Attachment C

City of Santa Barbara
Water Distribution Infrastructure Plan

EXECUTIVE SUMMARY

FINAL | February 2021

carollo

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Water Distribution Infrastructure Plan

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FINAL | February 2021

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Abbreviations

AACE	Association for the Advancement of Cost Engineering
ADD	average day demand
AMI	Advance Metering Infrastructure
Carollo	Carollo Engineers, Inc.
CCI	Construction Cost Index
CEQA	California Environmental Quality Act
CIP	Capital Improvement Plan
City	City of Santa Barbara
CMMS	computerized maintenance management system
ENR	Engineering News Record
GIS	Geographic Information System
HP	horsepower
MDD	maximum day demand
MG	million gallons
mgd	million gallons per day
MinDD	minimum day demand
PRS	pressure reducing station
PRV	pressure reducing valve
PS	Pump Station
psi	pounds per square inch
R&R	rehabilitation and replacement
ROW	right-of-way
SCADA	supervisory control and data acquisition
SCC	South Coast Conduit
TM	Technical Memorandum
VFD	variable frequency drive
WDIP	Water Distribution Infrastructure Plan
WTP	Water Treatment Plant

Acknowledgments

We would like to thank the following City of Santa Barbara staff for their assistance and oversight of this project:

- Carson Wollert, P.E., Supervising Engineer.
- Joshua Haggmark, Water Resources Manager.
- Matthew Ward, Acting Water System Manager.
- Catherine Taylor, Acting Water Supply Manager.
- Caitlin Walker, Project Engineer.
- Roger Arroyo, Water Distribution Supervisor.
- Jose Delgado, Water Distribution Lead Operations Technician.
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- Theresa Lancy, Acting Water Distribution Superintendent.
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The following Carollo Engineers, Inc. staff members were principally involved in this project:

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- Assistant Hydraulic Modeler: Ryan Hejka.
- Planning Support: Amy Martin.
- Staff Engineer: Aimee Zhao.
- GIS Support: Jackie Silber and Kevin Christenson.

We would also like to thank the following team members from MNS Engineers, Inc.:

- Project Manager: Mark Reinhardt, PLS.
- Lead Surveyor: Shane Sobecki, PLS.

EXECUTIVE SUMMARY

This Executive Summary presents a brief background of City of Santa Barbra (City) water distribution system. It also describes the need for this Water Distribution Infrastructure Plan (WDIP) and the proposed improvements to mitigate system deficiencies. A summary of capital improvement project costs is also included.

1.0 Introduction

In January 2019, the City approved a professional service agreement with Carollo Engineers, Inc. (Carollo), to prepare the WDIP. The scope of work included the following main tasks:

- Task 1 – Project Management and Oversight.
- Task 2 – Coordination with City Staff.
- Task 3 – Model Update.
- Task 4 – Infrastructure Evaluation.
- Task 5 – Distribution Infrastructure Plan.

The City has conducted numerous studies of the water distribution system in the past decade, each for its own specific purpose. The City developed a water system hydraulic model in the early 2000s. This model, which was updated in 2006 by Carollo, was primarily used for water quality studies. The model was subsequently updated and calibrated by Carollo in 2014. This updated model has been used by the City to conduct several specific studies and various "what if" analyses. For example, the model was used extensively to analyze the impact of conveyance on the hydraulics and water quality mixing as result of the recommissioning of the Charles Meyer Desalination Plant (Desal Plant). However, a system-wide master planning effort had not been performed since the hydraulic model was updated and recalibrated in 2014.

The City identified the need to develop this WDIP to provide strategic guidance and practical recommendations that address the City's water distribution and water supply needs through the planning year 2050. The 30-year planning horizon was chosen to take a long-term perspective as infrastructure decision often have consequences for decades. To assist with the implementation of the recommendations, the Capital Improvement Plan (CIP) is phased in three periods that prioritize near-term (2021-2030), mid-term (2031-2040), and long-term (2041-2050) projects and programs.

Specifically, the City needs to make important investment decisions related to the rehabilitation and replacement of distribution system storage. One of the key planning questions of the WDIP is to determine which storage reservoirs could potentially be taken out of service without compromising system performance, while improving water quality and saving cost of rehabilitating or replacing reservoirs that are near the end of their useful life.

This WDIP considers the City's aging water system infrastructure, capacity driven improvements, and potential operational changes to increase reliability, resiliency, and efficiency of the City's distribution system.

Work on the WDIP was broken up into four major phases as indicated below:

- Phase 1, Basis of Planning. This phase of work consisted primarily of data gathering activities, the identification of existing and future water demands, and the development of planning and analysis criteria.
- Phase 2, Hydraulic Model Update. This phase of work consisted of updating the City's hydraulic model to reflect the changes (e.g., pipeline replacements) that have occurred since the most recent major model update (2014). It included updating the elevations of all the City's major water system facilities based on elevation surveys conducted by MNS Engineers, Inc. (MNS). It also included re-calibration of the updated water system hydraulic model.
- Phase 3, Infrastructure Evaluation. This phase of work included an evaluation of the distribution system, including a storage and pumping capacity analysis, a benchmark hydraulic analysis of the distribution system, and an analysis of 10 "stress scenarios". It also included the development of recommendations for improvements, which included capacity recommendations, rehabilitation/replacement project recommendations, and recommendations to optimize system performance, reliability, and operations.
- Phase 4, Capital Improvement Plan (CIP) and Infrastructure Plan. This phase of work consisted of the development of capital cost estimates for the recommended improvement projects, phasing of recommendations, and documentation of the findings of the WDIP.

The key documents and studies that were utilized in the preparation of this report are listed in Appendix A.

2.0 Study Area

The City is located between the Pacific Ocean and the Santa Ynez Mountains in Santa Barbara County, about 90 miles north of Los Angeles. The City is a coastal community of approximately 93,500 residents, encompassing 21 square miles, with varied topography ranging from steep mountain terrain to flat land near the ocean. Figure ES.1 illustrates the City's current water service area.

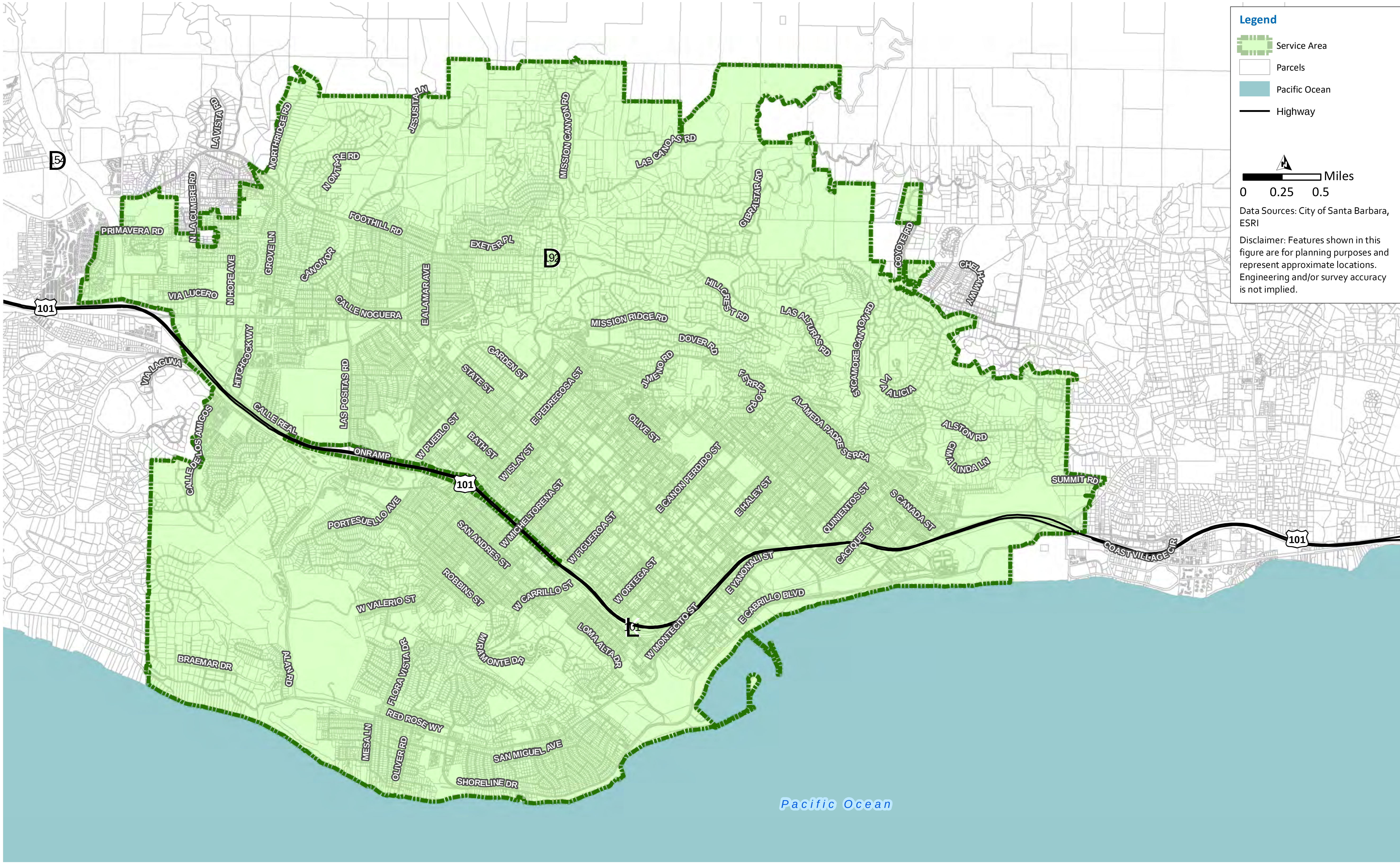

Figure 1 Water Distribution System Service Area

3.0 Study Purpose and Goals

The purpose of this WDIP is to provide a holistic evaluation of the City's water distribution system, to provide optimized solutions for the system in terms of hydraulics, operations, and capital investment, and to develop a prioritized plan to implement these solutions. Specific goals of the WDIP include:

- Update the City's 2014 hydraulic model to incorporate important system changes that have been implemented to obtain an accurate and reliable planning tool. The key system changes that needed to be incorporated include changes in water demands, approximately 18 miles of pipeline replacements/lining, the Desal Plant), and proposed changes as outlined in TM3.
- Determine which facilities should be replaced, rehabilitated, or possibly taken out of service.
- Identify operational strategies and/or capital improvement solutions to improve system reliability and redundancy for planned and unplanned outages, single point of failures, and other conceivable scenarios that would stress the City's water distribution system.

4.0 Planning Horizon

This WDIP is intended to serve as a guiding document for the planning and implementation of water system improvements to accommodate future growth within the service area through year 2050. The planning horizon is consistent with the City's Water Conservation Technical Analysis and the 2020 Urban Water Management Plan (UWMP).

5.0 Water Demands

According to the City's planning documents, a minor amount of growth is expected to occur in the next decades due to the City's nearly build out conditions. Table ES.1 summarizes the projected demands through the year 2050. The City's average day demand (ADD) and maximum day demand (MDD) are projected to approach 11.62 million gallons per day (mgd) and 20.91 mgd by 2050, respectively. This equates to an annual growth rate of 0.85 percent compared to the current (year 2019) ADD of 8.93 mgd.

The projected demands provided in Table ES.1 were developed for the City as part of the City's Water Conservation Technical Analysis, which was completed by Maddaus Water Management in December 2019 (see Appendix 2A).

Table ES.1 Future Demand Projections through 2050

Year	Projected ADD (mgd)	Projected MDD(2) (mgd)
2019 (existing)	8.93	16.07
2020	9.13	16.44
2025	9.43	16.97
2030	10.43	18.87
2035	10.66	19.19
2040	10.92	19.65
2045	11.24	20.23
2050	11.62	20.91

Notes:
(1) Source: City of Santa Barbara Water Conservation Strategic Plan (Maddaus, 2019).
(2) MDD/ADD peaking factor = 1.8 (See Table 2.2 in TM-2).

6.0 Water Distribution System and Hydraulic Model

This section summarizes the existing water distribution system and the process used to update the City's hydraulic model.

6.1 Existing Water Distribution System

The City's existing water distribution system is shown on Figure ES.2. The City's modeled water distribution system consists of approximately 300 miles of pipelines, ranging from 4-inch up to 42 inches in diameter. To provide acceptable operating pressures throughout the system, the City has been hydraulically separated into 17 pressure zones.

The City's water supply portfolio currently consists of treated water from William B. Cater Water Treatment Plant (Cater WTP) and Charles D. Meyer Desalination Plant (Desal Plant). Water can also be supplied from eight groundwater wells. Four groundwater wells (Alameda, Hope, Los Robles, and San Roque) discharge directly into the distribution system. The remaining four groundwater wells (High School, Corp Yard, Vera Cruz, and City Hall) are conveyed to the Ortega Groundwater Treatment Plant (Ortega WTP) for treatment prior to being pumped into the Low Level zone.

The City's distribution system has 13 active storage reservoirs with total volumes ranging from 0.6 million gallons (MG) to 10.0 MG. The total usable storage volume is estimated to be nearly 32.0 MG.

The City has 14 booster pump stations that deliver water from lower pressure zones to upper pressure zones of the distribution system. The City's distribution system includes 20 pressure reducing valves (PRV) Stations, which convey and regulate water. Several of these PRV stations function in a standby, or backup role.

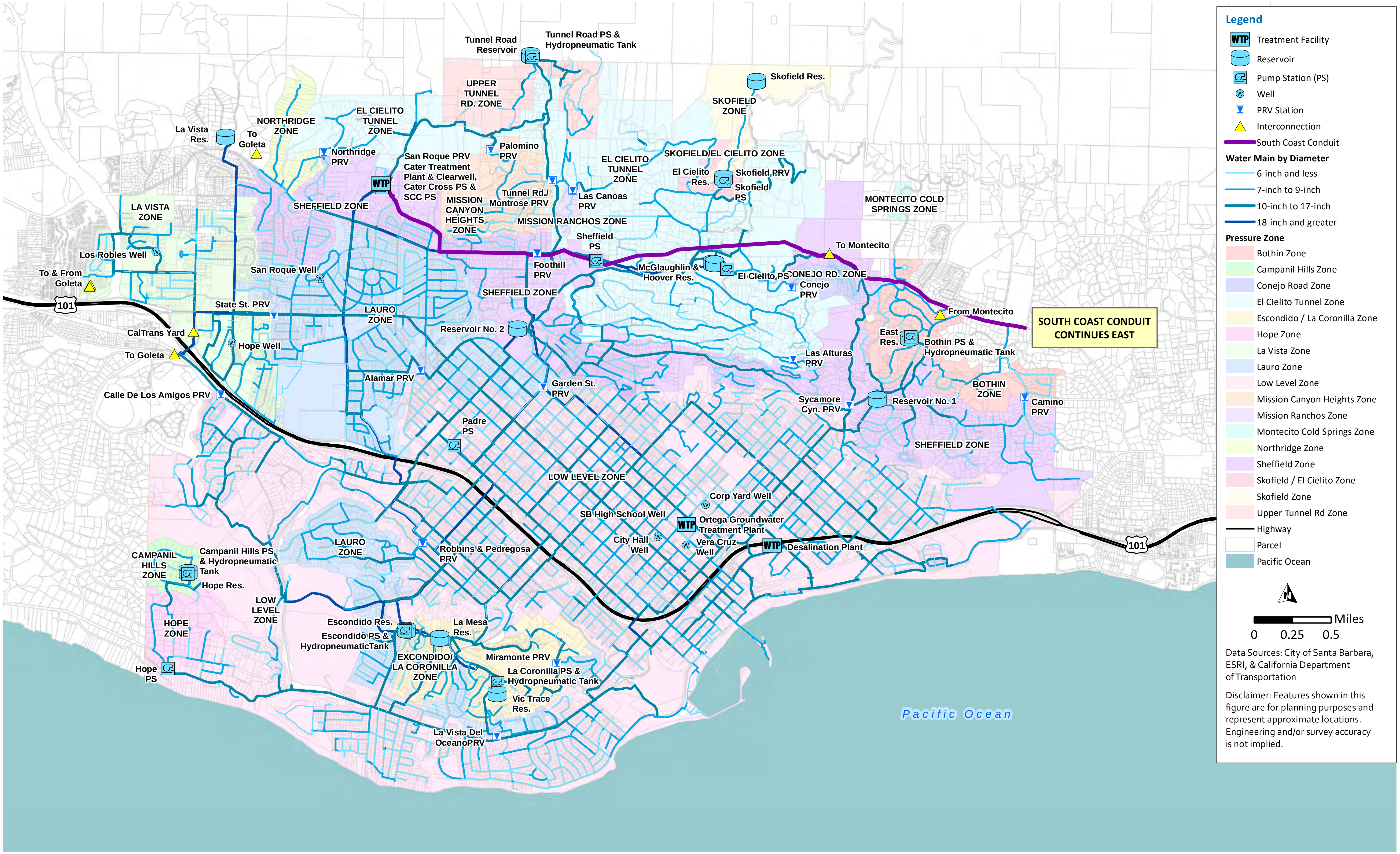

Figure 2 Existing Water Distribution System Overview

6.2 Hydraulic Model Update and Calibration

A hydraulic model was utilized for the analysis of the water distribution system. A brief summary of the hydraulic model update is provided below, while a detailed description of the water model updates and calibration are provided in Technical Memorandum 1 (TM-1) of this WDIP.

The City's water system hydraulic model was originally constructed in the early 2000's and was most recently updated and calibrated in 2014 by Carollo. Since 2014, the City's hydraulic model has been used to conduct several analyses of the City's water system, particularly related to the reactivation of the City's Desal Plant. As part of this project, the distribution network was updated to reflect the most recent GIS data to incorporate new, abandoned, and replaced pipelines. In addition, the water system facilities configurations and controls were updated based on input from City operations staff.

In addition, Carollo sub-contracted with MNS to obtain field measured elevations for the City's water system facilities. The elevation surveying information provided by MNS was used to update the City's hydraulic model elevations for the major water system facilities (tanks, booster pump stations, and PRV stations).

Allocation of water demands to appropriate nodes in the hydraulic model was accomplished by geocoding the City's water billing records from year 2018. The City's water distribution system hydraulic model was calibrated using a three-step process that included, a macro calibration, a fire flow test calibration, and an EPS calibration. The calibrated model was used for the distribution system analysis presented in this WDIP. Details regarding the model calibration results are included in Appendix 1A, 1B and 1C of TM 1.

7.0 Infrastructure Evaluation

Following model calibration, an evaluation of the water system infrastructure was performed. The evaluation included the following:

- Storage Analysis. A desktop storage analysis was performed under both existing and 2050 system demands, which is documented in detail in TM 2 of this WDIP. These analyses demonstrated that the City has a significant surplus in storage capacity. Five additional storage analyses were conducted to evaluate the available storage with specific reservoirs out of service. For more detail on these storage analysis scenarios, refer to TM 2.
- Pump Station Analysis. Similar to the storage analysis, a desktop analysis was performed on the City's pump stations to identify if each pump station has a sufficient firm capacity to meet its required pumping capacity for existing and 2050 demands. The results of the pumping analysis are described in detail in TM 2 of this WDIP. The analysis showed that, with a few exceptions, the City's pump stations are adequate to meet current and year 2050 demands.
- Fire Flow Analysis. The calibrated hydraulic model was used to conduct a fire flow evaluation of the distribution system. The system was evaluated to verify that a minimum residual pressure of 20 pounds per square inch (psi) was met under fire flow demand conditions. Based on a combination of fire flow runs with the hydraulic model and subsequent field verifications, a total of 22 hydrants out of a total of 2,240 hydrants were classified as deficient, which equates to approximately 1 percent of the City's hydrants.

The CIP includes 13 fire flow improvement projects to address these deficiencies. For detailed information regarding the fire flow analysis, refer to TM 3 of this WDIP.

- Benchmark Hydraulic Analysis. The benchmark analyses help predict the distribution system performance under normal operating conditions using 2019 demands. The benchmark analysis used the hydraulic model to identify pressure deficiencies, water main velocity deficiencies, and reservoir levels under existing ADD, Minimum Day Demand (MinDD), and MDD conditions. For detailed information regarding the benchmark hydraulic analysis, refer to TM 3 of this WDIP.
- Stress Analysis. The purpose of the stress analysis is to analyze the distribution system performance when key water system facilities and/or transmission mains are out of service. Ten stress scenarios were defined that are intended to capture the most important critical outages that were evaluated using the hydraulic model. The hydraulic model was used to mimic these scenarios and analyze system pressures, velocities, and reservoir levels to determine potential capital improvement projects and/or operational modifications. The ten stress scenarios are summarized in Table ES.2, indicating the type of scenario and whether it included the planned 24-inch diameter dedicated Desalination Conveyance Transmission Main (also referred to as the Desal TM). Detailed information regarding the analysis results can be found in TM 3 of this WDIP.

Table ES.2 Stress Scenario Summary

Scenario No.	Description	Type	With or Without Desal TM?
1	Main break along a 24-inch diameter pipeline (E9-4) near Robbin Street	Operations	Without
2	Main break along a 36-inch diameter pipeline (D3-50) at the intersection of San Roque Road and Foothill Road.	Operations	With
3	Cater WTP has lost connection to Gibraltar Reservoir and Lake Cachuma so is not producing water, but the Cater Clearwell can receive/distribute water from other sources.	Supply	With
4	Cater WTP has lost connection to Gibraltar Reservoir and Lake Cachuma, but the Cater Clearwell can receive/distribute water from other sources.	Supply	Without
5	Vic Trace Reservoir is out of service, due to rehabilitation. Evaluated for 7-days EPS.	Operations	Without
6	La Vista Reservoir out of service, and all the division gates between La Vista Zone and Lauro Zone are opened eliminating the La Vista Zone increasing the Lauro Zone. Downsize existing 22-inch to a 12 –inch diameter pipeline down Hope Avenue, and add a 12 inch diameter pipeline from San Roque and Foothill to La Vista Reservoir.	Operations	Without

Scenario No.	Description	Type	With or Without Desal TM?
7	Reservoirs 1 and 2 and La Mesa Reservoir are out of service, to show how the Low Level Zone functions without an open reservoir.	Operations	With
8	Reservoirs 1 and 2 and La Mesa Reservoir are out of service to show how the Low Level Zone functions without an open reservoir.	Operations	Without
9	Desalination Plant is out of service. This scenario will evaluate the reverse flow in the proposed dedicated 24-inch diameter pipeline using the new Yanonali PRV station.	Operations	With
10	Evaluates how the City wants to operate their system by 2050. Scenario 10 involves taking many reservoirs out of service in order to allocate resources to less facilities. See TM-3 for a detailed description.	Operations/Supply	With

8.0 System Improvements

Recommended improvements were developed based on the findings of the infrastructure analysis. These improvements are summarized in this section, while more detailed documentation is included in TM 2 and TM 3 of this WDIP. To provide a comprehensive summary of distribution system improvements, the CIP of this WDIP also includes projects that were already studied, recommended, and planned for implementation, such as the already planned Desalination Conveyance Transmission Main and rehabilitation and replacement (R&R) projects identified in the City's Water Distribution Section Asset Management Program Risk and Condition Assessment Phase 1 Report, developed by Brown & Caldwell in 2014. The R&R projects included in this WDIP are limited to those that have not been implemented to-date. Cost estimate adjustments were made to account for changes in the Engineering News Record (ENR) index between January 2013 and March 2020.

