
J-380-103	210	5.16	80	2248
J-380-552	155	0.58	123	2255
J-380-487	175	4.17	96	2256
J-380-177	142	4.70	109	2257
J-380-303	156	3.36	122	2272
J-380-141	141	0.30	110	2288
J-380-369	143	1.73	127	2291
J-380-499	143	4.43	116	2292
J-380-284	203	2.67	96	2294
J-380-553	157	5.55	122	2304
J-380-229	204	1.36	101	2308
J-380-140	142	5.70	109	2311
J-380-112	143	0.07	109	2330
J-380-419	206	0.67	100	2333
J-380-312	172	0.39	114	2338
J-380-420	207	2.50	100	2345
J-380-370	143	0.33	127	2369
J-380-113	145	0.22	108	2388
J-380-421	213	0.76	97	2453
J-380-102	195	1.23	87	2461
J-380-041	248	27.75	82	2462
J-380-298	219	0.43	88	2472
J-380-422	214	1.58	97	2477
J-380-036	248	60.53	82	2494
J-380-498	141	0.65	117	2507
J-380-342	249	2.48	76	2538

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-380-190	143	1.60	127	2573
J-380-423	216	0.70	96	2577
J-380-316	166	1.31	116	2591
J-380-035	232	41.33	89	2603
J-380-017	261	0.20	77	2624
J-380-039	229	35.28	90	2626
J-380-104	187	0.23	91	2633
J-380-596	244	6.27	78	2642
J-380-010	271	0.21	72	2669
J-380-497	141	0.30	117	2672
J-380-038	222	0.26	93	2714
J-380-504	217	3.09	76	2733
J-380-503	181	0.68	93	2757
J-380-530	211	0.16	78	2776
J-380-106	192	0.72	87	2778
J-380-345	193	0.33	102	2810
J-380-525	217	2.56	75	2813
J-380-175	153	0.24	104	2835
J-380-526	254	1.05	44	2864
J-380-208	154	5.14	104	2914
J-380-008	231	3.35	89	2946
J-380-496	137	2.30	119	2954
J-380-139	154	0.36	104	2960
J-380-444	212	2.41	98	2995
J-380-458	176	4.19	95	2996
J-380-066	146	5.26	126	3056
J-380-009	213	0.07	97	3068
J-380-187	186	1.85	109	3073
J-380-180	211	3.05	98	3078
J-380-138	154	0.33	104	3119
J-380-061	187	24.99	109	3145
J-380-491	170	0.25	99	3173
J-380-064	170	6.74	116	3222
J-380-184	193	6.40	106	3229
J-380-418	167	1.17	117	3230
J-380-570	187	1.05	109	3269
J-380-321	181	0.48	110	3278
J-380-032	180	40.20	112	3290
J-380-571	194	0.33	106	3297
J-380-582	181	4.30	110	3328
J-380-506	261	0.30	40	3337
J-380-176	154	0.67	104	3348
J-380-567	195	0.10	105	3366
J-380-260	196	0.39	101	3468
J-380-475	254	1.12	44	3479

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SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-380-307	198	0.62	104	3533
J-380-297	216	0.73	90	3546
J-380-137	156	0.54	103	3611
J-380-558	183	2.35	110	3638
J-380-338	189	0.65	106	3712
J-380-166	217	6.67	89	3727
J-380-278	206	6.44	95	3729
J-380-004	217	1.26	90	3753
J-380-560	192	0.02	106	3847
J-380-108	189	8.73	101	3861
J-380-274	193	2.19	104	3885
J-380-452	167	1.52	97	3931
J-380-451	167	5.13	96	3934
J-380-453	165	1.18	98	3991
J-380-210	222	0.84	61	4006
J-380-136	160	0.83	101	4008
J-380-209	221	0.32	62	4028
J-380-454	164	0.54	99	4029
J-380-460	156	0.14	118	4047
J-380-490	158	3.32	105	4067
J-380-158	160	0.66	114	4073
J-380-098	210	1.80	69	4112
J-380-227	149	2.52	125	4119
J-380-097	213	0.87	66	4122
J-380-257	156	2.52	118	4126
J-380-541	182	8.64	111	4130
J-380-083	160	4.49	114	4135
J-380-214	184	1.31	86	4175
J-380-202	135	0.26	118	4208
J-380-430	148	56.28	126	4210
J-380-548	183	0.28	111	4245
J-380-540	183	0.44	110	4264
J-380-325	184	0.97	110	4265
J-380-489	156	1.84	106	4276
J-380-075	143	1.24	127	4285
J-380-201	129	2.35	121	4310
J-380-163	195	4.52	99	4312
J-380-302	188	0.50	107	4327
J-380-211	191	3.39	80	4327
J-380-164	194	1.84	99	4329
J-380-532	184	0.13	110	4337
J-380-413	142	1.08	128	4338
J-380-322	185	4.70	110	4349
J-380-212	188	0.28	83	4352
J-380-481	188	0.11	83	4356