8.1 Capacity and Reliability Improvements

Figure ES.3 provides a graphical illustration of the improvements recommended to address the capacity deficiencies, as documented in TM-2 and TM-3 of this WDIP. The recommended improvements include projects to improve the systems reliability by adding redundancy. The following summarizes these capacity and reliability improvements:

- **Storage Improvements:**
  - Cater Clearwell (SR-1A and SR-1B)[1]. Due to the nature of the seismic vulnerabilities (i.e., structural and geotechnical) and the critical function that the Cater Clearwell plays in the overall water supply, the City is studying options to replace or upgrade the Cater Clearwell.

[1] Since the completion of the WDIP analysis, the City has further investigated the Cater Clearwell site configuration options. The current plan (Feb 2021) is to build a 2.0 MG CT tank, in addition to the 5.0 MG Clear Well that will operate in series, allowing the clear well to be dedicated to usable storage.

For the purposes of this WDIP's CIP, it is recommended that the existing Cater Clearwell be upgraded to meet seismic standards, Although the City is currently evaluating alternatives, it is assumed for the purpose of this WDP that the Cater Clearwell be replaced with a minimum of 4.5 MG of storage, consisting of two elements:

  - Cater Contact Basin (SR-1A)[1]. A new chlorine contact basin (or CT tank) with a minimum volume of 2.3 MG for contact time and backwash. The required contact basin volume is dependent on the baffling factor and treatment capacity.
  - Cater Distribution Storage (SR-1B)[1]. A new distribution storage clearwell with a minimum volume of 2.2 MG to provide gravity distribution storage for the Lauro Zone. Since the completion of the WDIP analysis
  - Revised Cater Clearwell (SR1A and SR1B). Since the completion of the WDIP analysis, the City has further investigated the Cater Clearwell site configuration options. The current plan (February 2021) is to build a 2.0 MG CT tank, in addition to the 5.0 MG Clear Well that will operate in series, allowing the clear well to be dedicated to usable storage. Hence, a total of 7.0 MG of storage would be sited at the Cater WTP.

- Vic Trace Reservoir Replacement (SR-2). Replace Vic Trace Reservoir with an equally sized reservoir of 10.0 MG that is below ground to maximize its useful life. If possible, this project should be deferred until completion of projects SR-1A, SR-1B, and RRV-1 and both Hoover and McLaughlin Reservoirs should be online during construction to provide sufficient storage.
- El Cielito Reservoir Replacement (SR-3). Replacement of El Cielito Reservoir with a new 1.5 MG tank that matches the HGL of Tunnel Reservoir when the condition of the reservoir triggers a major upgrade.

- **Fire Flow Improvements:**
  - Fire Flow Improvements (FF-1 through FF-13). The fire flow analysis identified the need for 13 fire flow improvements projects which are listed in Table 3.2 of TM 3 of this WDIP. These improvements are shown on Figure ES.3. The proposed fire flow improvements involve replacing and upsizing existing pipelines, completing pipeline loops, and connecting a few hydrants to higher pressure zones. Approximately 450 feet of new pipeline is proposed. Additionally, 9,800 feet or 1.9 miles
  - Foothill Road Transmission Main (TM-3). Construct approximately 5,200 feet (or nearly 1 mile) of new 12-inch diameter water main along Foothill Road between San Roque Road and Barger Canyon Road.
  - Stanwood Drive Transmission Main Replacement (TM-4). Construct approximately 2,300 feet of 12-inch diameter pipeline along Stanwood Drive between El Cielito Pump Station and East of Orizaba Lane. This project improves the reliability of Sheffield Zone and Bothin Zone and to get the pipeline out of an easement that is difficult to maintain.
  - Sunrise Vista Way (TM-5). Instead of replacing approximately 200 feet of 6-inch diameter pipeline segment along a ROW between Surf View Drive and Calle Cortita within Escondido La Coronilla Zone. It is recommended that approximately 600 feet of new 8-inch diameter pipeline be constructed along Sunrise Vista Way.

- Conveyance from Ortega WTP to Desalination Transmission Main tie-in (TM-6). This project will allow delivery of supply from the Ortega Treatment Plant to the Desalination Conveyance Transmission Main via approximately 1,300 feet of 16-inch diameter water main and an automated tie-in connection.
- Mountain Drive Water Main Upsize (TM-7). Replace approximately 1,000 feet of 8-inch diameter water main along Mountain Drive between Las Canoas Road and Rockwood Drive with a 12-inch diameter water main. Scenario 10 showed that this segment of water main exceeded the maximum velocity criteria of 8 fps under 2050 MDD conditions.

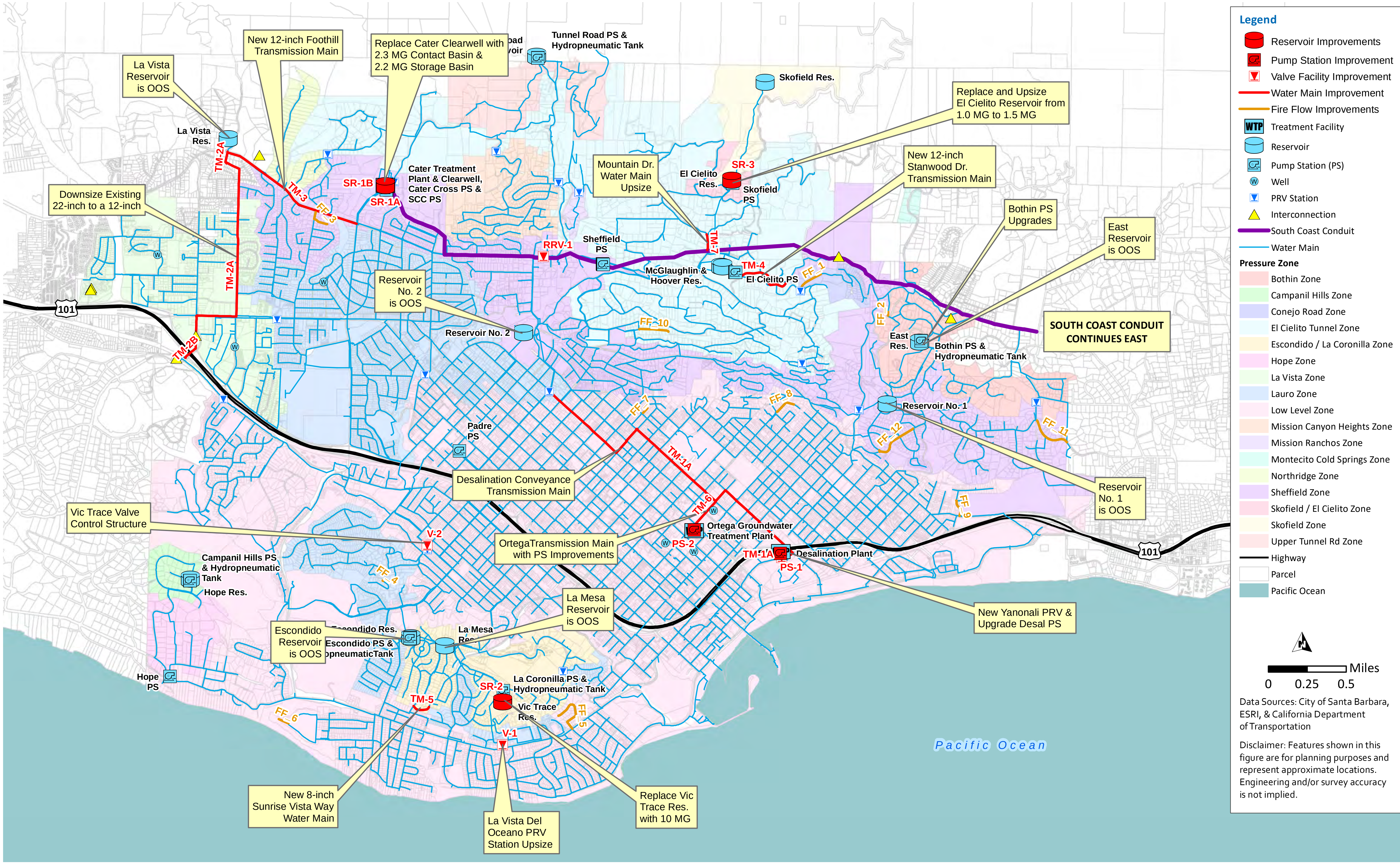

Figure 3 Proposed System Improvements

- **Pump Station Improvements**
  - Desal Pump Station Upgrade (PS-1). Upgrade the Desalination PS so it can pump the additional head required to reach the Cater Clearwell. This projects is paired with project TM-1A.
  - Ortega Pump Station Replacement (PS-2). This project should be completed with proposed project TM-6. This project includes upgrading the Ortega Pump Station so that it can pump the additional 140-feet of head required to reach the Cater Clearwell, as well as the addition of a surge tank at this site. This project is paired with project TM-6.
- **PRV Station Improvements:**
  - La Vista del Oceano PRV Station Upsize (V-1). Replace and upsize the La Vista del Oceano PRV Station to increase gravity conveyance capacity from Lauro Zone to Low Level Zone.
  - Valve Automation at Robbins Street and Pedregosa Street (V-2). To improve system operations at Vic Trace, add automation to the 24-inch diameter valve at Robbins Street and Pedregosa Street based on Vic Trace Reservoir level.

8.2 Rehabilitation and Replacement Improvements

The R&R project recommendations included in this WDIP were compiled from a review of the 2014 Water Distribution Section Asset Management Program Risk and Condition Assessment Phase 1 Report, the City's existing CIP from March 2019, and discussions with City staff throughout the development of the WDIP. The following summarizes the recommended R&R improvements:

- **Water Main R&R:**
  - Transmission Main Renewal Projects (RRWM-1). This category includes already planned renewal projects through year 2024 to help extend the useful life of transmission mains that are reaching the end of their useful life or in are poor condition.
  - Water Main Replacement Program (RRWM-2). These projects were identified in the City's 2019 CIP, which reflect main replacements through year 2024 to achieve the City's goal of annually replacing approximately 2 percent, or six miles, of the City's 300 miles of water mains. It should be noted that fire flow and capacity related project costs were deducted from the annual project budget in the near-term phase to maintain a consistent investment level.
  - Transmission Main Replacement/Relining Study (RRWM-3). The purpose of this study is determine if transmission main lining is a cost-effective approach to extend the useful life of this critical infrastructure that supplies the Lower Zone with water from the Cater WTP by comparing the life cycle cost of full replacement and relining.
  - Water Main Replacement Program Continued (RRWM-4). These projects were identified in the City's 2019 CIP, which reflect main replacements between year 2025 and 2050 to achieve the City's goal of annually replacing approximately 2.0 percent, or six miles, of the City's 300 miles of water mains. It should be noted that capacity water main project costs were deducted from the annual project budget to maintain the same distribution system investment level.

- **Pump Station R&R:**
  - Bothin PS Hydraulic Analysis Study and PS Upgrades (RRPS-1). This project was identified in the City's 2014 Asset Management Program. A hydraulic analysis study is recommended to identify pump station modifications to improve the pump station operation with the associated East Reservoir. It is recommended that the pump station be upgraded based on the study.
  - La Coronilla PS Condition Assessment Study and Rehabilitation (RRPS-2). This project was identified in the City's 2014 Asset Management Program. A condition assessment study is recommended due to the pump stations age. It is recommended that the pump station rehabilitated to make it operational.
  - Rocky Nook PS Control Panel (RRPS-3). This project was identified in the City's 2014 Asset Management Program. The existing pump station's control system does not have the City's standard control panel. It is recommended that the existing pump station's control panel be replaced with a control panel with the City's standard graphics.
  - Sheffield PS - Upgrade Pumps 3 & 4 with Variable Frequency Drives (VFDs) (RRPS-4). This project was identified in the City's 2014 Asset Management Program. It is recommended that the pump station's pumps 3 and 4 be upgraded with VFDs and motor control center (MCC).
  - Annual Pump Station R&R Program (RRPS-5). The annual pump station R&R program is an annual budget for future projects not identified at this time. This was included for planning purposes.
- **Reservoir R&R:**
  - La Mesa Reservoir, replace interior piping and valves (RRSR-1). This project was identified in the City's 2014 Asset Management Program. The interior piping shows signs of severe corrosion. It is recommended that the interior pipes and valves be replaced.
  - Hope Reservoir, acquire easement and rehabilitation of reservoir roof and floor (RRSR-2). This project was identified in the City's 2014 Asset Management Program. Floor and exterior concrete cracks were identified during the inspection. It is recommended that the floor and exterior concrete roof cracks be sealed to prevent water infiltration and reinforcement corrosion. In order to work on Hope Reservoir, the City must obtain the necessary easements and is included in this project.
  - East Reservoir, geotechnical study, seismic evaluation, and seismic/structural upgrades (RRSR-3). This project was identified in the City's 2014 Asset Management Program. The inspection showed ground movement around the reservoir and possible slope stability on the northeast side of the reservoir. A geotechnical investigation is recommended to help determine mitigation projects. And it is recommended that the appropriate seismic/structural upgrades be implemented.

- Multiple Reservoirs Out of Service (RRSR-4 through RRSR-9). The reservoirs listed below can be taken out of service, but remain in-place at the current locations, based on the reservoir analysis presented in TM 2 of this WDIP. The sequencing these reservoir should consider the condition of each reservoir by minimizing rehabilitation cost for these facilities that are planned to be taken offline in the future. If possible, all these projects should be deferred until Cater Clearwell is replaced (Projects SR-1A and SR-1B), Vic Trace Reservoir is replaced (Project SR-2), El Cielito Reservoir is replaced (Project SR-3) and Foothill PRV station is rehabilitated (Project RRV-1).
  - Escondido Reservoir (RRSR-4). This reservoir is currently out of service and no project is required before taken out of service. The City would close valves WV-D10-080 and WV-D10-018 to take Escondido Reservoir out of service.
  - East Reservoir (RRSR-5). This project requires completion of projects SR-1A, SR-1B, SR-2, and SR-3 before East Reservoir can be taken out of service. This project includes field piping such that Bothin PS can bypass East Reservoir. The City would close valves WV-K05-076 and WV-K05-036 to take East Reservoir out of service.
  - Reservoir No. 2 (RRSR-6). This Project requires the completion of projects SR-2, and V-1 before taking out of service. The City must install pressure relief valves to avoid over-pressurization in the Low Level Zone before the last gravity reservoir is taken out of service. The City would need to close valves WV-E05-008 and WV-E05-003 to take Reservoir 2 out of service.
  - La Mesa Reservoir (RRSR-7). This Project requires the completion of projects SR-2, and V-1 before La Mesa Reservoir is taken out of service. The City must install pressure relief valves to avoid over-pressurization in the Low Level Zone before the last gravity reservoir is taken out of service. The City would need to close valves WV-E10-035 and (missing ID) to take La Mesa Reservoir out of service.
  - La Vista Reservoir (RRSR-8). This project requires completion of Projects SR-1A, SR-1B, SR-2, TM-3, and RRV-1 before La Vista Reservoir is taking out of service. It is recommended that the City also consider completing the projects TM-2A and TM-2B before taking La Vista Reservoir out of service to enhance conveyance redundancy to the Low Level Zone. The City would need to close valve WV-B02-019 to take La Vista Reservoir out of service.
  - Reservoir No. 1 (RRSR-9). Based on the storage capacity balance, Reservoir No. 1 could also be taken out of service in the future, but should remain available to be put back in service as needed. This Project requires the completion of projects SR-2 and V-1 before Reservoir No. 1 is out of service. The City must install pressure relief valves to avoid over-pressurization in the Low Level Zone before the last gravity reservoir is decommissioned. The City would need to close valves WV-K06-057 and WV-K06-050 to take Reservoir 1 out of service.
- Annual Storage Reservoir R&R Program (RRSR-10). The annual reservoir R&R program is an annual budget for future projects not identified at this time. This program was included for planning purposes.

• **Valve R&R:**
  - Foothill PRV Station Rehabilitation (Project RRV-1). The PRV Station is currently out of service and needs to be rehabilitated to become operational.

  - Camino Viejo PRV Rehabilitation (Project RRV-2). This project was identified in the City's 2014 Asset Management Program. Due to the critical nature of this PRV station, a station rehabilitation is recommended to be programmed following the inspection.
  - Annual PRV Station R&R Program (Project RRV-3). This project was identified in the City's 2014 Asset Management Program. Annual budget to ensure the City has funding for storage reservoir R&R projects that have yet to be identified.
- **Groundwater Treatment:**
  - Groundwater Program (Project RRGW-1). This project is included in the City's 2019 CIP and addresses capital improvements for the City's groundwater system, such as well cleaning, pump and motor upgrades, and well rehabilitation.

8.3 Other Projects

Other projects consist of additional projects identified by the City and or projects not related to capacity or R&R. The following summarizes other projects and/or improvements:

- **System Upgrades:**
  - Computerized Maintenance Management System (CMMS) Upgrade (Project SU-1): Identified by the City as a budget item to provide sufficient funds to periodically upgrade its existing CMMS (e.g., every 10 years) and for annual software maintenance. This was included for planning purposes.
  - Supervisory Control and Data Acquisition (SCADA) System Upgrades (Project SU-2): Identified by the City as a budget item to provide sufficient funds to periodically replace and upgrade the City's existing SCADA system and radio communication system(e.g., every 10 years) to improve the efficiency and reliability of system operations communications and update automation to current available technologies.
  - City-wide Advance Metering Infrastructure (AMI) Upgrade (Project SU-3): Replace all customer meters with remote advanced reading technology. The major metering overhall is anticipated to be completed by 2023:
  - Baseline Metering Program Upgrades (Project SU-4): This program includes ongoing replacement of the City's water meters and associated improvements, including replacing meter boxes and related infrastructure as needed.
- **Studies:**
  - Water Distribution Infrastructure Plan Update (Project ST-1): This project includes periodic budget to update the City's WDIP and hydraulic model.
  - Asset Management Program Report Update (Project ST-2): This project includes a periodic update of the City's asset management report.
  - SCADA Master Plan Update (Project ST-3): This project includes periodic budget to update the City's SCADA Master Plan.

9.0 30-Year CIP

A summary of the capital project costs described above are presented in Table ES.3. As shown, the proposed capital improvements are prioritized based on their urgency to mitigate existing deficiencies and other factors. The capital improvements were phased into one of the following phases:

- Near-Term (2021-2030): This phase includes projects that are included in the first ten years of the CIP because these project are either already ongoing or expected to be implemented in the near-term.

- Mid-Term (2031-2040): This phase includes system improvements that are anticipated to be completed by year 2040.
- Long-Term (2041-2050): This phase includes programmatic improvement that extend through the planning horizon of this plan, as well as project improvements that are currently not expected to be initiated in the near- or mid-term.

As shown, each project includes a construction and capital cost. As explained in the Cost Assumption Details included in Appendix B of this Executive Summary, most projects include a 65.75 percent markup from the baseline construction cost to the capital cost to account for construction cost contingency, as well as, engineering, construction management, and project administration costs. It should be noted that 65.75 percent markup was not applied to all projects in cases where the estimated project was developed from another source, a proposed study, and land acquisition. Where appropriate, cost estimates from previous studies were scaled to the ENR Construction Cost Index (CCI) Greater Los Angeles of 12,403 (March 2020).

The 30-year water distribution system CIP is summarized by phase and project type in Table ES.4. As shown in Table ES.4, out of the total $447 million in capital projects, $205 million (46 percent) are targeted for implementation in the Near-Term and an additional $124 million (28 percent) are targeted for the Mid-Term. The remaining $118 million (26 percent) of capital improvements has been included in the Long-Term Phase. The total phase costs by project type is illustrated in Figure ES.4. This is approximately $20.5 million, $12.4 million, and $11.8 million of annual spending for the Near-Term, Mid-Term, and Long-Term, respectively.

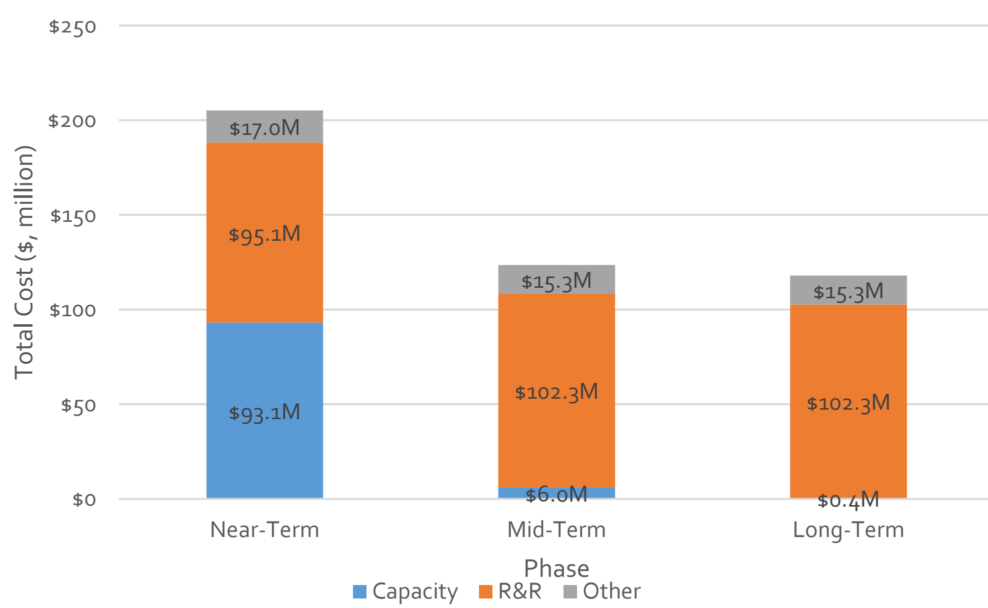

Figure ES.4 Water Distribution System CIP by Phase, and Project Type

Table ES.4 - 30-Year Water Distribution CIP Summary

Project ID	Project Name	Existing Size	Proposed Size	Pipeline Length	Project Type	Study/Project Unit Cost ($)	Unit Cost[1] ($)	Unit	Total Cost Estimate(1)(2)(3)(4)(5) ($)	CIP Phase											
										Near Term										Mid Term	Long Term
										2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031-2040	2041-2050
Hydraulic Capacity Improvements						$ 275,000			$ 99,543,000	$ 20,150,000	$ 829,000	$ 3,083,000	$ 19,178,000	$ 194,000	$ 41,938,000	$ -	$ 2,155,000	$ 5,594,000	$ -	$ 6,008,000	$ 414,000
Transmission & Distribution Main		Diameter (in)	Diameter (in)	Length (ft)		$ -			$ 26,992,000	$ 17,000,000	$ -	$ -	$ 5,553,000	$ 194,000	$ -	$ -	$ 2,155,000	$ -	$ -	$ 1,676,000	$ 414,000
TM-1A	Desalination Conveyance Transmission Main (incl. new Yanonali PRV)[6]	--	24	13,000	New	$ -	--	LS	$ 17,000,000	$ 17,000,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
TM-1B	Desalination Conveyance Transmission Main - Cater Clearwell Connection[6]	--	--	--	New	$ -	--	LS	$ 1,600,000	$ -	$ -	$ -	$ 1,600,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
TM-2A	La Vista Zone Transmission Main Downsize	22	12	8,500	Replace	$ -	$250	$/ft	$ 3,522,000	$ -	$ -	$ -	$ 3,522,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
TM-2B	La Vista Zone Transmission Main Downsize - Highway Crossing	22	12/24	500	Replace	$ -	$520	$/ft	$ 431,000	$ -	$ -	$ -	$ 431,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
TM-3	Foothill Road Transmission Main	--	12	5,200	New	$ -	$250	$/ft	$ 2,155,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,155,000	$ -	$ -	$ -	$ -
TM-4	Stanwood Drive Transmission Main Replacement	12/14/16	12	2,300	Replace	$ -	$250	$/ft	$ 953,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 953,000	$ -
TM-5	Sunrise Vista Way	--	8	600	New	$ -	$195	$/ft	$ 194,000	$ -	$ -	$ -	$ -	$ 194,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
TM-6	Ortega GWTP Transmission Main and tie-in to the Desal TM.	--	16	1,300	New	$ -	$335	$/ft	$ 723,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 723,000	$ -
TM-7	Mountain Drive Water Main Upsize	8	12	1,000	Replace	$ -	$250	$/ft	$ 414,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 414,000
Pump Stations									$ 7,150,000	$ 3,150,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 4,000,000	$ -
PS-1	Desal Pump Station Upgrade	--	--	--	New	$ -	--	LS	$ 3,150,000	$ 3,150,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
PS-2	Ortega Pump Station Replacement (with electrical upgrades and surge tank)	--	--	--	Replace	$ -	--	LS	$ 4,000,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 4,000,000	$ -
Storage Reservoir		Capacity (MG)	Capacity (MG)						$ 64,240,000	$ -	$ -	$ 3,082,800	$ 13,625,200	$ -	$ 41,938,000	$ -	$ -	$ 5,594,000	$ -	$ -	$ -
SR-1A	Cater WTP Chlorine Contact Basin 2.25 MG[8]	3.30	2.30	--	New	$ 50,000	$2.00	$/gal	$ 9,001,000	$ -	$ -	$ -	$ 9,001,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SR-1B	Cater Clear Well, Seismic	1.70	2.20	--	Replace	$ -	$1.75	$/gal	$ 7,707,000	$ -	$ -	$ 3,082,800	$ 4,624,200	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SR-2	Vic Trace Reservoir - Below Ground[9]	10.00	10.00	--	Replace	$ 500,000	$2.50	$/gal	$ 41,938,000	$ -	$ -	$ -	$ -	$ -	$ 41,938,000	$ -	$ -	$ -	$ -	$ -	$ -
SR-3	El Cielito Reservoir: Rebuild to match HGL of Tunnel Reservoir	1.00	1.50	--	Replace	$ -	$2.25	$/gal	$ 5,594,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 5,594,000	$ -	$ -	$ -
Valve		Size	Size						$ 1,161,000	$ -	$ 829,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 332,000	$ -
V-1	Upsize La Vista Del Oceano PRV Station	4" & 8"	6", 8", & 12"	--	Replace	$ -	$500,000	$/station	$ 829,000	$ -	$ 829,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
V-2	Plug Valve Automation at Robbins St. & Pedregosa St. to fill Vic Trace from the Lauro Zone	24"	24"	--	Upgrade	$ -	--		$ 332,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 332,000	$ -
Rehabilitation and Replacement Projects						$ 176,000			$ 299,638,000	$ 10,214,000	$ 9,752,000	$ 9,835,000	$ 5,571,000	$ 10,043,000	$ 10,547,000	$ 10,370,000	$ 8,248,000	$ 10,237,000	$ 10,237,000	$ 102,296,000	$ 102,288,000
Water Main		Diameter (in)	Diameter (in)	Length (miles)			($/ft)		$ 280,300,000	$ 6,575,000	$ 9,100,000	$ 9,100,000	$ 5,037,000	$ 9,608,000	$ 9,802,000	$ 9,802,000	$ 7,647,000	$ 9,802,000	$ 9,802,000	$ 96,419,000	$ 97,606,000
RRWM-1	Transmission Main Renewal Projects[5]	--	--	--	R&R	$ -	Varies	$/year	$ 5,565,000	$ 1,890,000	$ 845,000	$ 1,340,000	$ 1,490,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
RRWM-2	Water Main Replacement Program [10]	Varies	Varies	10.3	R&R	$ -	Varies	$/year	$ 24,247,000	$ 4,685,000	$ 8,255,000	$ 7,760,000	$ 3,547,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
RRWM-3	Transmission Main Rreplace/Lining Study	--	--	--	Study	$ 75,000	$75,000	$/study	$ 75,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 75,000	$ -
RRWM-4	Water Main Replacement Program Continued	Varies	Varies	182.0	R&R	$ -	Varies	$/year	$ 250,413,000	$ -	$ -	$ -		$ 9,608,000	$ 9,802,000	$ 9,802,000	$ 7,647,000	$ 9,802,000	$ 9,802,000	$ 96,344,000	$ 97,606,000
Fire Flow		Diameter (in)	Diameter (in)	Length (ft)		$ -			$ 2,525,000	$ 2,525,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FF-1	Conejo Rd. and Orizaba Ln.	6	8	950	Replace	$ -	$195	$ft	$ 241,000	$ 241,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FF-2	Sycamore Vista Rd. and Canon View Rd.	2	4	150	Replace	$ -	$160	$ft	$ 31,000	$ 31,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FF-3A	Langlo Terr.	4	6	500	Replace	$ -	$180	$ft	$ 117,000	$ 117,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FF-3B	N Ontare Rd.	6	8	300	Replace	$ -	$195	$ft	$ 77,000	$ 77,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FF-4A	La Cima Rd.	4	6	100	Replace	$ -	$180	$ft	$ 23,000	$ 23,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FF-4B	La Cima Rd.	--	6	350	New	$ -	$180	$ft	$ 82,000	$ 82,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FF-5	La Marina and Cliff Dr.	6	8	1,750	Replace	$ -	$195	$ft	$ 443,000	$ 443,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FF-6	Arroyo Burro Beach	4	6	400	Replace	$ -	$180	$ft	$ 94,000	$ 94,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FF-7	De La Vista Ave. and N Salsipuedes St.	4	6	250	Replace	$ -	$180	$ft	$ 59,000	$ 59,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FF-8	E De La Guerra St. and Chiquita Rd.	4	6	750	Replace	$ -	$180	$ft	$ 176,000	$ 176,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FF-9	Harbor View Dr. and Old Coast Hwy.	6	8	600	Replace	$ -	$195	$ft	$ 152,000	$ 152,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FF-10	Mira Vista Ave. and San Carlos Rd.	4	6	1,050	Replace	$ -	$180	$ft	$ 246,000	$ 246,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FF-11	Alston Rd. and Summit Rd.	6	8	1,450	Replace	$ -	$195	$ft	$ 368,000	$ 368,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FF-12	Alameda Padre Serra and Knoll Cir Dr.	6	8	1,550	Replace	$ -	$195	$ft	$ 393,000	$ 393,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FF-13	Holly Rd.	--	6	100	New	$ -	$180	$ft	$ 23,000	$ 23,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Pump Station		Capacity (HP)	Capacity (HP)						$ 3,559,000	$ 166,000	$ 117,000	$ 100,000	$ 100,000	$ 100,000	$ 410,000	$ 100,000	$ 266,000	$ 100,000	$ 100,000	$ 1,000,000	$ 1,000,000
RRPS-1	Bothin PS Hydraulic Analysis Study & PS Upgrades[11]	--	--	--	Study, R&R	$ 25,000	$25,000	$/study	$ 66,000	$ 66,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
RRPS-2	La Coronilla PS Condition Assessment Study & Full PS Rehabilitation[11]	--	25	--	R&R	$ 12,000	$180,000	LS	$ 310,000	$ -	$ -	$ -	$ -	$ -	$ 310,000	$ -	$ -	$ -	$ -	$ -	$ -
RRPS-3	Rocky Nook PS Install Control Panel[11]	--	--	--	R&R	$ -	$10,000	$/panel	$ 17,000	$ -	$ 17,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
RRPS-4	Sheffield PS Upgrade Pumps 3 & 4 with VFDs[11]	--	--	--	R&R	$ -	$100,000	LS	$ 166,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 166,000	$ -	$ -	$ -	$ -
RRPS-5	Annual Pump Station R&R Program	--	--	--	R&R	$ -	$100,000	$/year	$ 3,000,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 1,000,000	$ 1,000,000
Storage Reservoir		Capacity (MG)	Capacity (MG)						$ 11,239,000	$ 547,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 433,000	$ 300,000	$ 300,000	$ 300,000	$ 4,527,000	$ 3,332,000
RRSR-1	La Mesa Reservoir, replace interior piping and valves[11]	--	--	--	R&R	$ -	$125,000	LS	$ 207,000	$ 207,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
RRSR-2	Hope Reservoir, acquire easement and rehabilitation of reservoir roof and floor[11]	--	--	--	Land, R&R	$ 200,000	$400,000	LS	$ 863,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 863,000	$ -
RRSR-3	East Reservoir, Geotechnical Site Study, Seismic Evaluation, & Seismic/Structural Upgrades (incl. tank	--	--	--	Study, R&R	$ 40,000	$80,000	LS	$ 173,000	$ 40,000	$ -	$ -	$ -	$ -	$ -	$ 133,000	$ -	$ -	$ -	$ -	$ -
RRSR-4	Modifications take Escondido Reservoir out of service	--	--	--	Out of Service	$ -	$100,000	LS	$ 166,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 166,000	$ -
RRSR-5	Modifications to take East Reservoir out of service	--	--	--	Out of Service	$ -	$100,000	LS	$ 166,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 166,000	$ -
RRSR-6	Modifications to take Reservoir No. 2 out of service	--	--	--	Out of Service	$ -	$100,000	LS	$ 166,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 166,000	$ -
RRSR-7	Modifications to take La Mesa Reservoir out of service	--	--	--	Out of Service	$ -	$100,000	LS	$ 166,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 166,000	$ -
RRSR-8	Modifications to take La Vista Reservoir out of service	--	--	--	Out of Service	$ -	$100,000	LS	$ 166,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 166,000
RRSR-9	Modifications to take Reservoir No. 1 out of service	--	--	--	Out of Service	$ -	$100,000	LS	$ 166,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 166,000
RRSR-10	Annual Storage Reservoir R&R Program				R&R	$ -	$300,000	$/year	$ 9,000,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 3,000,000	$ 3,000,000
Pressure Reducing Valve		Size	Sive			$ -			$ 1,315,000	$ 201,000	$ 35,000	$ 35,000	$ 134,000	$ 35,000	$ 35,000	$ 35,000	$ 35,000	$ 35,000	$ 35,000	$ 350,000	$ 350,000
RRV-1	Foothill PRV Station Rehabilitation	12" & 12"	12" & 12"	--	R&R	$ -	$100,000	$/station	$ 166,000	$ 166,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
RRV-2	Camino Viejo PRV Rehabilitation[10]	3" & 6"	3" & 6"	--	R&R	$ -	$60,000	$/station	$ 99,000	$ -	$ -	$ -	$ 99,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
RRV-3	Annual PRV Station R&R Program	--	--	--	R&R	$ -	$35,000	$/year	$ 1,050,000	$ 35,000	$ 35,000	$ 35,000	$ 35,000	$ 35,000	$ 35,000	$ 35,000	$ 35,000	$ 35,000	$ 35,000	$ 350,000	$ 350,000
Groundwater						$ -			$ 700,000	$ 200,000	$ 200,000	$ 300,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
RRGW-1	Groundwater Program[10]	--	--	--	R&R	$ -	Varies	$/year	$ 700,000	$ 200,000	$ 200,000	$ 300,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

Table ES.4 - 30-Year Water Distribution CIP Summary

Project ID	Project Name	Existing Size	Proposed Size	Pipeline Length	Project Type	Study/Project Unit Cost ($)	Unit Cost[1] ($)	Unit	Total Cost Estimate[1][2][3][4][5] ($)
Other Projects									$ 47,490,000
System Upgrades						$ -			$ 44,290,000
SU-1	CMMS Upgrade	--	--	--	Upgrade	$ -	$10,000	$/year	$ 790,000
SU-2	Periodic SCADA System Upgrades	--	--	--	Upgrade	$ -	$5,000,000	$/upgrade	$ 15,000,000
SU-3	City-Wide AMI Upgrades	--	--	--	R&R	$ -	Varies	$/year	$ 19,500,000
SU-4	Baseline Metering Program Upgrades	--	--	--	R&R	$ -	$300,000	$/year	$ 9,000,000
Studies									$ 3,200,000
ST-1	Water Distribution Infrastructure Plan Update	--	--	--	Study	$ 250,000	$250,000	$/study	$ 1,250,000
ST-2	Asset Management Program Report Update	--	--	--	Study	$ 200,000	$200,000	$/study	$ 1,200,000
ST-3	SCADA Master Plan Update	--	--	--	Study	$ 250,000	$250,000	$/study	$ 750,000
CIP Total									$ 446,671,000
Annual Cost									N/A

Project ID	CIP Phase: Near Term 2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Mid Term 2031-2040	Long Term 2041-2050
Other Projects	$ 3,800,000	$ 4,310,000	$ 1,010,000	$ 310,000	$ 560,000	$ 310,000	$ 310,000	$ 760,000	$ 310,000	$ 5,310,000	$ 15,250,000	$ 15,250,000
System Upgrades	$ 3,800,000	$ 4,310,000	$ 810,000	$ 310,000	$ 310,000	$ 310,000	$ 310,000	$ 310,000	$ 310,000	$ 5,310,000	$ 14,100,000	$ 14,100,000
SU-1	$ 500,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 100,000	$ 100,000
SU-2	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 5,000,000	$ 5,000,000	$ 5,000,000
SU-3	$ 3,000,000	$ 4,000,000	$ 500,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 6,000,000	$ 6,000,000
SU-4	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 3,000,000	$ 3,000,000
Studies	$ -	$ -	$ 200,000	$ -	$ 250,000	$ -	$ -	$ 450,000	$ -	$ -	$ 1,150,000	$ 1,150,000
ST-1	$ -	$ -	$ -	$ -	$ 250,000	$ -	$ -	$ -	$ -	$ -	$ 500,000	$ 500,000
ST-2	$ -	$ -	$ 200,000	$ -	$ -	$ -	$ -	$ 200,000	$ -	$ -	$ 400,000	$ 400,000
ST-3	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 250,000	$ -	$ -	$ 250,000	$ 250,000
CIP Total	$ 34,164,000	$ 14,891,000	$ 13,928,000	$ 25,059,000	$ 10,797,000	$ 52,795,000	$ 10,680,000	$ 11,163,000	$ 16,141,000	$ 15,547,000	$ 123,554,000	$ 117,952,000
Annual Cost	$ 34,164,000	$ 14,891,000	$ 13,928,000	$ 25,059,000	$ 10,797,000	$ 52,795,000	$ 10,680,000	$ 11,163,000	$ 16,141,000	$ 15,547,000	$ 12,355,000	$ 11,795,000

Notes:

(1) ENR Greater LA Construction Cost Index for March 2020 is 12,403.

(2) Estimated Construction Cost includes a 30% contingency of the direct cost.

(3) Total project costs includes a 27.5% for engineering, legal, admin, permitting, and CM.

(4) Total Mark-Up is 65.8% of the direct costs. No mark-up applied to studies.

(5) Estimated projects were costs developed by another source do not include Mark-Up from this WDIP. However, these costs estimates were scaled using the ENR from this WDIP.

(6) Source: Desalination Conveyance Transmission Main Preliminary design reports.

(7) Existing City project that is expected to be completed before year 2021.

(8) Assumed a 50% percent mark up to the storage reservoir unit cost for the additional appurtenances for a chlorine contact basin.

(9) Vic Trace assumed a higher unit cost because the City is interested in having it replaced with a robust reservoir.

(10) Source: Brown & Caldwell - Water Distribution Section Asset Management Program Risk and Condition Assessment Phase 1 (February 2014).

The distribution of capital costs by project type are shown in Table ES.4 and Figure ES.5. As listed in Table ES.4, the estimated cost for transmission and distribution main R&R projects account for the largest portion of the capital improvement project costs, contributing to $299 million (67 percent) of the $449 million CIP. Capacity improvement projects account for roughly $102 million (23 percent) of the total CIP costs, with transmission and distribution main ($27 million) and storage reservoir ($64 million) accounting for the majority of the capacity improvement costs, while pump station and valve related projects account for the remaining $11 million.

Table ES.4 30-Year Water Distribution System CIP Summary

Improvement Type	CIP Cost Estimate ($, million)	CIP Cost Estimate by Phase ($, Million)		
		Near-Term 2021-2030	Mid-Term 2031-2040	Long-Term 2041-2050
Capacity Improvements	**$99.5**	**$93.1**	**$6.0**	**$0.4**
Transmission & Distribution Main	$27.0	$24.9	$1.7	$0.4
Pump Station	$7.2	$3.2	$4.0	$0.0
Storage Reservoir	$64.2	$64.2	$0.0	$0.0
Valve	$1.2	$0.8	$0.3	$0.0
Rehabilitation and Replacement	**$299.6**	**$95.1**	**$102.3**	**$102.3**
Transmission & Distribution Main	$280.3	$86.3	$96.4	$97.6
Fire Flow	$2.5	$2.5	$0.0	$0.0
Pump Station	$3.6	$1.6	$1.0	$1.0
Storage Reservoir	$11.2	$3.4	$4.5	$3.3
Valve	$1.3	$0.6	$0.4	$0.4
Groundwater	$0.7	$0.7	$0.0	$0.0
Other Projects	**$47.5**	**$17.0**	**$15.3**	**$15.3**
System Upgrades	$44.3	$16.1	$14.1	$14.1
Studies	$3.2	$0.9	$1.2	$1.2
Total CIP	**$446.7**	**$205.2**	**$123.6**	**$118.0**
Average Annual Cost	**$14.9**	**$20.5**	**$12.4**	**$11.8**

Notes:
(1) ENR Greater Los Angeles Construction Cost Index for March 2020 is 12,403.
(2) Estimated Construction Cost includes a 30% contingency of the direct cost.
(3) Total project costs includes a 27.5% for engineering, legal, admin, permitting, and Construction Management.
(4) Total Mark-Up is 65.75% of the direct costs. No mark-up applied to studies.
(5) Estimated projects were costs developed by another source do not include Mark-Up from this WDIP. However, these costs estimates were scaled using the ENR from this WDIP.

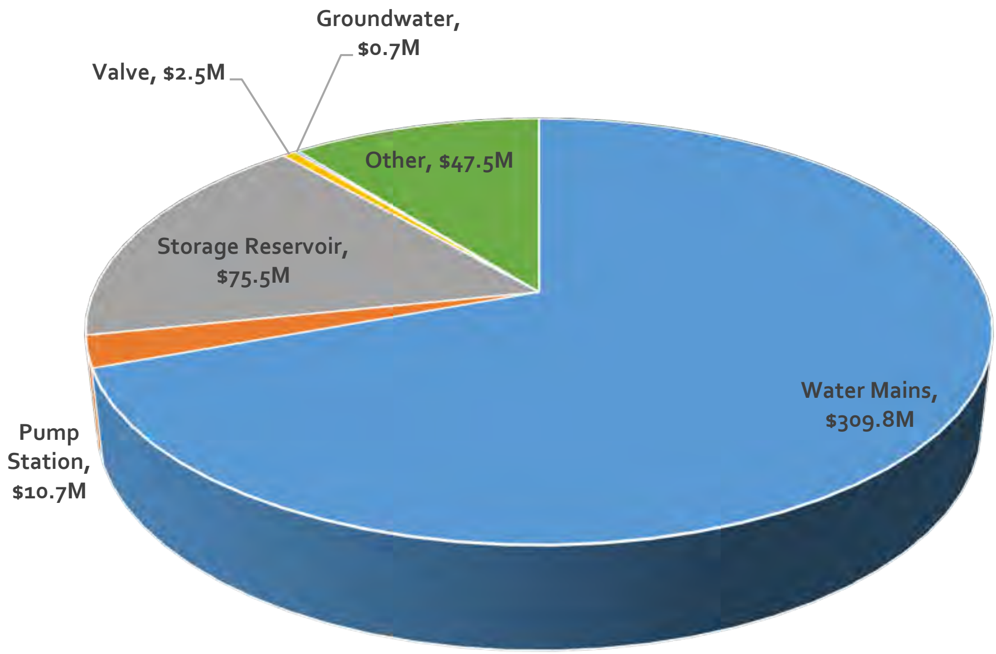

Figure ES.5 30-Year Water Distribution System CIP by Project Type

Appendix ES.A

REFERENCES

1. City of Santa Barbara Hydraulic Model Report, RBF Consulting, Final, May 2002.
2. City of Santa Barbara Hydraulic Model Update and Calibration Report, Carollo Engineers, Inc., Final, June 2014.
3. City of Santa Barbara Preliminary Design Services to Recommission the Charles Meyer Desalination Plant, Carollo Engineers, Inc., Final, November 2014.
4. City of Santa Barbara Water Conservation Strategic Plan, Maddaus Water Management, Inc., Draft, December 10, 2019.
5. City of Santa Barbara Water Distribution Section Asset Management Program Risk and Condition Assessment Phase 1, Brown and Caldwell, Final, February 2014.
6. City of Santa Barbara Urban Water Management Plan, 2015 Updated, Adopted June 2016.