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RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-380-134	151	1.45	107	4360
J-380-161	193	0.42	100	4375
J-380-301	188	1.01	107	4398
J-380-411	141	56.28	128	4416
J-380-283	198	0.87	99	4444
J-380-128	156	1.51	106	4469
J-380-272	194	0.49	103	4482
J-380-415	130	0.16	133	4486
J-380-271	197	1.64	100	4487
J-380-492	127	1.06	123	4511
J-380-132	151	3.04	107	4514
J-380-087	145	0.61	121	4519
J-380-493	127	0.59	123	4563
J-380-437	121	0.29	137	4601
J-380-129	144	0.58	111	4700
J-380-133	144	0.34	111	4814
J-380-287	142	0.28	121	4842
J-380-519	127	1.97	123	4865
J-380-131	143	1.40	112	4926
J-380-464	143	0.39	120	4933
J-380-127	127	2.24	123	4996
J-380-292	127	0.54	128	5006
J-380-101	127	0.32	123	5013
J-380-092	127	0.13	128	5019
J-380-091	127	0.11	127	5034
J-380-107	143	0.15	120	5040
J-380-093	127	0.25	127	5115
J-380-494	127	0.43	125	5216
J-380-256	136	0.51	123	5329
J-380-465	135	0.50	123	5356
J-380-500	127	1.09	125	5563
J-380-501	127	0.55	126	5628
J-380-495	127	0.57	125	5668
Zone 390				
J-390-028	260	2.13	60	402
J-390-177	281	0.11	56	576
J-390-128	307	0.20	49	576
J-390-132	280	2.08	56	586
J-390-131	301	1.44	52	591
J-390-166	306	0.42	50	632
J-390-167	306	0.44	50	633
J-390-181	206	1.31	89	648
J-390-182	206	5.30	89	651
J-390-137	298	0.07	53	667
J-390-151	296	1.43	54	673

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RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-390-180	260	3.28	69	703
J-390-133	255	1.30	67	740
J-390-067	270	1.34	69	755
J-390-107	265	1.59	71	779
J-390-147	268	0.02	69	808
J-390-146	268	6.19	69	815
J-390-174	233	3.50	79	831
J-390-136	229	1.02	80	858
J-390-041	227	6.61	79	883
J-390-068	223	0.44	89	902
J-390-135	229	0.71	80	905
J-390-175	235	2.30	78	924
J-390-074	233	0.39	85	929
J-390-158	233	0.37	79	934
J-390-051	224	1.40	89	934
J-390-073	225	0.39	89	960
J-390-040	144	2.64	115	969
J-390-176	213	2.88	87	970
J-390-043	206	3.49	97	1000
J-390-118	200	0.44	92	1006
J-390-144	200	0.95	92	1006
J-390-145	200	1.03	92	1008
J-390-047	200	3.69	99	1021
J-390-045	199	1.06	100	1022
J-390-142	206	8.33	96	1035
J-390-019	169	6.44	104	1037
J-390-123	195	0.33	101	1045
J-390-168	194	0.18	101	1064
J-390-124	194	0.52	101	1066
J-390-053	185	1.75	106	1070
J-390-076	185	0.51	106	1072
J-390-039	182	0.67	99	1104
J-390-015	182	3.41	99	1110
J-390-016	182	0.59	99	1115
J-390-018	168	1.99	104	1201
J-390-094	191	3.43	87	1210
J-390-034	172	4.73	102	1226
J-390-054	210	5.24	79	1234
J-390-060	217	3.36	76	1247
J-390-031	169	0.78	103	1261
J-390-059	212	0.14	78	1263
J-390-027	198	1.71	87	1321
J-390-057	198	1.18	84	1379
J-390-007	146	3.15	112	1420
J-390-008	196	1.15	88	1429