Appendix ES.B
COST ESTIMATING DETAILS

Capital Improvement Plan Cost Developments

This section presents the proposed Capital Improvement Plan City's CIP and a summary of the capital costs. The CIP is based on the evaluation of the City's water distribution system, along with City input, and previous studies.

Project Prioritization

The capital projects identified will allow the City to provide reliable service to its customers through the year 2050. Critical projects were phased in the earlier phases (years) of the 30-year CIP. Less critical projects were phased into later phases of the 30-year CIP.

Capital Improvement Project Costs

The capacity upgrades and other system capital improvements set the foundation of the City's water distribution system CIP. The cost estimates presented in this study are opinions developed from bid tabulations, cost curves, information obtained from previous studies, and Carollo experience on other projects. The costs are based on an Engineering News Record Construction Cost Index (ENR CCI) Greater Los Angeles of 12,403 (March 2020).

Cost Estimating Accuracy

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

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

Construction Unit Costs

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

All of the unit costs presented in this section include pipeline costs, excavation, and other appurtenances (e.g., valves, etc.). Water distribution system pipeline improvements range in size from 8-inches to 36-inches in diameter for this WDIP. Pipeline unit costs for relevant sized upgrades are shown in Table A. The unit costs are for "typical" field conditions with construction in stable soil.

Table ES.A Water Pipeline Unit Construction Costs

Diameter (inches)	Unit Construction Cost(1) ($/foot)
8	$195
10	$240
12	$250
14	$335
16	$335
20	$420
24	$480
30	$505
36	$605

Notes:
(1) ENR Greater Los Angeles Construction Cost Index for March 2020 is 12,403.
(2) For the purpose of this WDIP, lining costs are estimated at 75% of full replacement cost. Site specific conditions need to be considered in more detailed cost estimating.

This WDIP includes tank, pump station, and PRV improvement projects. The costs for these facilities were developed based on the unit costs shown in Table B, Table C, and Table D.

Table ES.B Unit Construction Costs - Reservoir Storage

Storage Size (MG)	Unit Construction Cost(1) ($/gallon)
< 1	$2.75
1 to 3	$2.25
3 to 5	$2.00
5 to 10	$1.75

Notes:
(1) ENR Greater Los Angeles Construction Cost Index for March 2020 is 12,403.

Table ES.C Unit Construction Costs - Pump Stations

Station Size (HP)	Unit Construction Cost(1) ($/HP)
100 HP and smaller	$14,000
100-500 HP	$9,000

Notes:
(1) ENR Greater Los Angeles Construction Cost Index for March 2020 is 12,403.
Abbreviation: HP – horsepower.

Table ES.D Unit Construction Costs - Pressure Reducing Valves

PRV Station's PRV Diameters (inches)	Unit Construction Cost(1) ($/PRV Station)
4" & 6"	$325,00
6" & 10"	$400,000
6", 8", & 12"	$500,000

Notes:
(1) ENR Greater Los Angeles Construction Cost Index for March 2020 is 12,403.

Project Costs and Contingencies

Project cost estimates are calculated based on elements, such as the project location, size, length, and other factors. Allowances for project contingencies consistent with an "Order of Magnitude" estimate are also included in the project costs prepared as part of this study, as outlined in this section. Note that projects developed outside of the WDIP, such as costs from the City's CIP for the Asset Management Program report (B&C, 2014) were assumed based on the project costs included in the appropriate report/source, but were scaled up to the current ENR CCI.

Baseline Construction Cost

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

- Pipelines: Calculated by multiplying the estimated length by the unit cost.
- Storage Tanks: Calculated by multiplying the tank volume by the unit cost.
- Booster Pump Stations: Calculated on a case-by-case basis depending on the type of work that is required.
- PRV Stations: Calculated based on the information presented in Table D.

Estimated Construction Cost

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

Since knowledge about site-specific conditions of each proposed project is limited at the master planning stage, a 30 percent contingency was applied to the Baseline Construction Cost to account for unforeseen events and unknown conditions.

Capital Improvement Cost

Other project construction contingency costs include costs associated with project engineering, construction phase professional services, and project administration. Engineering services associated with new facilities include preliminary investigation and reports, ROW acquisition, foundation explorations, preparation of drawings and specifications during construction, surveying and staking, sampling of testing material, and start-up services. Construction phase professional services cover items such as construction management, engineering services, materials testing, and inspection during construction. Finally, there are project administration costs, which cover items such as legal fees, environmental/California Environmental Quality Act (CEQA) compliance requirements, financing expenses, administrative costs, and interest during construction.

The cost of these items can vary, but for the purpose of this study, it is assumed that the other project contingency costs will equal approximately 27.5 percent of the Estimated Construction Cost.

As shown in the following simple calculation of the Capital Improvement Cost, the total cost of all project construction contingencies (construction, engineering services, construction management, and project administration) is 65.75 percent of the Baseline Construction Cost. Note that contingencies were not applied to land acquisition costs. Calculation of the 65.75 percent is the overall mark-up on the Baseline Construction Cost to arrive at the Capital Improvement Cost. It is not an additional contingency.

Example:

Baseline Construction Cost	**$1,000,000**
Construction Contingency (30%)	$300,000
Estimated Construction Cost	**$1,300,000**
Engineering Cost (10%)	$130,000
Construction Management (10%)	$130,000
Project Administration (7.5%)	$97,500
Capital Improvement Cost	**$1,657,500**

City of Santa Barbara
Water Distribution Infrastructure Plan

Technical Memorandum 1
HYDRAULIC MODEL UPDATE

FINAL | February 2021

City of Santa Barbara
Water Distribution System Infrastructure Plan

Technical Memorandum 1
HYDRAULIC MODEL UPDATE

FINAL | February 2021

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Abbreviations

AFY	acre-feet per year
Carollo	Carollo Engineers, Inc.
City	City of Santa Barbara
EPS	Extended Period Simulation
fps	feet per second
ft	feet
ft/kft	feet per thousand feet
GIS	geographic information system
gpm	gallons per minute
GWTP	Groundwater Treatment Plant
HGL	hydraulic grade line
HP	horsepower
in.	inch or inches
MG	million gallons
mgd	million gallons per day
MNS	MNS Engineers, Inc.
msl	mean sea level
O.O.S.	Out of Service
PRV	pressure reducing valve
psi	pounds per square inch
SCADA	supervisory control and data acquisition
WTP	water treatment plant

Technical Memorandum 1

HYDRAULIC MODEL UPDATE

1.1 Introduction

The City of Santa Barbara (City) is located between the Pacific Ocean and the Santa Ynez Mountains in Santa Barbara County, about 90 miles north of Los Angeles. The City is a coastal community of approximately 93,500 residents, encompassing 21 square miles, with varied topography ranging from steep mountain terrain to flat land near the ocean. The City operates a water distribution system that serves most of the current City limits, except for the City Airport and Coast Village Roads, and some areas outside of the City limits. The City's water distribution system consists of:

- 17 pressure zones
- 12 active storage reservoirs
  - 2 out of service (O.O.S.)
- 14 active pump stations
  - 1 standby, 1 O.O.S.
- 16 active pressure reducing valve (PRV) stations
  - 2 standby/normally closed PRV stations
  - 2 PRV stations O.O.S.
- The Cater Water Treatment Plant (WTP), which is the City's main supply source
- The Ortega Groundwater Treatment Plant (GWTP), which is used as needed to balance supply
- 8 active groundwater wells
  - 5 wells treated at the Ortega GWTP
  - 3 wells discharge directly into the distribution system
  - 1 well (Ortega) offline
- The Charles Meyer Desalination Plant (recently re-activated)

The City's water system hydraulic model was originally constructed in the early 2000s by RBF Consulting, and was most recently updated and calibrated in 2014 by Carollo Engineers, Inc. (Carollo). Since 2014, the City's hydraulic model has been used to conduct several analyses of the City's water system, particularly related to the reactivation of the City's desalination plant.

1.2 Hydraulic Model Update

This section summarizes the process used to update the City's hydraulic computer model of the water distribution system, including a summary of the previous model, modeling software selection, the hydraulic model elements, the model update process, water demand allocation, and the development of a revised diurnal curve.

1.2.1 Existing Model Assessment

In the early stages of this project, Carollo met with City operations staff to review the physical and operational characteristics of the City's major water system facilities such as reservoirs, pump stations, PRVs, and wells. The information obtained from City staff as part of this process was used to confirm that each modeled facility was represented accurately in the hydraulic model, and to revise the hydraulic model as appropriate.

In addition, Carollo obtained the City's most recent geographic information system (GIS) shapefiles of the water distribution system to identify pipelines that have been constructed (added to the system), abandoned, or replaced since the last model update in 2014. Carollo prepared a map comparing the previous modeled water system facilities to the current GIS database, which identified the location of these pipe segments that need to be updated or added to the model. This map was reviewed and edited by City staff.

1.2.2 Elements of the Hydraulic Model

The following provides a brief overview of the various elements of the hydraulic model and the required input parameters associated with each:

- Junctions: Locations where pipe sizes change, where pipelines intersect, or where water demands are applied are represented by junctions in the hydraulic model. Required inputs for junctions include service elevation and water demands.
- Pipes: Water mains are represented as pipes in the hydraulic model. Input parameters for pipes include length, roughness (Hazen Williams C factor), diameter, and whether or not the pipe is a check valve (i.e., does not allow reverse flow).
- Tanks:
  - Cylindrical and Variable Area Tanks: Water tanks are included in the hydraulic model as either cylindrical tanks or variable area tanks, depending on the complexity of the tank geometry. Required input parameters for cylindrical tanks include bottom elevation, maximum level, initial level, and diameter. Required input parameters for variable area tanks include bottom elevation, maximum level, initial level, and a curve that varies the cross sectional area of the tank depending on the tank level (developed as appropriate based on As-built drawings).
  - Fixed Head Reservoirs: For water distribution system modeling, fixed head reservoirs are used to represent a water source with a constant hydraulic grade line (HGL). Typically, fixed head reservoirs are used to represent water sources, such as groundwater or other sources (such as the Cater WTP). In the case of the Cater WTP turnouts, it was modeled as a fixed head reservoir with a flow control valve.
- Pumps: Pumps are included in the hydraulic model as nodes. Input parameters for pumps include pump curves and operational controls.
- Valves: A number of different valves, such as PRVs and float valves, are represented as nodes in the hydraulic model. Required input parameters for valves include diameter, operational controls, and other settings or head loss curves depending on the type of valve.
- Demands: Water demands are applied at specific junctions in the hydraulic model. Up to ten different demands can be assigned at a particular junction.

1.2.3 Model Facility Update/Expansion

Following the model assessment (see Section 1.2.1), it was determined that the most efficient method to update the hydraulic model was to only import pipelines from GIS that were missing from the previous model or were replaced since the previous model update. In addition, pipelines in the previous hydraulic model that have been abandoned were identified, tagged, and deactivated in the hydraulic model. Once the missing/replaced pipeline shapefiles were imported into the hydraulic model and abandoned pipelines were deactivated, the model was reviewed to ensure that each pressure zone was appropriately isolated.

In addition, Carollo sub-contracted with MNS Engineers, Inc. (MNS) to obtain essential elevations for the City's water system facilities, including the following:

- Floor and overflow elevations at 16 reservoirs
- Centerline elevations for
  - 16 potable water booster pump stations
  - Five recycled water pump stations
  - 19 PRV stations
  - Two recycled water PRV stations
  - Seven agency interties

The elevation information provided by MNS was used to update the City's hydraulic model elevations for the major water system facilities (tanks, booster pump stations, PRV stations, etc.). In general, the results of the field survey were similar to the elevations that were included in the City's previous hydraulic model. The most notable difference between the previous hydraulic model and the field survey elevation was at Vic Trace reservoir, which was found to be roughly 20-feet (ft) below the elevations previously used in the City's hydraulic model. Appendix A contains a summary of the field survey results.

Figure 1.1 shows the water system facilities that are included in the City's updated hydraulic model, including the pipeline diameters and alignments, as well as the locations of the City's WTPs, tanks, wells, booster pumps, PRVs, and pressure zones.

1.3 Hydraulic Model Facilities

The following sections summarize the modeled system facilities.

1.3.1 Distribution System

The City's modeled water distribution system consists of about 319 miles of pipelines up to 42 inches (Figure 1.1). Table 1.1 provides a breakdown by diameter of the modeled distribution system, while Figure 1.2 shows the information presented in Table 1.1 graphically. As shown on Figure 1.2, 64 percent of the City's modeled water distribution system consists of 6-inch and 8-inch diameter water mains. Ten percent of the City's modeled system is smaller than 6-inches in diameter. The remaining 27 percent of the system is 10-inches in diameter and larger.

Table 1.1 Modeled Water System Pipeline Summary by Diameter(1)

Diameter	Length (ft)	Length (miles)	Percent of Modeled System
4-inches and Smaller	166,978	31.6	9.9%
6"	488,031	92.4	29.0%
8"	580,892	110.0	34.5%
10"	40,325	7.6	2.4%
12"	248,892	47.1	14.8%
14"	15,582	3.0	0.9%
15"	2,583	0.5	0.2%
16"	35,728	6.8	2.1%
18"	9,291	1.8	0.6%
20"	8,287	1.6	0.5%
22"	8,915	1.7	0.5%
24"	37,688	7.1	2.2%
30"	17,891	3.4	1.1%
36"	23,035	4.4	1.4%
42"	452	0.1	0.0%
Total	**1,684,567**	**319.0**	**100.0%**

Notes:
(1) Source: City of Santa Barbara hydraulic model.

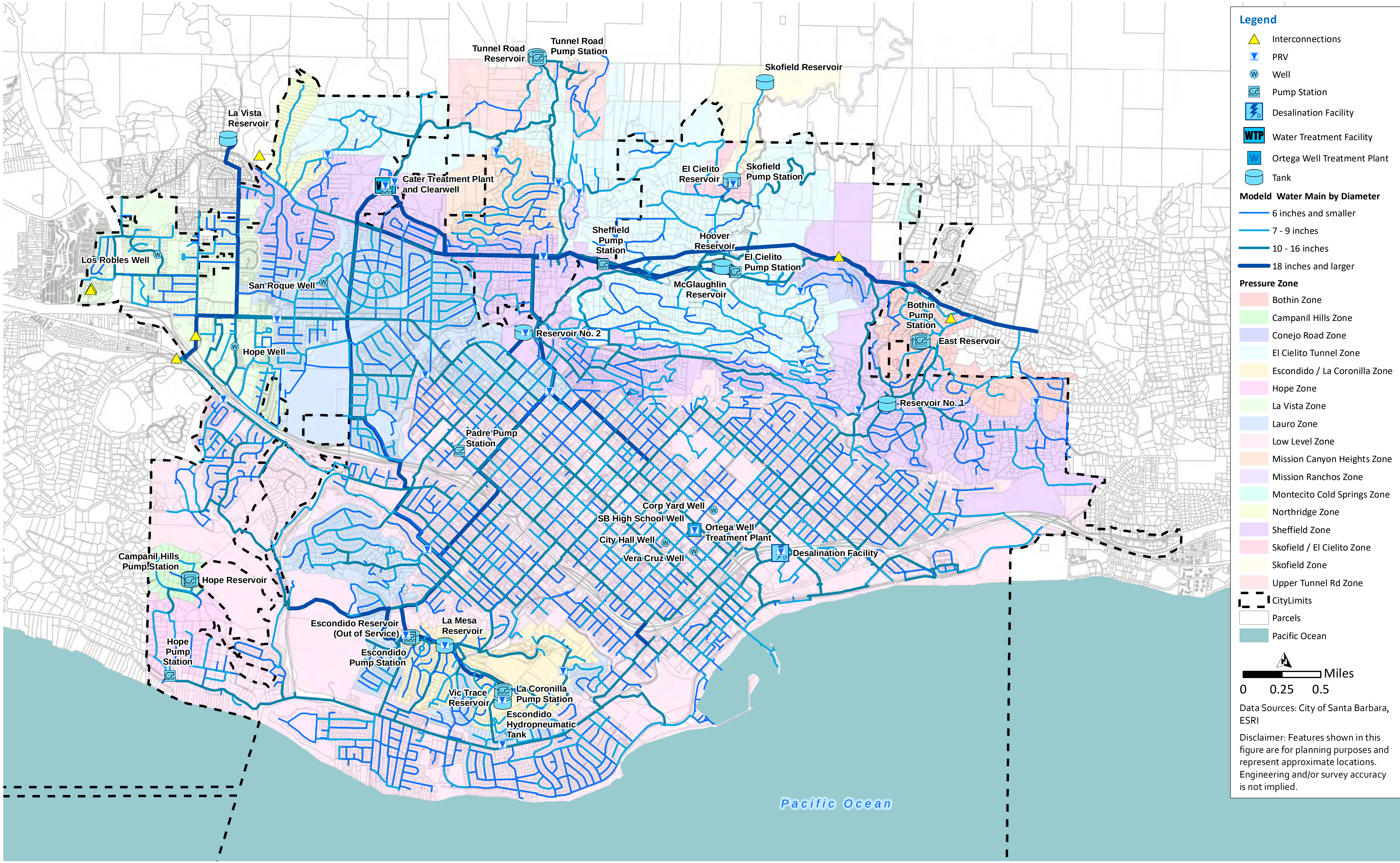


Figure 1.1 Modeled Water Distribution System

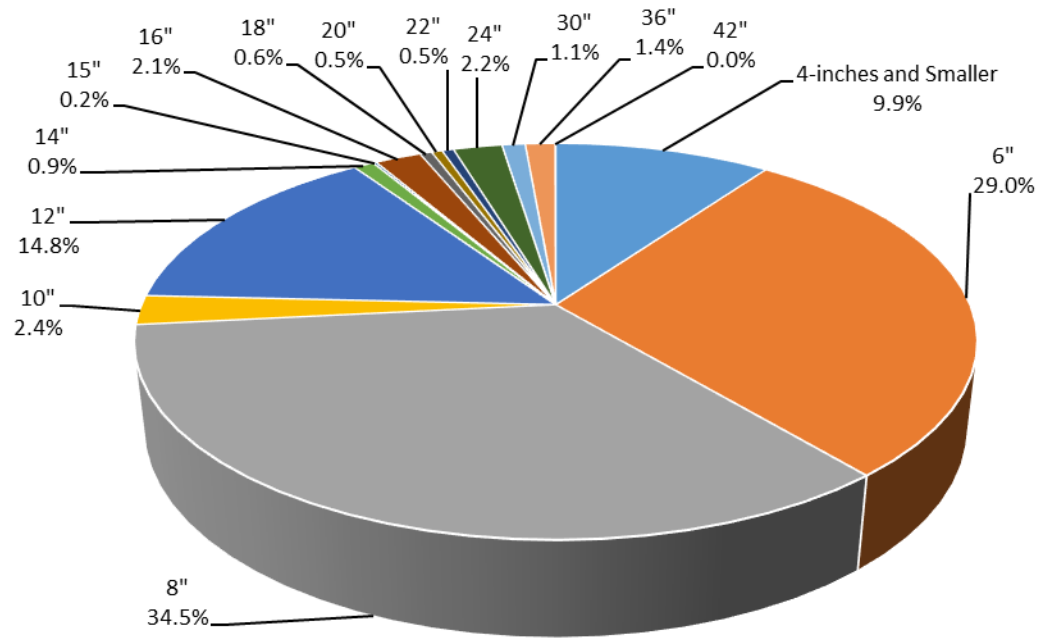


Figure 1.2 Modeled Pipeline Summary by Diameter

Table 1.2 and Figure 1.3 provide a breakdown by material of the modeled distribution system. As shown in Figure 1.3, cast iron, ductile iron, and polyvinyl chloride are the most common materials in the City's water distribution system, accounting for approximately 36-percent, 25-percent, and 25-percent of the system, respectively.

Table 1.2 Modeled Water System Pipeline Summary by Material(1)

Material	Length (ft)	Length (miles)	Percent of Modeled System
Asbestos Cement	47,288	9.0	2.8%
Cast Iron	598,889	113.4	35.6%
Copper	26,860	5.1	1.6%
Ductile Iron	422,053	79.9	25.1%
Galvanized Iron	5,926	1.1	0.4%
High Density Polyethylene	2,960	0.6	0.2%
Polyvinyl Chloride	418,020	79.2	24.8%
Steel	136,971	25.9	8.1%
Other	2,629	0.5	0.2%
Unknown	22,971	4.4	1.4%
Total	**1,684,567**	**319.0**	**100.0%**

Notes:
(1) Source: City of Santa Barbara hydraulic model.

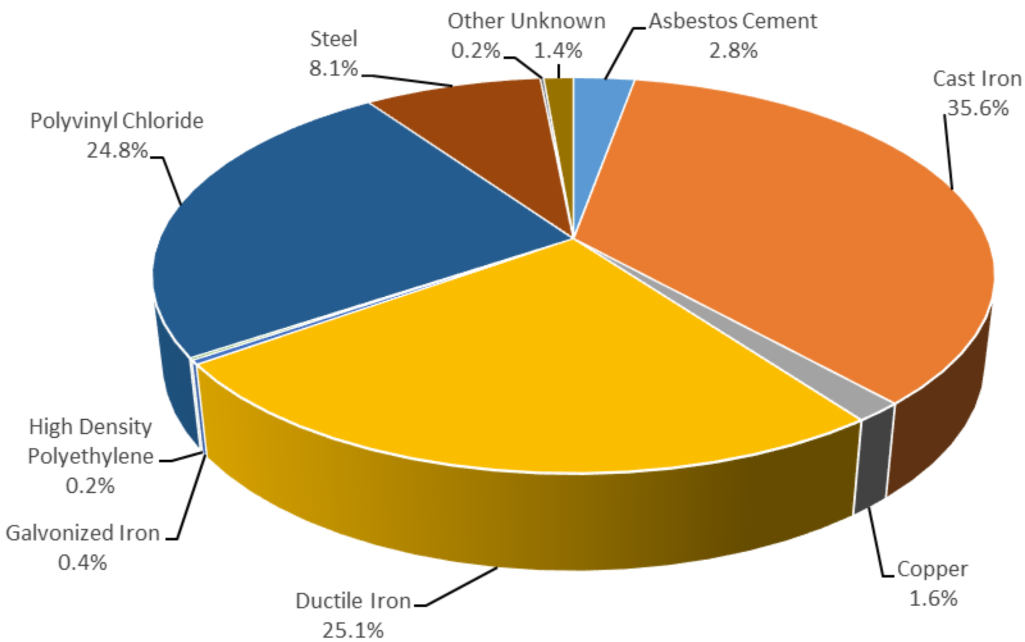


Figure 1.3 Modeled Pipeline Summary by Material

1.3.1.1 Hazen-Williams Roughness Coefficient

The Hazen-Williams roughness coefficient is a friction coefficient that is commonly used in water systems to represent the smoothness of pipe walls. Hazen-Williams roughness coefficients generally range from a low of 50 for badly corroded pipes to 150 for new smooth pipe (such as plastic). Hazen-Williams roughness coefficients vary by age, material, and pipe condition. Table 1.3 summarizes typical planning level assumptions for the Hazen-Williams roughness coefficient.

Table 1.3 Typical Hazen-Williams Roughness Coefficients(1)

Material	Pipe Age (Years)					
	<10	11-20	21-30	31-40	41-50	>50
Asbestos Cement	140	130	125	120	115	110
Cast Iron	130	120	110	100	90	80
Copper	150	140	135	130	125	120
Ductile Iron	130	120	110	100	90	80
Galvanized Pipe	130	125	120	115	110	105
Polyethylene	150	145	140	135	130	130
Polyvinyl Chloride	150	145	140	135	130	130
Steel	120	115	110	105	100	95
Other	130	130	130	130	130	130
Unknown	130	130	130	130	130	130

Notes:
(1) Values are typical of water distribution systems. These values were used to assign initial roughness coefficients into the hydraulic model, and were refined during model calibration based on fire flow field test data.

1.3.2 Water Supply

The City's water is supplied from two reservoirs formed by dams on the Santa Ynez River, by groundwater within the Santa Barbara groundwater basins, and by the recently re-activated desalination plant. Supplies from Lake Cachuma and Gibraltar Reservoir are transmitted to the coastal side of the Santa Ynez Mountains via tunnels. Infiltration into the City's Mission Tunnel also contributes to the supply. Both of the reservoir supplies require treatment.

From Lake Cachuma, water is conveyed through the Tecolote Tunnel into the South Coast Conduit and past the turnout to the Goleta Water District to Lauro Reservoir, which serves as a balancing reservoir to the South Coast Conduit. Lauro Reservoir is adjacent to the Cater WTP. The Cater WTP is the City's main supply source. This facility is represented in the model by a fixed head reservoir with a flow control valve.

Water can also be supplied from eight groundwater wells. Four groundwater wells (Alameda, Hope, Los Robles, and San Roque) discharge directly into the distribution system. The remaining four groundwater wells (High School, Corp Yard, Vera Cruz, and City Hall) are conveyed to the Ortega GWTP for treatment prior to being discharged into the Low Level zone. The City's wells are used seasonally in the summertime. Table 1.4 summarizes the City's groundwater wells.

The City's desalination plant treats seawater and discharges the treated water directly into the Low Level zone, however, the City is currently considering the construction of a dedicated transmission main to convey water from the Desalination Plant to the Cater Clearwell, where it can be distributed throughout the City's distribution system.

Table 1.4 Groundwater Well Summary

Name	Pressure Zone	Well Parameters	
		Ground Elevation (ft)	Pumping Capacity (gpm)
Hope	La Vista	172	250
Los Robles	La Vista	187	70
San Roque	Lauro	270	390
Ortega GWTP(1)	Low Level	17	3 at 1,160 gpm
Alameda(1)	Low Level	136	380
Corp Yard(1)	Low Level	16	700
Vera Cruz(1)	Low Level	24	400
City Hall(1)	Low Level	37	400
High School(1)	Low Level	68	208

Notes:
Abbreviation: gpm - gallons per minute.
(1) Ortega GWTP output varies depending on the number of wells in operation. For modeling purposes, only the Ortega GWTP discharge is included in the model.

1.3.3 Storage Reservoirs

Water distribution systems rely on stored water to help equalize daily fluctuations between supply and demand, to supply sufficient water for firefighting, and to meet demands during an emergency or an unplanned outage of a major source of supply.

The locations of the City's existing reservoirs are shown on Figure 1.1, while detailed information for each of the reservoirs is summarized in Table 1.5. The City's hydraulic model includes 13 storage reservoirs with total volumes ranging from 0.58 million gallons (MG) to 10.0 MG. Some of the City's reservoirs include unusable (or "dead" volume) at either the top or bottom of the reservoir. The City's usable volume for the City's reservoirs ranges from 0.47 MG to 10.0 MG, as shown in Table 1.5.

Table 1.5 Storage Reservoir Summary(1)

Name	Pressure Zone Served		Tank Geometry				
	Name	Zone HGL (ft)	Tank Shape	Bottom Elevation (ft)	Top Elevation (ft)	Total Volume (MG)	Useable Volume (MG)
Cater Clearwell	Lauro	492	Square	478.98	494.19	5.00	1.70
East	Bothin via P.S.	780	Cylindrical	571.04	602.61	1.00	0.58
El Cielito	El Cielito Tunnel	1,058	Cylindrical	1,046.20	1,061.70	1.10	0.98
Hoover	Sheffield	661	Cylindrical	635.03	668.07	6.50	5.34
Hope	Hope	613	Rectangular	599.09	615.64	0.86	0.72
La Mesa (Typically O.O.S.)	Low Level	356	Cylindrical	343.34	363.45	1.50	1.50
La Vista	La Vista	440	Square	428.45	445.12	2.30	2.25
McLaughlin	Sheffield	661	Cylindrical	635.03	668.09	6.50	5.34
Res. 1	Low Level	356	Ellipse	339.59	354.71	1.08	0.75
Res. 2	Low Level	356	Oval	339.72	358.80	1.68	1.58
Skofield	Skofield	1,396	Cylindrical	1,390.96	1,415.50	0.58	0.47
Tunnel	El Cielito Tunnel	1,058	Cylindrical	1,028.89	1,061.02	1.06	0.76
Vic Trace	Low Level via P.R.V.	356	Rectangular	444.11	464.10	10.0	10.0

Notes:
(1) Values are typical of water distribution systems. These values were used to assign initial roughness coefficients into the hydraulic model, and were refined during model calibration based on fire flow field test data.

1.3.4 Booster Pump Stations

The City has 14 booster pump stations that deliver water from lower pressure zones to upper pressure zones of the distribution system. The hydraulic characteristics for each pump are summarized in Table 1.6, and the location of each pump station is provided on Figure 1.1.

Typically, pump stations consist of multiple pump units, including one spare pump to provide reliability in case of a breakdown or repair. In addition, critical booster pumping stations may be equipped with emergency power supplies in case of failure of the primary power source.

Model controls listed in Table 1.6 reflect the current operating conditions during the model calibration period. Pump stations serving smaller pressure zones without storage will typically have a hydropneumatic tank to help regulate pressures. Table 1.6 lists the pump stations that have a hydropneumatic tank.

Table 1.6 Pump Station Summary

Name	From Zone		To Zone		Pump Information					Model Controls			Notes
	Name	Zone HGL (ft)	Name	Zone HGL (ft)	Pump No.	Survey Elevation (ft)	Power (HP)	Design Head (ft)	Design Capacity (gpm)	On	Off	Control Facility	
Bothin	East Res.	603	Bothin	780	1	572.59	40	141	840	70 psi	82 psi	Hydro. Tank	
					2	572.6	40	141	840	65 psi	82 psi		
					3	572.66	40	141	840	60 psi	82 psi		
Calle Las Calleras (Hope)	Low Level	356	Hope	613	1	167.73	60	390	500	5.0'	6.0'	Hope Res.	
					2	167.66	60	390	500	4.0'	6.0'		
Campanil Hill	Hope	613	Champanil Hills	740	1	601.61	15	166	450	45 psi	73 psi	Hydro. Tank	
					2	601.55	15	166	450	40 psi	73 psi		
					3	601.51	30	166	825	35 psi	73 psi		
Cater-Cross	Cater Clear Well	499	El Cielito Tunnel	1,058	1	490.83	300	600	1,325	15.5'	18.0'	Tunnel Res.	
					2	490.83	300	600	1,325	14.0'	18.0'		
					3	490.8	300	600	1,325	12.0'	18.0'		
El Cielito	Sheffield	661	El Cielito Tunnel	1,058	1	638.82	170	508	1,100	4.0'	8.0'	El Cielito Res.	
					2	638.87	170	508	1,100	5.0'	8.0'		
					3	638.92	170	508	1,100	6.0'	8.0'		
Escondido	Lauro	492	Escondido La Coronilla	640	1	365.92	50	163	975	90 psi	110 psi	Hydro. Tank	
					2	65.98	50	163	975	85 psi	110 psi		
					3	395.92	50	163	975	80 psi	110 psi		
La Coronilla	Lauro	492	Escondido La Coronilla	640	1	421.01	25	133	645	50 psi	60 psi	Pressure Switch	Normally offline, used as a backup for La Escondido or for fire flow.
Northridge (O.O.S.)	Sheffield	661	Northridge	750	1	493.09	25	90	100	--	--	--	O.O.S.
					2	492.11	40	90	100	--	--	--	
Padre	Low Level	356	Lauro	492	1	131.47		171	500	7.0'	5.0'	Res. 1	
					2	131.47		171	500	--	--	--	
Rocky Nook (Standby)	Sheffield	661	El Cielito Tunnel	1,058	1	442.95	60	450	400	--	--	--	Normally offline, used as a backup for Cater-Cross or for fire flow.
					2	442.93	60	450	400	--	--	--	
					3	442.96	60	450	400	--	--	--	
Tunnel Road	El Cielito Tunnel	1,058	Upper Tunnel Road	1,206	1	1,026.32	15	236	190	75 psi	105 psi	Hydro. Tank	
					2	1,026.34	15	236	190	70 psi	105 psi		
					3 (Fire)	1,026.57	50	205	550	65 psi	105 psi		
Sheffield	Lauro	492	Sheffield	661	1	440.64	125	231	1,000	Manually Operated			A maximum of two pump run at once.
					2	440.62	125	231	1,000				
					3	440.64	125	231	1,000				
					4	440.64	125	231	1,000				
Skofield Inside	El Cielito Tunnel	1,058	Skofield	1,396	1	1,037.30	40	370	210	7.0'	12.0'	Skofield Res.	Primary Pumps
					2	1,037.31	40	370	300	6.5'	12.0'		
Skofield Outside	El Cielito Tunnel	1,058	Skofield	1,396	1	1,039.97	50	370		--	--	El Cielito Res.	Used as backup pumps for Skofield Inside
					2	1,039.99	50	370		--	--		
South Coast Conduit	Cater Clear Well	499	Sheffield PS		1	491.95	300	70	12,000	Manually Operated			
					2	491.94	300	70	12,000				
					3	491.95	100	36	7,000				
					4	492.11	100	36	7,000				

1.3.5 Pressure Reducing Stations

PRV stations allow distribution systems to transfer water from upper pressure zones to lower pressure zones without exceeding the allowable pressures in the lower zones or completely draining the pressure out of the higher zone. The water is transferred through a valve that reduces the pressure to a specified pressure setting.

The City's distribution system includes 20 PRVs, which convey and regulate water. Several of these PRV stations function in a standby, or backup role. The locations of these PRVs are shown on Figure 1.1, while detailed information for the PRV at each station is summarized in Table 1.7.

1.3.6 Pressure Zones

The topography of the City is varied, and consists of steep mountainous terrain and a relatively flat lowland area. The ground elevations within the service area range from 7-ft above mean sea level (msl) to 1,420-ft. In order to provide acceptable operating pressures throughout the system, the City has been separated into 17 pressure zones. Table 1.8 documents the HGL of each pressure zone within the distribution system, which range from 356 ft to 1,396 ft above msl. As shown in Table 1.8, the two largest zones are the Low Level Zone at 4.69 million gallons per day (mgd) (53 percent of the total 2019 demand) and the Lauro Zone at 1.26 mgd (14 percent of the total 2019 demand).

1.4 Water Demands

The City provided historical and projected demand estimates that were used as part of this project. Figure 1.4 shows the historic and projected annual water usage. As shown on Figure 1.4, the City's water use has varied significantly in the past 35 years. Since 1984, the City's use has dropped from a high of over 16,000 acre-feet per year (AFY) to the current water demand of 10,002 AFY). The year 2050 annual demand is projected to increase to 13,013 AFY.

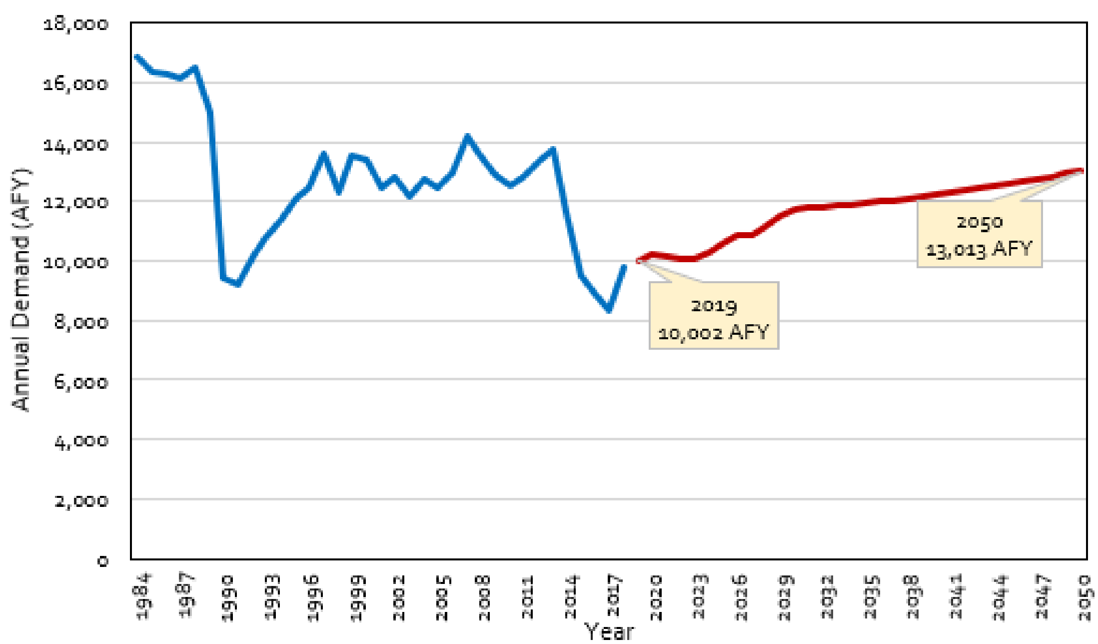


Figure 1.4 Historical and Projected Demands

Table 1.7 PRV Station Summary

Name	From Zone		To Zone		PRV Information		
	Name	HGL (ft)	Name	HGL (ft)	Diameter (in.)	Ground Elevation (ft)	Setting (psi)
Alamar	Lauro	492	Low Level	356	6 2	180.6 181.56	53 58
Calle De Los Amigos	La Vista	440	Low Level	356	6	152.14	62
Barker Pass (Standby, Intertie)	MWD		Bothin	780			
Camino Viejo	Bothin	780	Sheffield	661	3 (OOS) 6	-- 344.44	-- 110
Conejo Road	El Cielito Tunnel	1,058	Conejo	729	2 6	584.18 584.42	38 33
Foothill Road (Normally Closed)	Sheffield	661	Lauro	492	12 12	420.84 420.83	23 23
Garden Street	Lauro	492	Low Level	356	4 12	225.96 224.26	41 36
Las Alturas	El Cielito Tunnel	1,058	Sheffield	661	3 6	516.61 515.08	45 40
La Vista Del Oceano	Lauro	492	Low Level	356	4 8	199.59 199.59	63 58
Las Canoas	El Cielito Tunnel	1,058	Mission Ranchos	737	2 4	613.10 611.46	62 57
Miramonte	Escondido La Coronilia	640	Lauro	492	2 6	344.69 344.26	52 47
Northridge (Replaced PS)	El Cielito Tunnel	1,058	Northridge	750	3 6	509.98 508.92	180 175
Ontare Road	El Cielito Tunnel	1,058	Sheffield	661	3 6	509.98 508.91	67 62
Palomino	El Cielito Tunnel	1,058	Mission Canyon Heights	976	3 6	742.87 742.69	60 55
Tunnel Road & Montrose	El Cielito Tunnel	1,058	Mission Canyon Heights	976	4 8 4 (blowoff)	655.08 655.27 --	110 105 120
Robbins St. & Pedregosa	Lauro	492	Low Level	356	3 8	97.18 95.42	92 87
Skofield	Skofield	1,396	Skofield El Cielito	1,058	2 6	1,028.98 1,029.17	62 57
State Street (bypass)	Lauro	492	La Vista	440	--	204.72	--
Sycamore (O.O.S.)	Sheffield	661	Low Level	356	3 8	93.23 91.89	11 108
San Roque	El Cielito Tunnel	1,058	Sheffield	661	8 3	490.29 490.38	7 --

Table 1.8 Pressure Zones

Pressure Zone	Nominal Hydraulic Grade Line (ft)	Existing (2019) Average Day Demand (mgd)(1)	2050 Average Day Demand (mgd)(1)
Bothin	780	0.13	0.17
Campanil Hills	740	0.03	0.04
Conejo Road	729	0.01	0.02
El Cielito/Tunnel	1,058	0.45	0.58
Escondido/La Coronilla	640	0.19	0.24
Hope	613	0.06	0.07
La Vista	440	1.07	1.40
Lauro	492	1.26	1.63
Low Level	356	4.69	6.10
Mission Canyon Heights	976	0.11	0.15
Mission Ranchos	737	0.01	0.02
Northridge	750	0.04	0.05
Sheffield	661	0.84	1.09
Skofield	1,396	0.01	0.01
Skofield/El Cielito	1,083	0.00	0.01
Upper Tunnel Road	1,206	0.03	0.04
Total	**-**	**8.93**	**11.62**

Notes:
(1) Citywide existing (2019) and 2050 annual demands were provided by City staff. The 2019 and 2050 annual demands include water loss and are estimated to be 10,002 AFY and 13,013 AFY, respectively. The distribution of demands by pressure zone was determined based on existing water consumption records, geocoded by address. Future demands are assumed to be distributed similarly to the existing demand distribution.

1.4.1 Diurnal Pattern Update

As a part of the calibration process, the City provided hourly supervisory control and data acquisition (SCADA) for all system supplies (i.e., Cater WTP) and reservoirs. This data was used to establish a daily diurnal demand pattern by balancing the total inflow into the water distribution system and the change in storage. Figure 1.5 presents the resulting hourly demand factors, which is based on the April 12, 2019 water demands. As shown in this figure, the City's water demand peaks at around 7:00 a.m. with an hourly peaking factor of 1.68. This peaking factor and diurnal pattern was applied for the model calibration.

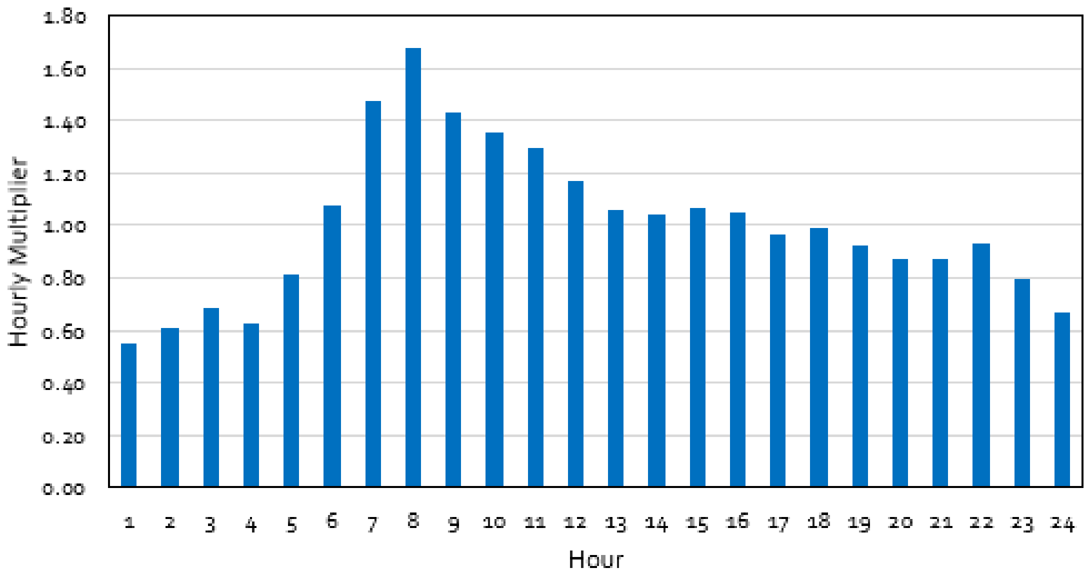


Figure 1.5 Diurnal Pattern

1.5 Hydraulic Model Calibration

This section summarizes overall methodology employed to calibrate the City's water system hydraulic model, and provides a detailed description of each of the major components of the model calibration process.

1.5.1 Model Calibration Data Collection

To coordinate the data requirements for model calibration and field testing, a model calibration plan was prepared, which described what SCADA and field data needs were required to calibrate the updated hydraulic model. The calibration plan included site maps for specific fire flow test locations, pressure logger locations, and included a list of the SCADA data needs, durations, time intervals, and units. This section summarizes the data collection process that was conducted per the calibration plan.

1.5.1.1 SCADA Data Gathering

Field testing and data gathering for model calibration took place from March 24, 2019 through April 16, 2019. Carollo coordinated with City staff to obtain 15-minute data for all of the major SCADA points within the water distribution system, including reservoir levels, booster pump station flows, suction pressures, and discharge pressures, as well as PRV flows and pressures, where available. None of the City's groundwater wells were online during model calibration. This does not impact model calibration, however, these facilities are assumed to be operational in the maximum day demand scenario in the hydraulic model. The groundwater wells are typically operated during the summer months. The location of the major facilities in the system where SCADA data were available are shown on Figure 1.6. This data was primarily used to generate the system-wide diurnal pattern and for the Extended Period Simulation (EPS) model calibration. Table 1.9 identifies the SCADA data sources that were provided by the City.