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RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-390-037	150	3.36	110	1441
J-390-006	145	0.24	112	1443
J-390-065	197	0.43	84	1573
J-390-061	197	6.18	84	1576
J-390-056	197	1.41	85	1626
J-390-009	170	0.96	98	1747
J-390-093	188	0.56	88	1811
J-390-010	164	0.48	101	1814
J-390-062	169	1.99	97	2017
J-390-086	168	1.06	97	2038
J-390-119	190	0.60	88	2121
J-390-078	187	2.15	89	2208
J-390-121	197	0.19	84	2432
J-390-091	197	0.81	84	2446
J-390-083	224	1.47	72	2520
J-390-004	168	1.34	97	2560
J-390-025	228	6.56	71	2582
J-390-002	168	4.02	97	2590
J-390-085	225	0.27	72	2592
J-390-020	170	5.49	97	2594
J-390-114	235	0.59	138	3236
Zone 415				
J-415-002	284	6.04	76	665
J-415-001	275	1.22	80	676
J-415-005	285	2.60	75	799
J-415-006	283	1.93	76	815
J-415-008	281	1.08	77	892
Zone 430				
J-430-144	353	0.33	30	936
J-430-131	348	0.33	32	1185
J-430-150	275	2.47	64	1214
J-430-130	347	1.61	33	1263
J-430-054	340	2.19	36	1420
J-430-133	298	0.26	54	1796
J-430-127	305	0.13	51	2251
J-430-136	240	0.75	79	2404
J-430-092	299	0.27	54	2423
J-430-101	298	0.26	54	2485
J-430-020	277	5.59	63	2860
J-430-099	273	0.23	65	2967
J-430-064	277	2.03	63	2989
J-430-120	275	0.31	64	3029
J-430-023	274	0.24	65	3063
J-430-019	274	3.25	65	3175
J-430-122	200	0.70	97	3510

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RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-430-065	199	3.14	97	3613
J-430-061	244	0.55	77	3845
J-430-100	244	0.32	78	3900
J-430-096	244	0.84	78	3935
J-430-119	291	0.05	57	4210
J-430-075	179	3.74	106	4383
J-430-117	284	3.99	60	4436
J-430-050	229	0.44	84	4504
J-430-088	237	1.07	81	4528
J-430-051	228	0.13	85	4565
J-430-152	239	40.52	80	4592
J-430-125	222	0.47	87	4756
J-430-076	214	2.26	91	4764
J-430-095	223	0.37	87	4975
J-430-086	229	0.78	84	5161
J-430-036	200	16.20	97	5178
J-430-079	231	0.44	83	5209
J-430-078	221	0.61	87	5255
J-430-074	238	0.78	80	5303
J-430-081	218	0.28	89	5317
J-430-080	210	0.85	93	5699
J-430-084	208	0.20	93	5756
J-430-053	205	0.10	94	5817
J-430-039	95	64.32	142	5819
J-430-005	207	4.24	93	5843
J-430-052	202	0.41	96	5891
J-430-038	109	64.32	136	5971
J-430-147	215	14.46	90	6234
J-430-058	267	2.08	68	6263
J-430-059	263	3.46	69	6728
J-430-001	185	0.95	103	6788
J-430-116	218	2.43	89	6920
J-430-030	217	10.43	89	6986
J-430-140	270	1.02	66	8035
J-430-045	256	0.28	72	8283
J-430-139	284	0.63	60	8440
J-430-129	245	6.04	77	8445
J-430-110	232	0.34	83	8490
J-430-108	342	1.37	35	10572
Zone 460				
J-460-012	369	0.24	53	1104
J-460-013	282	0.30	91	1332
J-460-001	282	1.11	91	1338
J-460-002	326	0.69	72	1546
J-460-007	329	0.37	71	1553

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Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-460-003	307	0.50	80	1913
Zone 520				
J-520-006	381	3.33	34	272
J-520-003	364	2.30	41	359
J-520-073	373	1.58	38	407
J-520-056	385	1.72	33	626
J-520-005	252	8.03	90	628
J-520-001	286	0.56	75	654
J-520-013	288	0.99	74	661
J-520-071	287	1.03	75	673
J-520-014	289	0.93	74	683
J-520-055	360	3.43	43	707
J-520-057	382	0.73	34	715
J-520-015	286	2.11	75	716
J-520-061	381	0.89	34	723
J-520-016	288	3.48	74	744
J-520-058	381	0.74	34	745
J-520-070	381	0.59	34	767
J-520-060	380	0.19	35	777
J-520-059	380	2.11	35	798
J-520-018	269	1.41	82	845
J-520-022	315	0.46	63	872
J-520-023	309	0.69	65	873
J-520-037	315	0.07	63	876
J-520-036	303	0.58	68	884
J-520-039	315	1.65	62	884
J-520-021	262	1.78	86	885
J-520-028	281	0.15	77	889
J-520-033	298	0.88	70	893
J-520-034	292	1.31	72	894
J-520-035	288	0.96	74	895
J-520-038	318	0.24	61	959
J-520-054	362	3.28	42	972
J-520-053	361	0.84	43	1016
J-520-042	317	6.54	62	1148
J-520-052	359	0.98	44	1158
J-520-050	351	0.57	47	1339
J-520-051	344	0.34	50	1586
J-520-048	345	0.13	50	1826
J-520-049	346	0.82	49	1899
J-520-041	296	1.58	71	2763
J-520-046	318	0.15	61	5599
J-520-047	320	0.42	61	5852
Zone 555				
J-555-015	354	0.27	85	1582

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SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-555-014	354	2.76	85	1647
J-555-136	431	1.58	51	1849
J-555-017	383	5.13	72	2068
J-555-018	380	0.33	73	2087
J-555-016	359	0.74	83	2089
J-555-041	375	1.50	76	2104
J-555-019	378	0.14	75	2111
J-555-053	375	2.26	76	2136
J-555-054	372	0.90	77	2160
J-555-023	365	0.72	80	2214
J-555-022	364	1.92	81	2216
J-555-020	352	5.89	86	2244
J-555-021	354	0.89	85	2244
J-555-027	363	5.06	81	2252
J-555-024	361	0.30	82	2254
J-555-055	353	1.85	85	2332
J-555-151	453	1.57	41	2357
J-555-107	317	2.97	102	2432
J-555-108	303	1.56	108	2482
J-555-037	329	1.34	96	2508
J-555-105	308	2.47	106	2528
J-555-122	298	3.87	109	2550
J-555-091	296	1.56	111	2663
J-555-135	399	1.58	65	2668
J-555-139	402	1.32	63	2698
J-555-141	398	0.23	65	2704
J-555-138	399	0.44	64	2709
J-555-084	286	0.22	115	2712
J-555-038	301	1.32	108	2720
J-555-111	391	10.80	68	2777
J-555-029	289	3.00	113	2800
J-555-001	274	2.56	120	2849
J-555-086	366	6.27	79	2867
J-555-120	298	10.65	109	2888
J-555-099	346	1.56	87	2912
J-555-049	259	0.15	126	3024
J-555-046	258	2.39	127	3038
J-555-028	255	6.50	128	3052
J-555-100	256	5.27	128	3126
J-555-007	230	0.24	139	3275
J-555-008	230	2.00	140	3283
J-555-073	370	0.80	77	3330
J-555-117	333	0.45	94	3388
J-555-076	268	14.47	122	3410
J-555-098	299	2.24	108	3473