Table 1.9 EPS Calibration Data Gathering Parameters

Facility Name	Measurement	Unit	Interval	Source
Reservoirs				
Skofield	level	ft	15 min	SCADA
El Cielito	level	ft	15 min	SCADA
Tunnel Road	level	ft	15 min	SCADA
Hoover	level	ft	15 min	SCADA
McLaughlin	level	ft	15 min	SCADA
Hope	level	ft	15 min	SCADA
East	level	ft	15 min	SCADA
Vic Trace	level influent pressure effluent flow	ft psi gpm	15 min 15 min 15 min	SCADA SCADA SCADA
La Vista	level influent upstream pressure influent downstream pressure	ft psi psi	15 min 15 min 15 min	SCADA SCADA SCADA
La Mesa	level influent pressure effluent flow	ft psi gpm	15 min 15 min 15 min	SCADA SCADA SCADA
Reservoir 1	level influent psi	ft psi	15 min 15 min	SCADA SCADA
Reservoir 2	level flow	ft gpm	15 min 15 min	SCADA SCADA
PRV Stations				
Current PRV settings, all stations	pressure setting	psi	as adjusted	N/A
PRVs (as available)	upstream pressure downstream pressure flow	psi psi gpm	15 min 15 min 15 min	SCADA SCADA SCADA
3 PRV Stations – Location TBD	flow	gpm		Flow Meters

Table 1.9 EPS Calibration Data Gathering Parameters (continued)

Facility Name	Measurement	Unit	Interval	Source
Booster Stations				
Calle Las Caleras (Hope)	flow suction pressure discharge pressure	gpm psi psi	15 min 15 min 15 min	SCADA SCADA SCADA
Tunnel Road	flow suction pressure discharge pressure	gpm psi psi	15 min 15 min 15 min	SCADA SCADA SCADA
La Coronilla	flow suction pressure discharge pressure	gpm psi psi	15 min 15 min 15 min	SCADA SCADA SCADA
Bothin	flow suction pressure discharge pressure	gpm psi psi	15 min 15 min 15 min	SCADA SCADA SCADA
Skofield	flow suction pressure discharge pressure	gpm psi psi	15 min 15 min 15 min	SCADA SCADA SCADA
Campanil Hill	flow suction pressure discharge pressure	gpm psi psi	15 min 15 min 15 min	SCADA SCADA SCADA
Rocky Nook (if used)	flow suction pressure discharge pressure	gpm psi psi	15 min 15 min 15 min	SCADA SCADA SCADA
El Cielito	flow suction pressure discharge pressure	gpm psi psi	15 min 15 min 15 min	SCADA SCADA SCADA
Escondido	flow suction pressure discharge pressure	gpm psi psi	15 min 15 min 15 min	SCADA SCADA SCADA
Sheffield	flow suction pressure discharge pressure	gpm psi psi	15 min 15 min 15 min	SCADA SCADA SCADA
Cater-Cross	Flow PRV flow PRV psi	gpm gpm psi	15 min 15 min 15 min	SCADA SCADA SCADA
Pressure Loggers				
43 (FH-K09-010)	pressure	psi	15 min	PL
44 (FH-F11-022)	pressure	psi	15 min	PL
30 (FH-E07-024)	pressure	psi	15 min	PL
32 (FH-D12-037)	pressure	psi	15 min	PL
45 (FH-D05-012)	pressure	psi	15 min	PL
33 (FH-G05-003)	pressure	psi	15 min	PL

Table 1.9 EPS Calibration Data Gathering Parameters (continued)

Facility Name	Measurement	Unit	Interval	Source
Pressure Loggers (continued)				
35 (FH-A09-005)	pressure	psi	15 min	PL
36 (FH-D11-023)	pressure	psi	15 min	PL
37 (FH-C03-004)	pressure	psi	15 min	PL
38 (FH-B04-020)	pressure	psi	15 min	PL
39 (FH-F02-008)	pressure	psi	15 min	PL
40 (FH-F03-013)	pressure	psi	15 min	PL
41 (FH-H03-007)	pressure	psi	15 min	PL
42 (FH-K05-008)	pressure	psi	15 min	PL
46 (FH-C02-001)	pressure	psi	15 min	PL
47 (FH-J04-001)	pressure	psi	15 min	PL
System Inflows/Outflows				
Cater WTP	flow	gpm	15 min	SCADA
South Coast Conduit	flow	gpm	15 min	SCADA
Desalination Plant	flow	gpm	15 min	SCADA

Notes:
Abbreviation: TBD – to be determined.

1.5.1.2 Temporary Pressure Logger Installation

In addition to the data obtained from the City's SCADA system from the major system facilities, Carollo also provided 16 temporary pressure loggers to City staff that were attached to hydrants within the City's distribution system. The data obtained from the temporary pressure loggers consisted of pressure data for the duration of the EPS data gathering period. Figure 1.6 shows the hydrant locations where the temporary pressure loggers were installed.

Due to technical and/or insufficient battery life issues, six of the 16 loggers did not record pressures during the EPS data collection period. However, there were enough pressure loggers installed and SCADA data points available throughout the distribution system that this did not significantly impact the overall quality of the model calibration.

1.5.1.3 Fire Flow Field Testing

Carollo selected 24 fire flow testing sites, which are also shown on Figure 1.6. Fire flow tests were conducted on April 8, 2019 through April 10, 2019 at each of the 24 selected sites. Each of these tests consisted of a fire flow test using one or two flowing hydrants and two pressure hydrants, and were performed by City staff and observed by Carollo. The testing sites are distributed across the City and were selected based on location, accessibility, and representation of the various portions of the City's distribution system. Each of the testing sites are shown in detail on an individual detail map (Appendix A).

The test sites were selected such that they create a good geographical coverage of the City's entire distribution system and pressure zones. All tests involve smaller diameter pipelines and are located away from major transmission lines to increase the chance that a substantial pressure drop (generally greater than 10 pounds per square inch (psi) is observed during the tests. Additionally, the test sites were selected as to provide as little traffic impact as possible.

1.5.2 Model Calibration Methodology and Results

The purpose of a water system hydraulic model is to estimate, or predict, how the water distribution system will respond under a given set of conditions. One way to test the accuracy of the hydraulic model is to create a set of known conditions in the water system and then compare the results observed in the field against the results of the hydraulic model simulation using the same conditions. Flow tests conducted in the field on the water system can yield a profound tool in verifying data used in the hydraulic model and a greater understanding of how the water system operates.

Field testing can indicate errors in the data used to develop the hydraulic model, or show that a condition might exist in the field not otherwise known. Valves, which are reported as being open, might actually be closed (or vice versa), an obstruction could exist in a pipeline, or pressure settings for a PRV may be slightly different than noted. Field testing can also correct erroneous model data such as incorrect pipe diameters or connections. Aside from a few specific cases noted in the following subsections, no discrepancies were encountered during model calibration that hadn't already been addressed during the model update process. Data obtained from the field tests can be used to determine appropriate roughness coefficients for each pipeline, as roughness coefficient can vary with age and pipe material. Other parameters can also be adjusted to generate a calibrated model.

The calibration process for the City's water distribution system hydraulic model consisted of three parts, a macro calibration, a fire flow test calibration, and EPS calibration. In addition, a model validation process was performed after the model was successfully calibrated to ensure that the parameters built into the hydraulic model produce valid results for a second EPS model validation day.

1.5.2.1 Macro Calibration

Initially, the model was run under existing demand conditions and necessary adjustments were made to produce reasonable system pressures. Such adjustments include modifications of pipeline connectivity, operational controls, ground elevations, and facility characteristics.

The macro calibration process involves several steps to ensure that the model produces reasonable results:

- Transmission Main Connectivity. Using the connectivity features of the modeling software, the connectivity of the transmission mains within the distribution system was verified. Problems found using the connectivity locators were reviewed to determine whether adjustments were needed to the connectivity of the model. Output reports of pipe flow characteristics, such as head loss (feet per thousand feet [ft/kft]) and velocity (feet per second [fps]) were also used to locate problem areas where additional adjustments may be necessary.

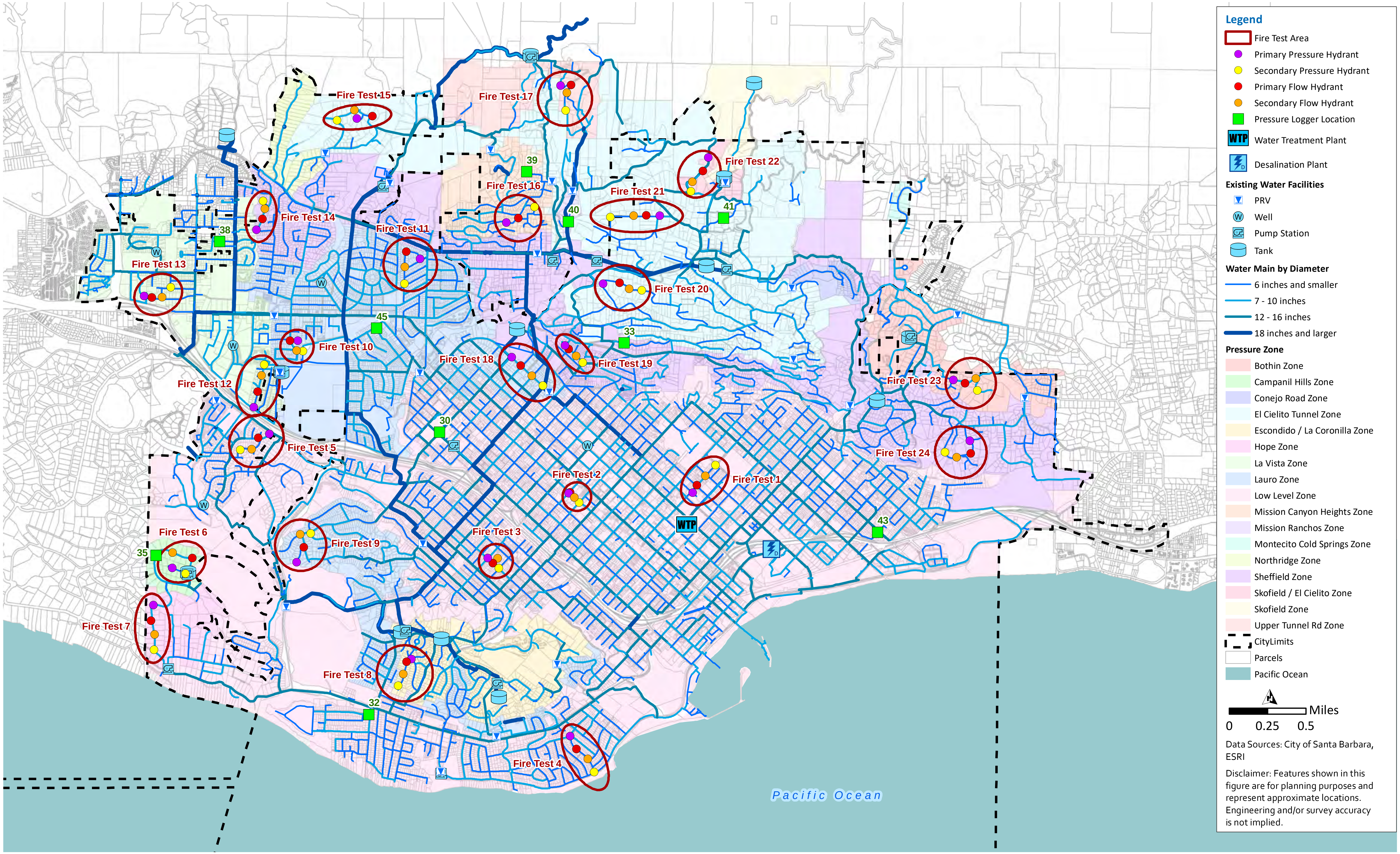


Figure 1.6 Overview of Fire Test and Pressure Logger Locations

- System Pressures. The macro calibration compared the model output to the typical pressures observed within the distribution system in psi. This process was used to locate major errors in model creation, elevations, or connectivity, as well as changes that reflect how operational controls of the system should be implemented in the model.
- Facility Characteristics. Hydraulic model results were compared to data provided by the City to verify that facility attributes entered into the model, such as the physical characteristics of the tanks and pumps, produced results comparable to what the City experiences.

1.5.2.2 Extended Period Simulation Calibration

The extended period calibration is intended to calibrate the EPS capabilities of the hydraulic model by closely matching the model pressures and flows to field conditions over a 24-hour period of similar demand and system boundary conditions. Pressure data and flows from meter connections were recorded to create diurnal patterns and obtain EPS calibration data. The primary varied parameters for this calibration were operational controls and pipeline roughness coefficients, although other parameters were also adjusted as calibration results were generated.

From the calibration period, Friday, April 12, 2019, was selected to be used for the 24-hour EPS calibration day. Friday was chosen because of the relatively high flows experienced and because there were no unusual flow spikes or dips in the system-wide diurnal for this day.

The estimated daily demand for this day was about 6,065 gpm (or 8.73 mgd). This equates to 98 percent of the 8.93 mgd average annual demand in 2019. For the EPS calibration, the 2019 ADD was scaled down by a factor of 0.98 to match this estimated demand condition during the calibration day.

The EPS calibration compared model simulated booster pump station flows, suction, and discharge pressures, reservoir levels, and PRV upstream and downstream pressures to the field measured data. In addition, model simulated pressures at the pressure recorder locations were compared to the actual field pressures recorded during the calibration day.

A comparison of model results to observed field conditions for the East Reservoir level and the Sheffield Pump Station flow is shown on Figure 1.7 and Figure 1.8, respectively. Similar model results for the remaining facilities are presented in Appendix B. Overall, the trends seen in the field data are well predicted by the model, with some minor differences. The level of accuracy shown on the EPS calibration results presented in Appendix B is appropriate for the City's intended use for its hydraulic model (i.e., to support the development of capital improvements for this Water Distribution Infrastructure Plan, and to support future operational "what-if" analyses, and to support future design efforts related to the water distribution system).

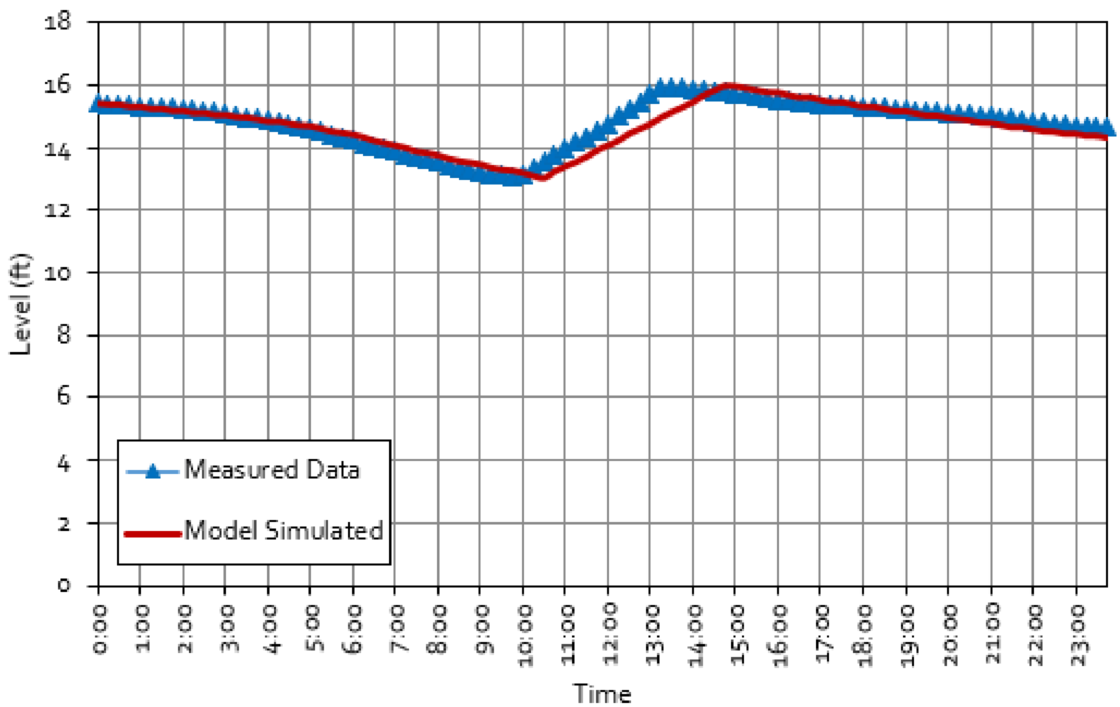


Figure 1.7 EPS Calibration Results, East Reservoir Level

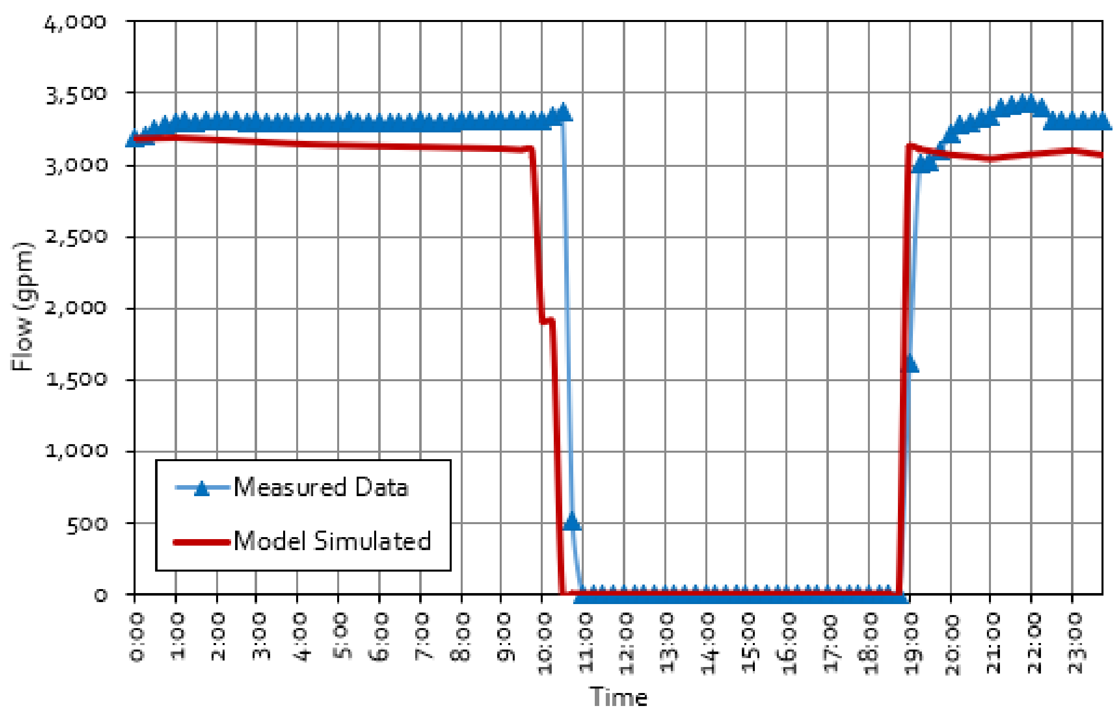


Figure 1.8 EPS Calibration Results, Sheffield Pump Station Flow

1.5.2.3 Fire Flow Test (Steady State) Calibration

The calibration of fire flow tests is intended to closely match model simulated pressures to field pressures under similar high demand and system boundary conditions. The primary varied parameter for this calibration is pipeline roughness coefficient, although other parameters can also be adjusted as calibration results are generated.

Hazen-Williams roughness coefficients, or C-factors, have industry accepted value ranges based on pipeline material, diameter, and age. Characteristics specific to the City water distribution system such as water quality, temperature, construction methodologies, material suppliers, and other factors may result in roughness coefficients that differ from the average of the industry accepted ranges. Fire flow calibration refines the initial estimation of the value of roughness coefficients that best indicate the conditions of the City's distribution system.

During average day flows, roughness coefficients have a relatively small effect on the operation of the distribution system. However, as the flows increase in the system on higher demand days, velocity within pipelines increase and roughness coefficients contribute more to overall system head loss. Fire flow tests artificially create high demand events to generate more head loss, allowing a better estimation of the pipeline roughness coefficients.

Fire flow tests stress the distribution system by creating a differential between the HGL at the point of hydrant flow and the system HGL at neighboring hydrants. This HGL differential increases the effect of the roughness coefficients on system losses and allows adjustments to the model to match model pressures to field pressures within an acceptable tolerance. As the model is adjusted to match system pressures, roughness coefficients should be adjusted only within a tolerance of industry accepted roughness coefficient ranges. If a model is unable to match the calibration results without leaving the acceptable range of roughness coefficient values for a given pipeline material and age, there may be cause for further investigation of a previously unknown field condition. Examples of such conditions, which typically arise during hydraulic model calibration, include closed valves, partially closed or malfunctioning valves, extreme corrosion within pipelines, connectivity and diameter errors in GIS layers or record drawings, and diurnal patterns of large water users.

A separate hydraulic model scenario was created for each flow test for both the static and the dynamic, or flowing, condition. The flow observed at each fire flow hydrant was assigned as a demand to the model node at the location of the hydrant. Because the fire flow calibration is a steady state simulation, model demands were adjusted in each fire test scenario to match the time that the tests were conducted. Residual pressures were then read at each hydrant location while the hydrant was flowing. Model results were generally considered acceptable if they fall within a 10 percent tolerance or a 10 psi value. Appendix C shows a summary of the fire test model calibration results.

As seen in Appendix C, the comparison of model results to observed field data are very good. The average static pressure is 1.4 psi, or 1.0 percent, higher within the model than seen in the field results. Modeled residual pressures averaged 0.6 psi, or 1.7 percent, higher than field results.