APPENDIX H
SOUTH SAN FRANCISCO WATER SUPPLY & FACILITIES MASTER PLAN
RESULTS OF FIRE FLOW SIMULATION

Node ID	Elevation (ft)	Maximum Day Demand (gpm)	Static Pressure (psi)	Available Flow @ 20 psi (gpm)
J-555-070	346	2.09	88	3507
J-555-150	329	1.86	95	3523
J-555-116	335	0.73	93	3525
J-555-034	201	6.67	152	3619
J-555-035	199	1.65	153	3643

Appendix I

Evaluation of Treatment System Improvements at Station 1

Appendix I
Evaluation of Treatment System Improvements at Station 1 Well Field South San Francisco Water Supply and Facilities Master Plan

This appendix provides information on improvements for the treatment facility at the Station 1 well field that will be needed to support higher levels of groundwater pumping. The required groundwater supply capacity for existing and future conditions is discussed in Section 8 of the master plan report. Appendix B of this report discusses the field assessment of the Station 1 facilities that was conducted as part of master plan.

The following topics are discussed in this appendix:

- Existing Wells
- Existing Station 1 Treatment System
- Overall Recommendations for Treatment System
- Expansion of Existing Treatment Facility
- Detailed Investigation of Expansion and Process Options

All figures are at the end of this appendix.

Existing Wells

Table 1 summarizes the capacities and recent water quality data at the existing Station 1 wells. The water quality data for each well shows the average of all samples and the maximum value. A flow weighted average of all wells is at the bottom of the table.

The total maximum pumping capacity of the seven existing wells is 1,205 gpm (1.74 mgd), with all wells in service. As identified in Section 8 of the master plan report, for supply reliability, a near-term groundwater pumping capacity of 3 mgd by 2015 is desirable and up to 5 mgd by 2030. To meet these goals, additional well capacity will be needed at or in the vicinity of the Station 1 well field by either or a combination of the following:

- Increase production of the wells at Station 1 by installing higher capacity pumps in some or all the wells. Upgrades or replacement of the old well pumps and motors will increase the efficiency of the facility.
- Construct additional wells at and in the vicinity of Station 1. HydroFocus has identified some potential sites in this area, as discussed in Appendix E.

Table 1
Summary of Existing Well Capacity and Water Quality Data

Well ID	Existing Capacity (gpm)	Fe		Mn		TDS		NO3		Hardness		pH	
		Avg mg/l	Max mg/l	Avg mg/l	Max mg/l	Avg mg/l	Max mg/l	Avg mg/l	Max mg/l	Avg mg/l	Max mg/l	Avg	Max
1-14	100	0.3	1.0	0.02	0.03	627	830	36	62	627	830	7.6	8.0
1-15	90	0.9	1.6	0.04	0.07	606	890	22	32	359	650	7.5	7.8
1-17	120			0.04	0.04	572	772	107	230	326	430	7.7	8.0
1-18	400	3.4	9.9	3.40	3.40	583	620	67	79	337	420	7.7	8.0
1-19	160	0.7	1.1	0.08	0.24	531	690	32	60	327	410	7.8	8.0
1-20	120	0.1	0.2	0.22	0.30	713	853	13	104	446	506	7.5	7.7
1-21	215	0.1	0.2	0.36	0.39	742	849	3	8	407	480	7.5	7.6
Total	1,205												
Flow Weighted Avg		1.3	3.7	1.23	1.27	622	746	44	76	384	490	7.6	7.9
MCL or SMCL Limit		SMCL	0.3	SMCL	0.05	SMCL	500	MCL	10		none		n/a
Max Flow	1.74 mgd (assumes all wells in operation)												

All seven existing wells contain iron (Fe) and manganese (Mn), with six of the seven wells exceeding at least one of these Secondary Maximum Contaminant Levels (SMCLs). The SMCLs are non-enforceable, recommended levels for constituents that affect the aesthetic quality of water; exceeding a SMCL will not present health risks to those who consume the drinking water. All the wells contain high concentrations of total dissolved solids (TDS), which is also a SMCL.