1.6 Summary

As part of the Water Distribution Infrastructure Plan, the City's existing hydraulic model, which was most recently updated and calibrated in 2014, was updated to reflect the current physical and operational configuration of the City's distribution system. These updates included the following:

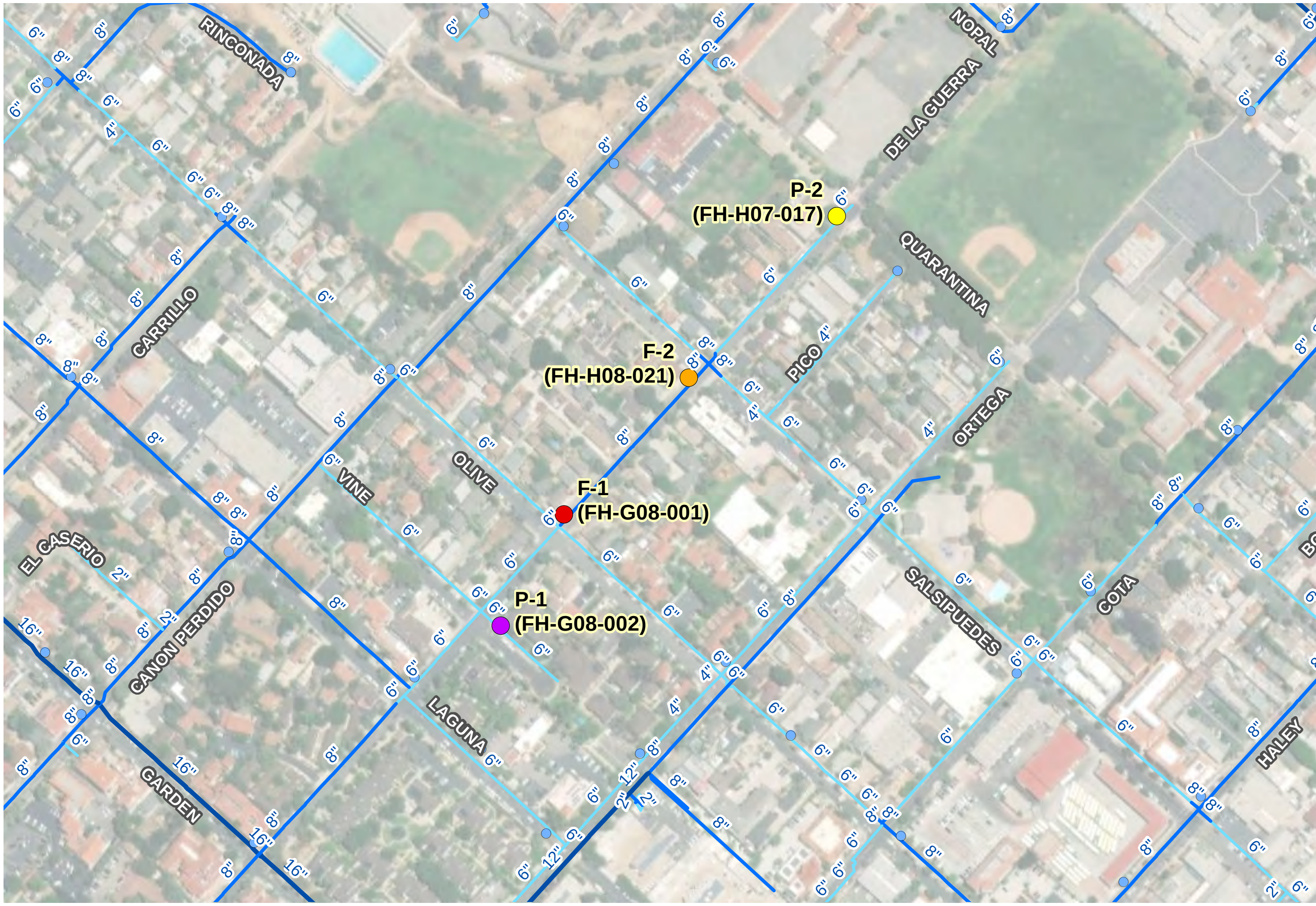
- The modeled distribution system pipeline configuration was updated to include new water mains that have been constructed since 2014, and abandoned pipelines have been deactivated in the model.
- The physical and operational parameters of each of the City's major water system facilities were revised based on updated information provided by City staff.
- Field survey of the City's major water system facilities was performed by MNS as part of this project. This survey information was used as a basis for updating facility elevations in the model.
- Model demands were reallocated based on 2018 water consumption data.

Once the model was updated, the model was calibrated against SCADA for a 24-hour EPS, as well as to fire flow field tests. The calibration results indicate the model predicts conditions similar to those observed in the field. Within a few isolated areas of the model, there are some very minor discrepancies, but the overall distribution system is very well represented by the model.

Based on the results presented in this technical memorandum, it can be concluded that the model is calibrated to steady state and extended period conditions. The model provides an accurate representation of the City's distribution system and system operations to a level suitable for this Water Distribution Infrastructure Plan and for the City's future hydraulic modeling needs.

Appendix 1A

FIRE FLOW FIELD TEST DETAIL MAPS



Legend

- Primary Pressure Hydrant (P-1)
- Secondary Pressure Hydrant (P-2)
- Primary Flow Hydrant (F-1)
- Secondary Flow Hydrant (F-2)
- Other Hydrant

Water Main by Diameter

- 6 inches and smaller
- 6 - 8 inches
- 10 inches and larger
- Ocean

Feet
0 125 250

Data Sources: City of Santa Barbara, ESRI

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Test Location: De La Guerra and Olive

Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant

Hydrant #: FH-G08-001
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1372 gpm
Duration:

Pressure Hydrant 1

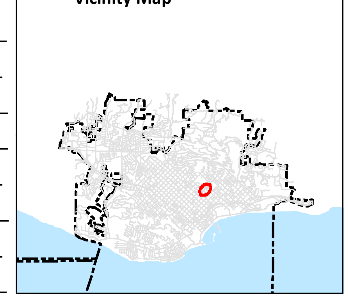
Hydrant #: FH-G08-002
Make:
Main Size:
Static PSI: 140 psi
Residual PSI: 130 psi

Pressure Hydrant 2

Hydrant #: FH-H07-017
Make:
Main Size:
Static PSI: 145 psi
Residual PSI: 105 psi

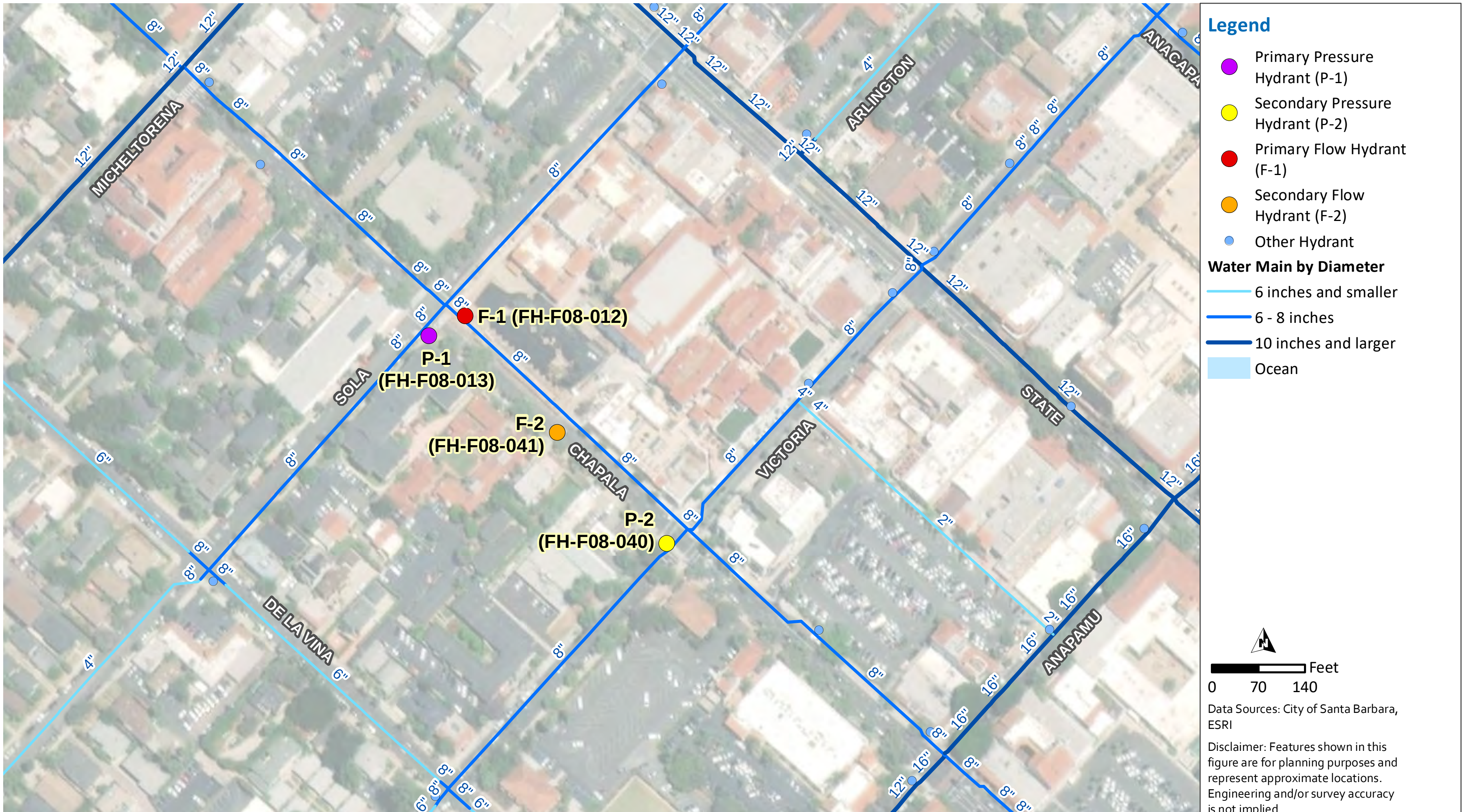
Hydrant #: FH-H08-021
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1341 gpm
Duration:

Vicinity Map



carollo

Figure 1 Fire Flow Test Site 1



Data Sources: City of Santa Barbara, ESRI

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Test Location: Chapala and Sola

Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant

Hydrant #: FH-F08-012
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1286 gpm
Duration:

Pressure Hydrant 1

Hydrant #: FH-F08-013
Make:
Main Size:
Static PSI: 105 psi
Residual PSI: 100 psi

Pressure Hydrant 2

Hydrant #: FH-F08-040
Make:
Main Size:
Static PSI: 110 psi
Residual PSI: 107 psi

Hydrant #: FH-F08-041
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1286 gpm
Duration:

Vicinity Map

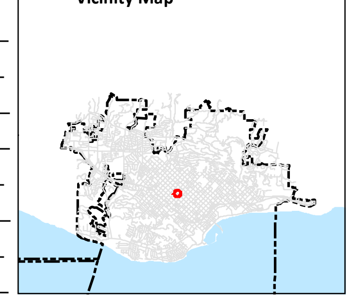
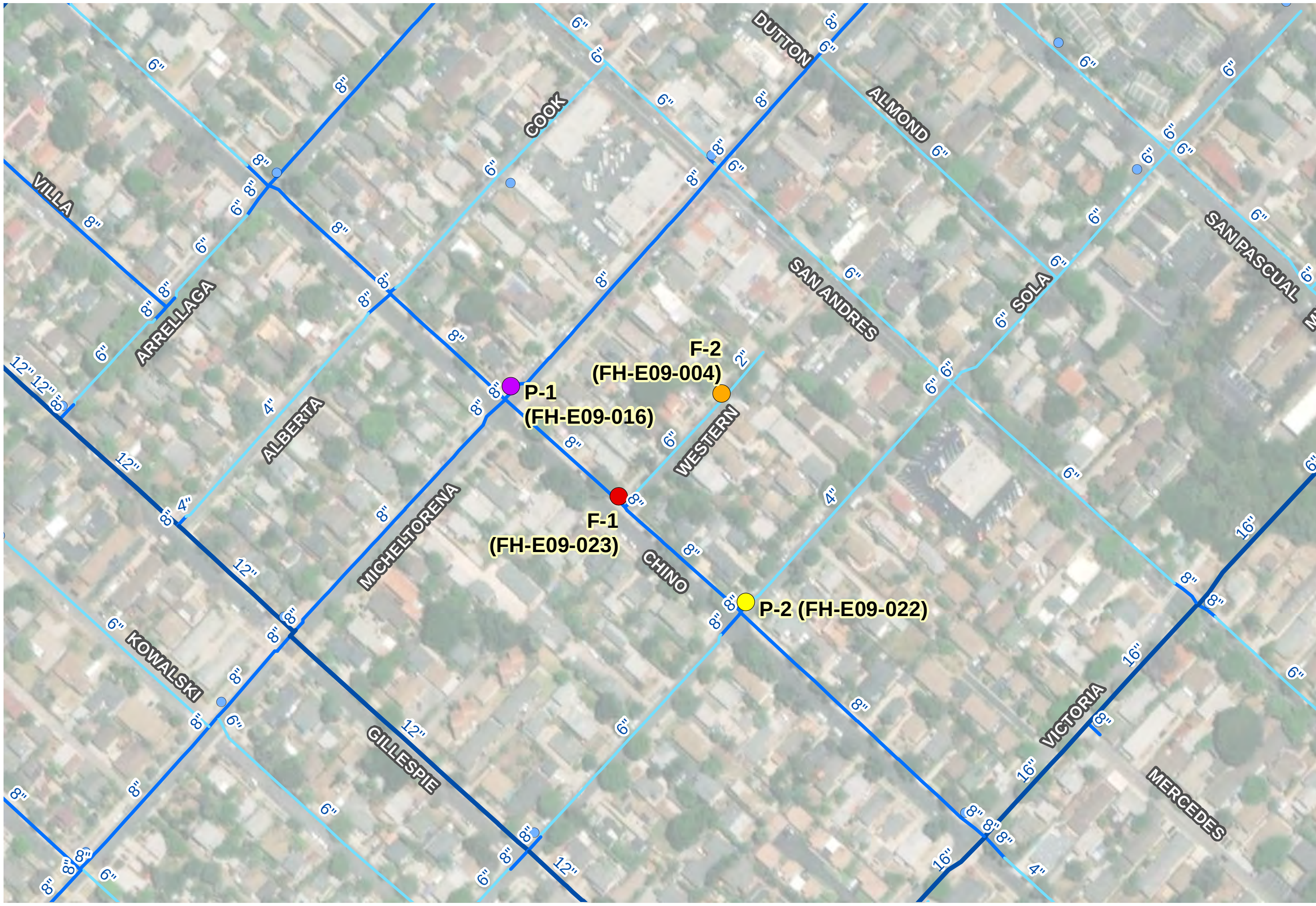


Figure 2 Fire Flow Test Site 2



Legend

- Primary Pressure Hydrant (P-1)
- Secondary Pressure Hydrant (P-2)
- Primary Flow Hydrant (F-1)
- Secondary Flow Hydrant (F-2)
- Other Hydrant

Water Main by Diameter

- 6 inches and smaller
- 6 - 8 inches
- 10 inches and larger
- Ocean

Feet
0 87.5 175

Data Sources: City of Santa Barbara, ESRI

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Test Location: Chino and Western

Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant

Hydrant #: FH-E09-023
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1383 gpm
Duration:

Pressure Hydrant 1

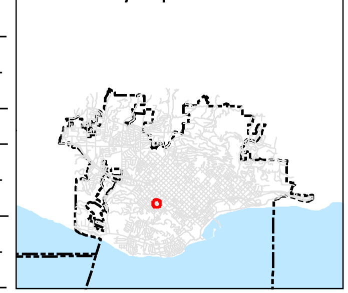
Hydrant #: FH-E09-016
Make:
Main Size:
Static PSI: 112 psi
Residual PSI: 104 psi

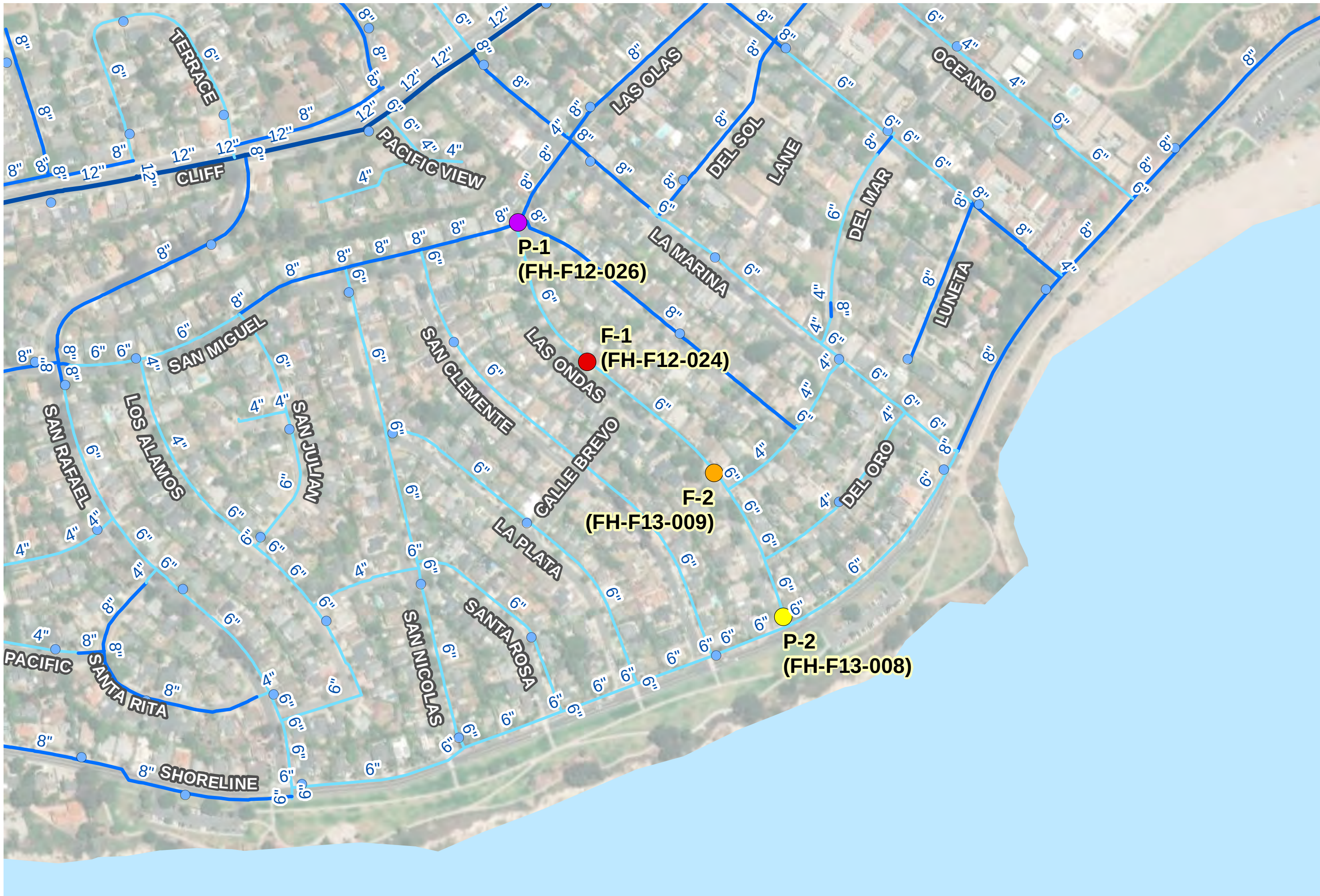
Pressure Hydrant 2

Hydrant #: FH-E09-022
Make:
Main Size:
Static PSI: 115 psi
Residual PSI: 105 psi

Hydrant #: FH-E09-004
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1095 gpm
Duration:

Vicinity Map





Legend

- Primary Pressure Hydrant (P-1)
- Secondary Pressure Hydrant (P-2)
- Primary Flow Hydrant (F-1)
- Secondary Flow Hydrant (F-2)
- Other Hydrant

Water Main by Diameter

- 6 inches and smaller
- 6 - 8 inches
- 10 inches and larger
- Ocean

Feet
0 170 340

Data Sources: City of Santa Barbara, ESRI

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Test Location: Las Ondas and Santa Catalina

Date/Time: ____

Temperature: ____

Notes/Observations: ____

Flowing Hydrant

Hydrant #: FH-F12-024
Make: ____
Main Size: ____
Static PSI: ____
Residual PSI: ____
Pitot PSI: ____
Flow GPM: 1330 gpm
Duration: ____

Pressure Hydrant 1

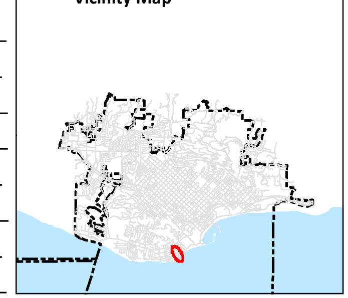
Hydrant #: FH-F12-026
Make: ____
Main Size: ____
Static PSI: 105 psi
Residual PSI: 92 psi

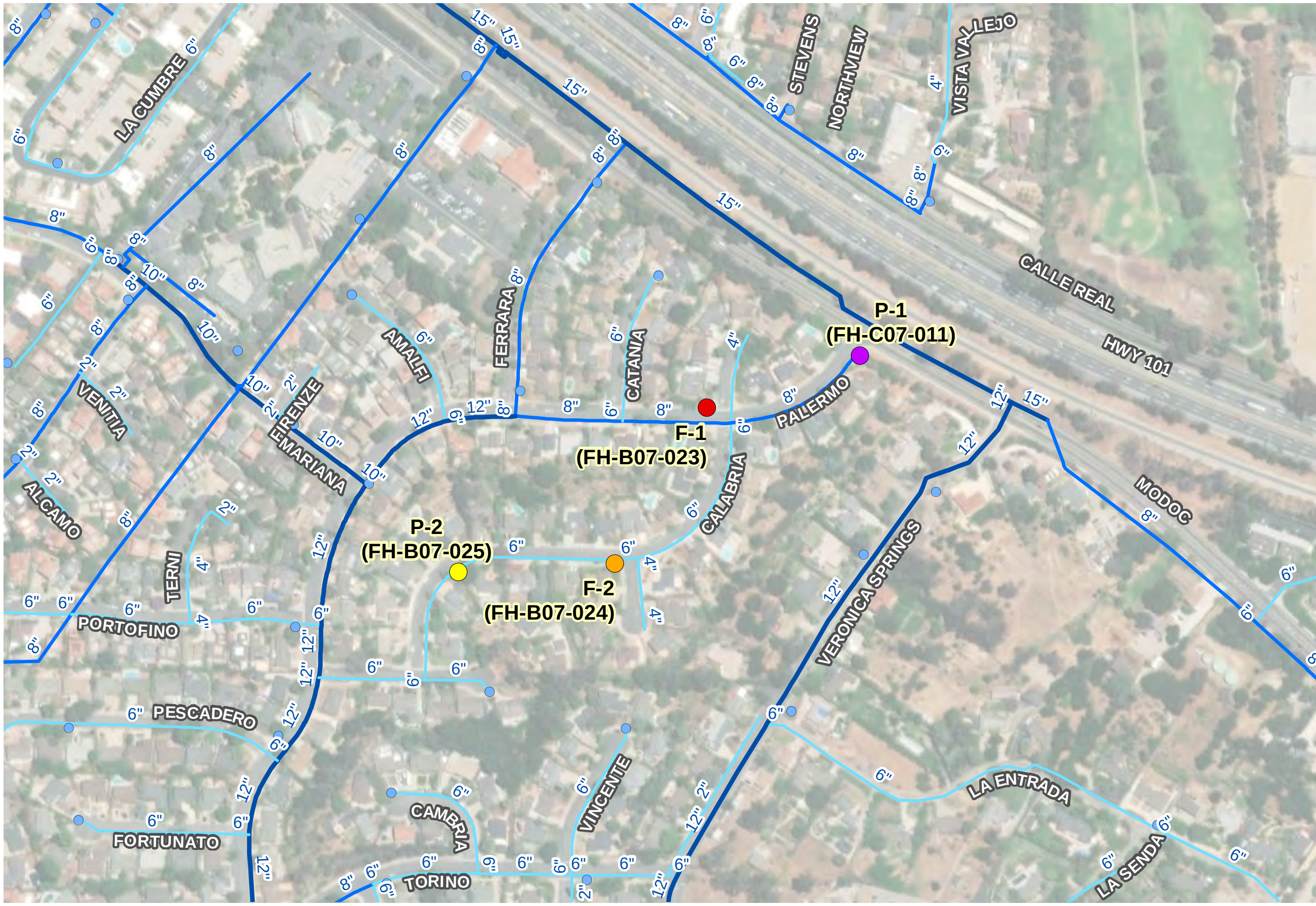
Pressure Hydrant 2

Hydrant #: FH-F13-008
Make: ____
Main Size: ____
Static PSI: 125 psi
Residual PSI: 110 psi