Water from all the wells contained measurable concentrations of nitrate (NO3), with five wells exceeding the Primary Drinking Water Standard Maximum Contaminant Limit (MCL). In contrast to the SMCLs, Primary Drinking Water Standards are health based regulations and exceeding an MCL results in a violation of State and/or Federal regulations. Currently, nitrate is controlled by blending with another water source. It is assumed that this practice will continue. However, the data indicates that nitrate concentrations in the Station 1 wells are increasing; therefore, allowance should be made for the future installation of a nitrate removal system.

Arsenic (As) and hydrogen sulfide (H2S), which are also Primary MCL's, are not reported to be a problem at any of the wells.

In particular Well 18 has much higher levels of iron and manganese than the other wells, although this is based on only one reported sample. Additional investigation should be done to determine the average water quality at Well 18 and whether its use should be avoided. The high concentrations at Well 18 will affect the treatment process when treating water blended from several wells. It may be possible to have a more effective and higher capacity treatment system by avoiding use of Well 18, perhaps reserving it as an emergency standby only. Future expansion studies of the existing treatment facility should carefully consider the anticipated groundwater quality.

Existing Station 1 Treatment System

Figure 1 provides a process flow diagram for the existing treatment system. The current capacity of the existing facility is 1.8 mgd with potential for expansion as described further later in this memo.

Well water is treated by an iron and manganese system consisting of chlorine oxidation followed by filtration. After the water leaves the filter, aqua ammonia is injected into the discharge pipe to convert the free chlorine to chloramines, so make the water compatible with the San Francisco surface water supply. Related facilities include sodium bisulfite chemical system (reduces chlorine concentration prior to adding aqua ammonia) and backwash reclamation system (separates iron hydroxide and manganese dioxide).

Finished water from the treatment facility is stored in an on-site 500,000 gallon steel tank. A pump station (3 pumps) then pumps from the clearwell into a pipeline that conveys the treated water to the Reservoir 2 in Zone 200.

The existing treatment system was supplied over ten years ago by Filtronics, Inc. The original facility was designed to ultimately provide 2,250 gpm with two HF-15 filters using Filtronic's Electromedia I media and a loading rate of 10 gpm/sf. Two reaction vessels (model H2250) were installed with a volume of 2,500 gpm each, however only one filter was installed with a 1,250 gpm capacity. Therefore, the actual capacity of the existing facility is 1.8 mgd.

The original pilot study determined the breakpoint chlorination dosage to be 4.4 mg/l and recommend the chlorination dosage to be 4.5 to 5.0 mg/l for a chlorine residual of 2.2 mg/l at filter effluent.

Sodium bisulfite addition (at a dose of 0.25 to 1.00 mg/L) was recommended if needed to remove objectionable tastes and odors caused by hydrogen sulfide. Based on the recent water quality data, it does not appear that hydrogen sulfide is an issue. It appears the sodium bisulfite is operated to provide dechlorination of the filter effluent.

New filter media was added about a year ago at the existing filter, so the existing media should be good for at least another 5 years.

Overall Recommendations for Treatment System

The treatment facility should continue to focus on iron and manganese in the near-term. Although nitrate is a concern, it is assumed that groundwater supply management and blending will continue to be implemented as required to ensure regulatory compliance. Expansion of the existing treatment processes (as described below) could provide the additional capacity. In addition, other alternative treatment options could be further investigated (as described below).

Sufficient space should be allowed at the site to accommodate future addition of ion exchange, reverse osmosis or other technologies for nitrate removal in the long term. Some of these technologies would also provide benefits by lowering TDS.

In addition to the treatment processes themselves, upgrades to the existing chemical storage and control building would be needed to bring it into compliance with current health & safety regulations and to simply operations. The treatment plant and well instrumentation and control system should also be reviewed to determine how it can be centralized and simplified.

Detailed studies, subsequent to the master plan, will be required to further evaluate and identify site-specific improvements. The Master Plan will contain near-term and long-term budget items at a conceptual planning level for expansion of the existing facility, upgrades to the existing building and control system, and future addition of a nitrate removal process. In addition, conceptual-level costs for adding new well capacity will be included.

Below is a discussion of expansion of the existing treatment facility, and subsequent detailed investigation for an expansion and to evaluate other potential treatment process options.

Expansion of Existing Treatment Facility

Representatives at Filtronics provided the following suggestions for possibly expanding the existing 1.8 mgd system:

- Adding one more filter to the existing plant at a 10 gpm/sf loading rate, the total treatment capacity would be doubled to 2,500 gpm (3.6 mgd). This would meet near-term needs to 2015.

- The installation is currently operating at 10 gpm/sf. Based on the water quality data, Filtronics believes it may be possible to increase the loading rate on the filters to 15 gpm/sf. If it is possible, the existing filter capacity would be 1,875 gpm, and with the addition of another filter the plant capacity would be 3,750 gpm (5.4 mgd). However, the higher filter loading rate would have to be confirmed by pilot-scale or full-scale testing. If the higher load rate is confirmed, this capacity would meet buildout needs.

Potential advantages of expanding the existing Filtronics system include:

- Process has performed well and operators are familiar with the process and equipment.

- Increase in plant footprint may be relatively small if filtration rates can be increased.

- It may be possible to conduct full-scale testing with the existing system in lieu of pilot-scale tests.
- Efforts to secure regulatory approval from the State of California Department of Health Services (DHS) and amend the operating permit issued may be lessened if the same process and similar facilities are proposed.

Potential disadvantages of expanding the existing Filtronics system include:

- Oxidation of iron is relatively fast, however, manganese typically requires a strong oxidant, relatively high pH and comparatively large reaction vessels to provide acceptable contact time before filtration.
- Manufacturer's suggestion that filtration rates can be increased to 15 gpm/sf has not been confirmed and must be verified with pilot- or full-scale testing.
- Chemical doses may require optimization to operate at the higher loading rates.
- The sodium bisulfite system may be retained to provide dechlorination as needed.
- Increasing the filtration rate may result in a higher percentage of washwater produced as compared to the treated water.
- The plant footprint will increase and further limit the space for future nitrate removal equipment or other facilities.

Detailed Investigation of Expansion and Process Options

More detailed studies (subsequent to the master plan) will be required to confirm the feasibility of expanding the facility with similar equipment. A thorough evaluation of the system including hydraulic capacity, chemical requirements, backwashing, process controls, residuals production, operational requirements, treated water storage, site and other issues must be conducted.

In addition, other treatment process options could be evaluated for comparison with expansion of the existing system. These other options may provide benefits with respect to more effective technologies, simplified operations, smaller footprints, and/or reduced waste products.

CDM identified the following three treatment options to expand the existing 2 mgd groundwater treatment facility up to an ultimate capacity of 5 mgd:

1. Chlorination-Pressure Filtration (existing system). Expand the existing (Filtronics) pressure filtration system with similar equipment and optimize the design and operation of the facility with information gathered from short-duration pilot-scale or full-scale testing.

2. Greensand Pressure Filtration. Conduct short-duration pilot-scale tests on the (Hungerford and Terry) greensand process for the removal of iron and manganese. Information from the pilot tests would be used to develop conceptual design criteria, an operating strategy, a layout, and cost estimates (capital and operating) for comparison with other process alternatives.

3. Proprietary Pressure Filtration. Kinetico's Macrolite pressure filter system would be compared to the Filtronics and Hungerford and Terry systems for iron and manganese removal. Based on initial design and cost information, it would be determined if pilot testing and more thorough evaluation is warranted.

Criteria for comparing the process alternatives would include: water quality, site requirements, residuals production, operational complexity, reliability, expandability, and costs (capital and operating).

Initially, CDM considered membrane filtration as an option. However, membrane filtration was dismissed because membrane manufacturers were unable to satisfactorily document the long-term, economical performance (i.e., greater than 5-years) of membrane systems for the removal of moderate to high levels of iron and manganese.

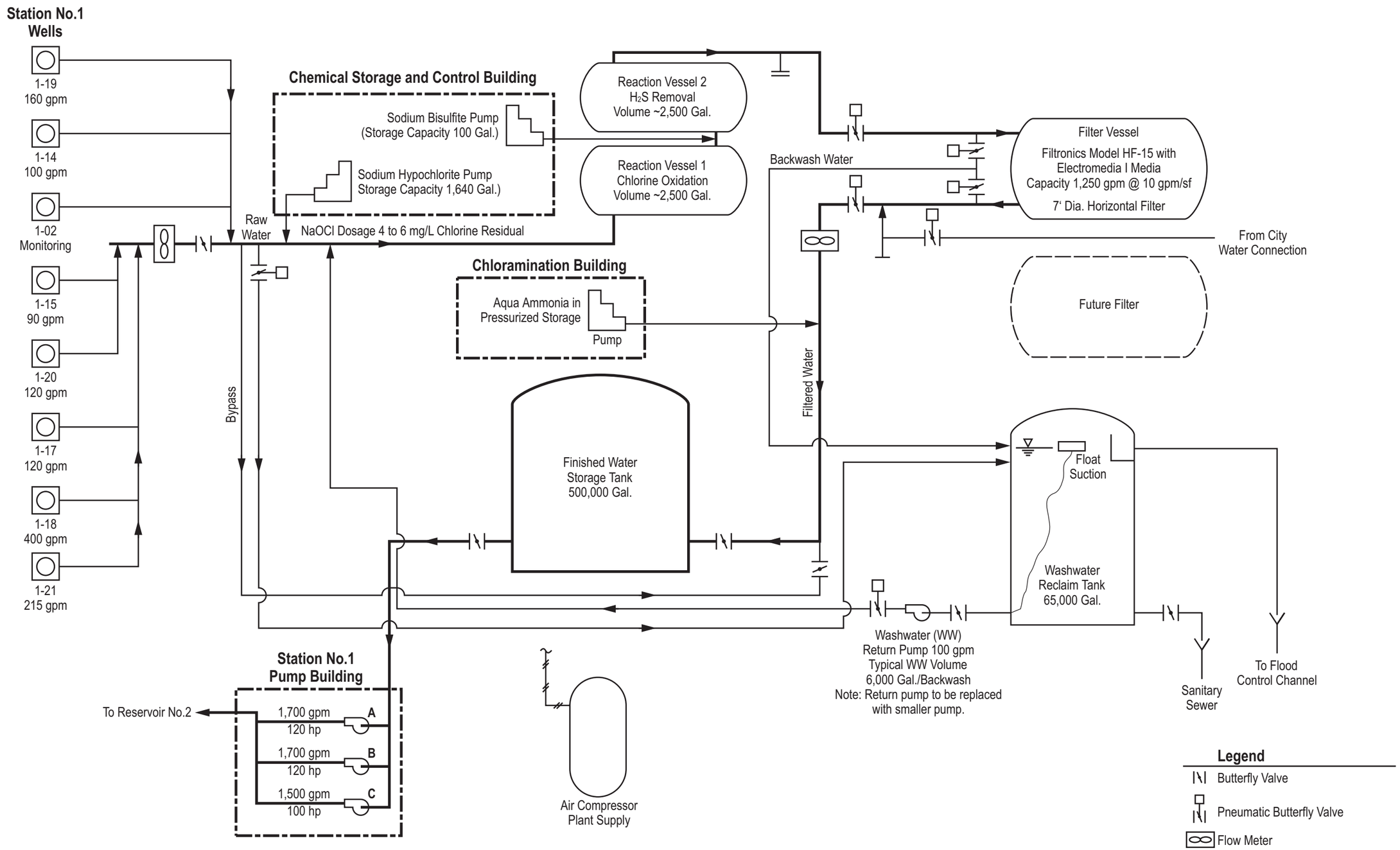

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Figure 1
Station 1 Treatment Facility
Process Flow Diagram

CDM