Hydrant #: FH-F13-009
Make: ____
Main Size: ____
Static PSI: ____
Residual PSI: ____
Pitot PSI: ____
Flow GPM: 1108 gpm
Duration: ____

Vicinity Map





Legend

- Primary Pressure Hydrant (P-1)
- Secondary Pressure Hydrant (P-2)
- Primary Flow Hydrant (F-1)
- Secondary Flow Hydrant (F-2)
- Other Hydrant

Water Main by Diameter

- 6 inches and smaller
- 6 - 8 inches
- 10 inches and larger
- Ocean

Feet
0 135 270

Data Sources: City of Santa Barbara, ESRI

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Test Location: Palermo and Calabria

Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant

Hydrant #: FH-B07-023
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1133 gpm
Duration:

Pressure Hydrant 1

Hydrant #: FH-C07-011
Make:
Main Size:
Static PSI: 74 psi
Residual PSI: 65 psi

Pressure Hydrant 2

Hydrant #: FH-B07-025
Make:
Main Size:
Static PSI: 80 psi
Residual PSI: 75 psi

Hydrant #: FH-B07-024
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM:
Duration:

Vicinity Map

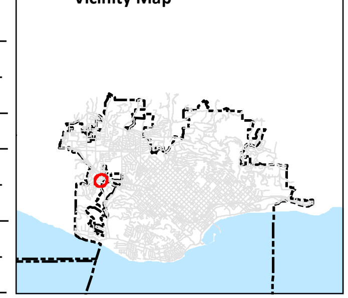


Figure 5 Fire Flow Test Site 5

Legend

- Primary Pressure Hydrant (P-1)
- Secondary Pressure Hydrant (P-2)
- Primary Flow Hydrant (F-1)
- Secondary Flow Hydrant (F-2)
- Other Hydrant

Water Main by Diameter

- 6 inches and smaller
- 6 - 8 inches
- 10 inches and larger
- Ocean

Feet
0 105 210

Data Sources: City of Santa Barbara, ESRI

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Test Location: Campanil and Centinela

Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant

Hydrant #: FH-B09-002
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 861 gpm
Duration:

Pressure Hydrant 1

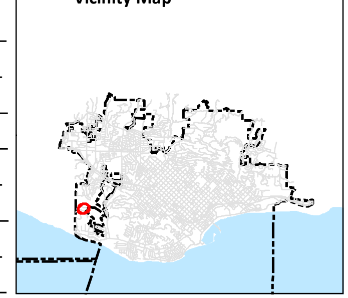
Hydrant #: FH-A09-003
Make:
Main Size:
Static PSI: 50 psi
Residual PSI: 32 psi

Pressure Hydrant 2

Hydrant #: FH-B09-003
Make:
Main Size:
Static PSI: 51 psi
Residual PSI: 35 psi

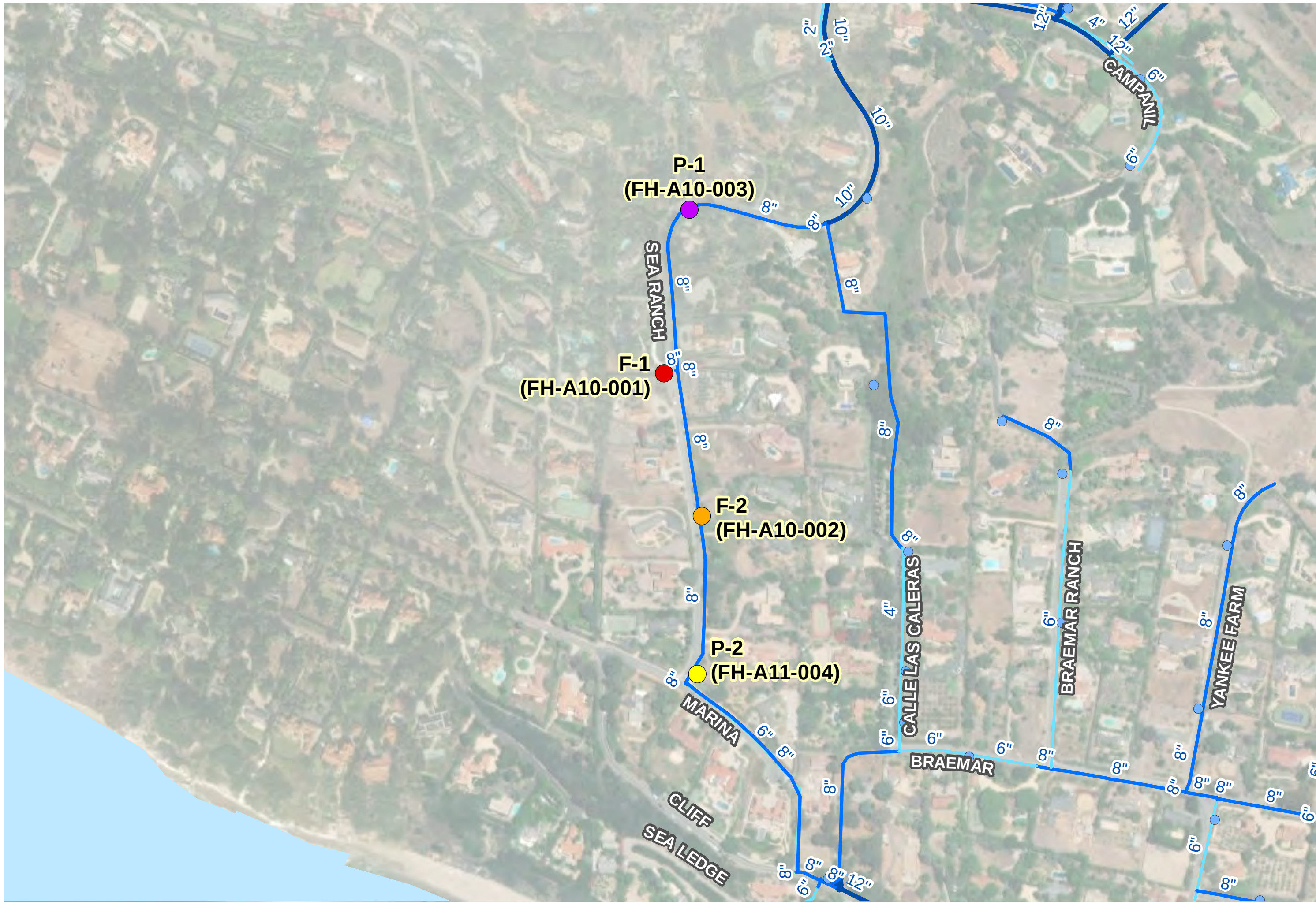
Hydrant #: FH-A09-004
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM:
Duration:

Vicinity Map



carollo

Figure 6 Fire Flow Test Site 6



Legend

- Primary Pressure Hydrant (P-1)
- Secondary Pressure Hydrant (P-2)
- Primary Flow Hydrant (F-1)
- Secondary Flow Hydrant (F-2)
- Other Hydrant

Water Main by Diameter

- 6 inches and smaller
- 6 - 8 inches
- 10 inches and larger
- Ocean

Feet
0 175 350

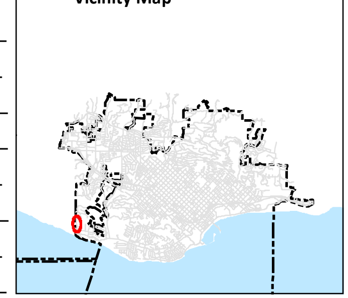
Data Sources: City of Santa Barbara, ESRI

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Test Location: Sea Ranch and Marina
Date/Time:
Temperature:
Notes/Observations:

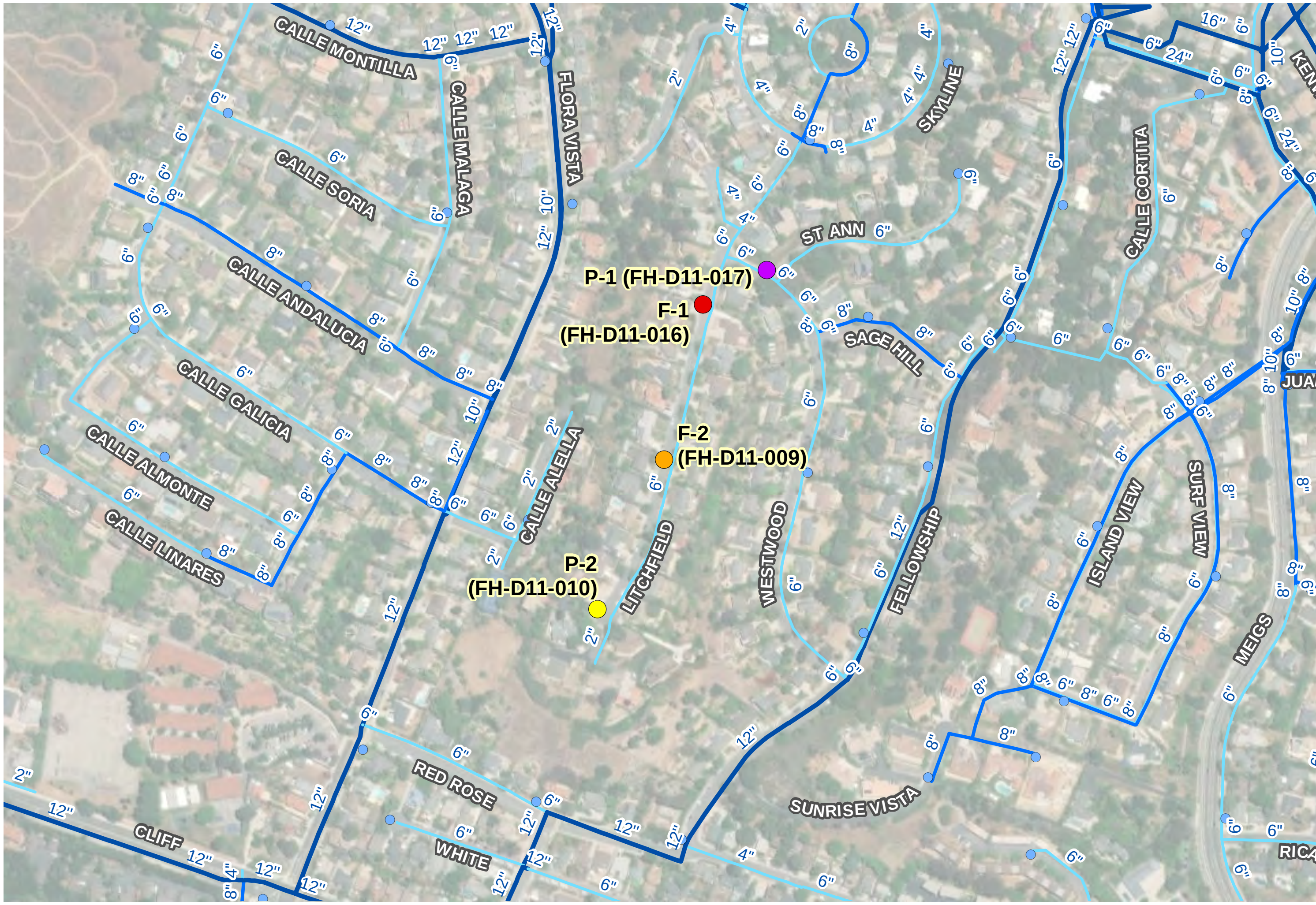
Flowing Hydrant	Pressure Hydrant 1	Pressure Hydrant 2	
Hydrant #: FH-A10-001	Hydrant #: FH-A10-003	Hydrant #: FH-A11-004	Hydrant #: FH-A10-002
Make:	Make:	Make:	Make:
Main Size:	Main Size:	Main Size:	Main Size:
Static PSI:	Static PSI: 112 psi	Static PSI: 177 psi	Static PSI:
Residual PSI:	Residual PSI: 100 psi	Residual PSI: 165 psi	Residual PSI:
Pitot PSI:			Pitot PSI:
Flow GPM: 1492 gpm			Flow GPM:
Duration:			Duration:

Vicinity Map



carollo

Figure 7 Fire Flow Test Site 7



Legend

- Primary Pressure Hydrant (P-1)
- Secondary Pressure Hydrant (P-2)
- Primary Flow Hydrant (F-1)
- Secondary Flow Hydrant (F-2)
- Other Hydrant

Water Main by Diameter

- 6 inches and smaller
- 6 - 8 inches
- 10 inches and larger
- Ocean

Feet
0 145 290

Data Sources: City of Santa Barbara, ESRI

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Test Location: Litchfield and Westwood

Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant

Hydrant #: FH-D11-016
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1146 gpm
Duration:

Pressure Hydrant 1

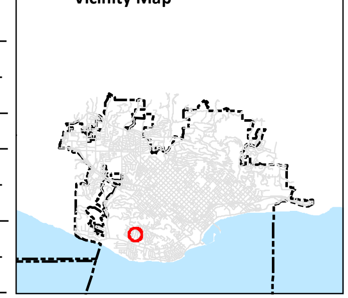
Hydrant #: FH-D11-017
Make:
Main Size:
Static PSI: 98 psi
Residual PSI: 85 psi

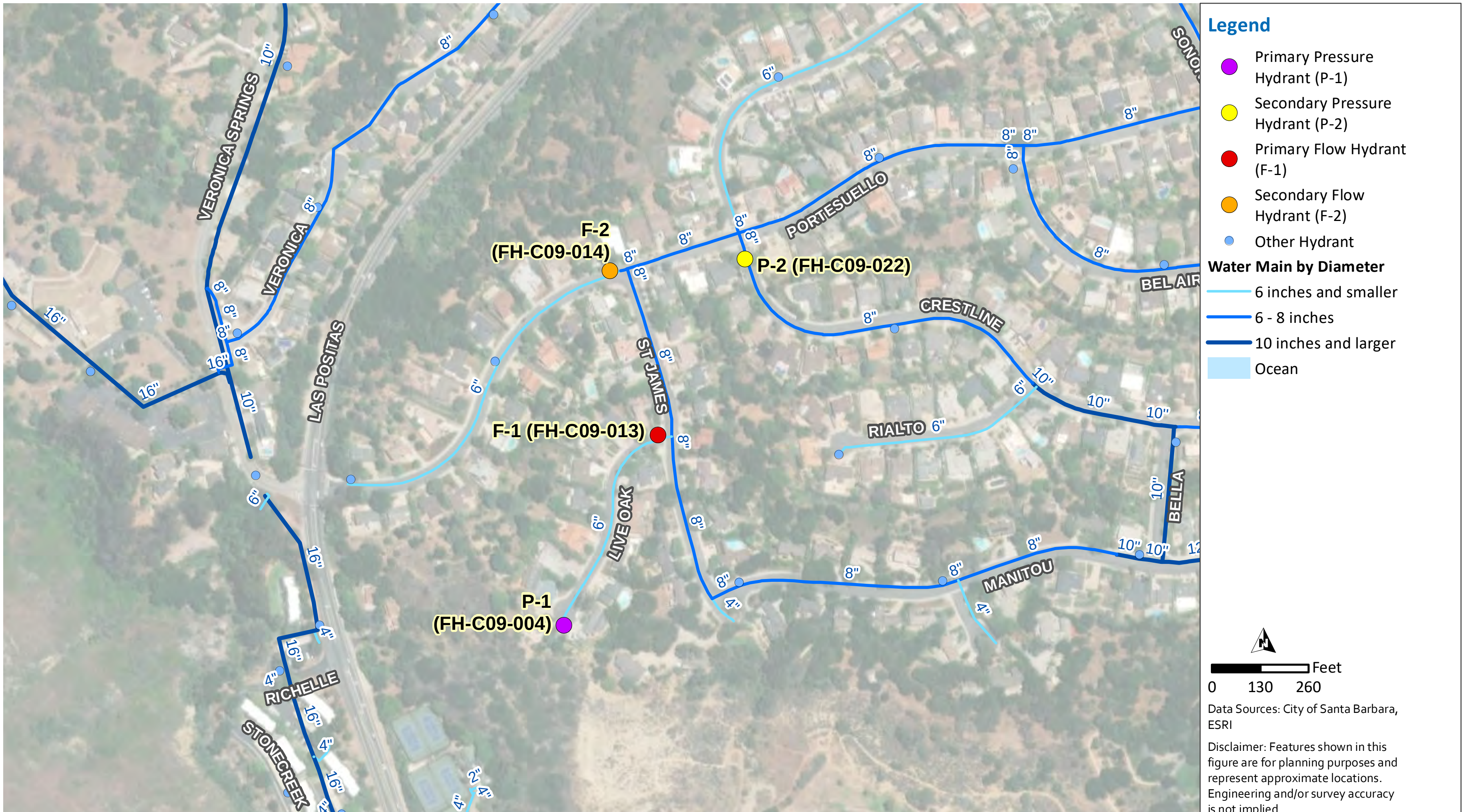
Pressure Hydrant 2

Hydrant #: FH-D11-010
Make:
Main Size:
Static PSI:
Residual PSI:

Hydrant #: FH-D11-009
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM:
Duration:

Vicinity Map





Test Location: St James and Live Oak

Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant

Hydrant #: FH-C09-013

Make:

Main Size:

Static PSI:

Residual PSI:

Pitot PSI:

Flow GPM: 1330 gpm

Duration:

Pressure Hydrant 1

Hydrant #: FH-C09-004

Make:

Main Size:

Static PSI: 102 psi

Residual PSI: 90 psi

Pressure Hydrant 2

Hydrant #: FH-C09-022

Make:

Main Size:

Static PSI: 105 psi

Residual PSI: 100 psi

Hydrant #: FH-C09-014

Make:

Main Size:

Static PSI:

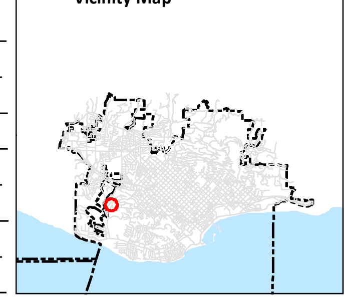
Residual PSI:

Pitot PSI:

Flow GPM:

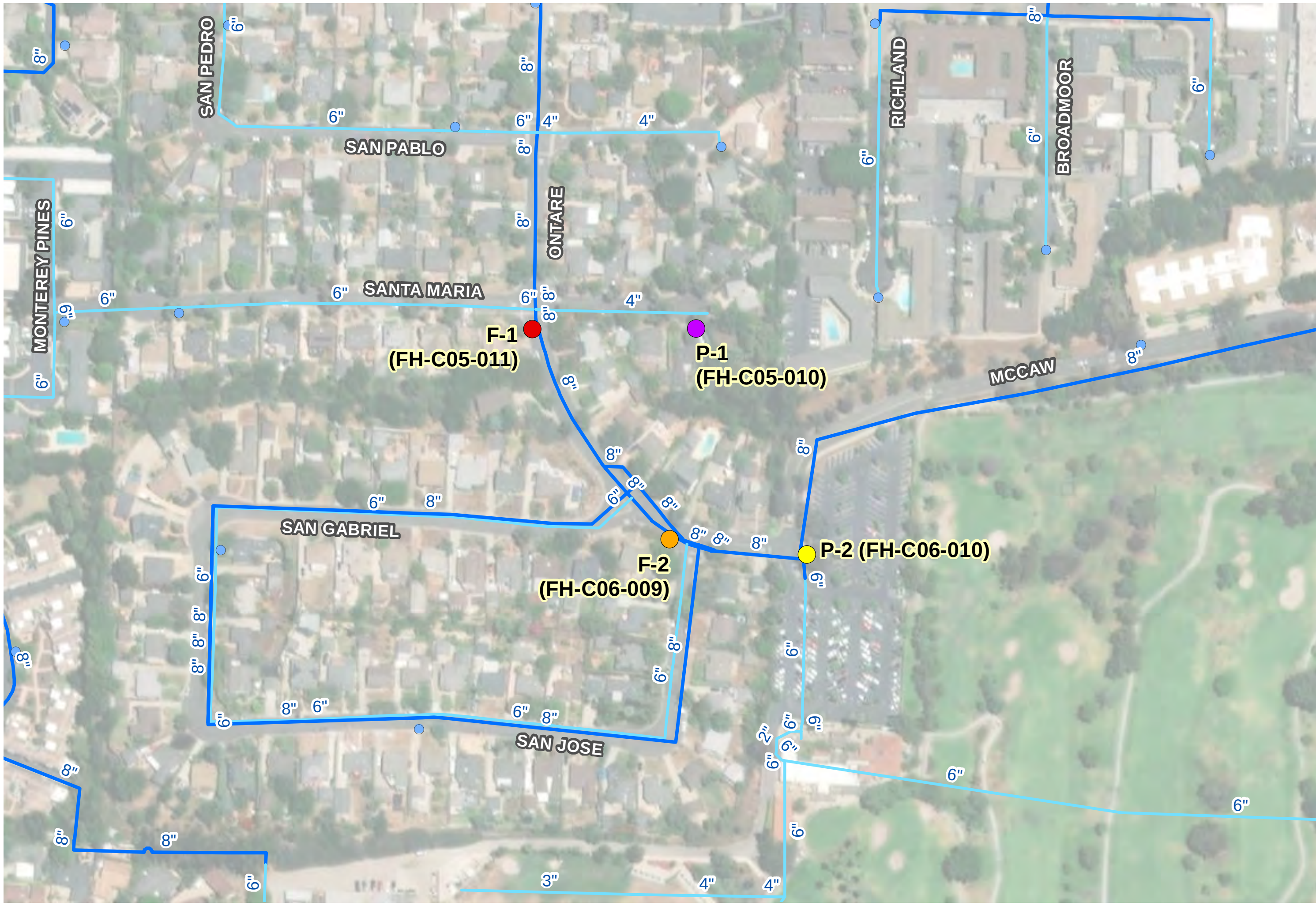
Duration:

Vicinity Map



carollo

Figure 9 **Fire Flow Test Site 9**



Legend

- Primary Pressure Hydrant (P-1)
- Secondary Pressure Hydrant (P-2)
- Primary Flow Hydrant (F-1)
- Secondary Flow Hydrant (F-2)
- Other Hydrant

Water Main by Diameter

- 6 inches and smaller
- 6 - 8 inches
- 10 inches and larger
- Ocean

Feet
0 85 170

Data Sources: City of Santa Barbara, ESRI

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Test Location: Ontare and Santa Maria

Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant

Hydrant #: FH-C05-011
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1372 gpm
Duration:

Pressure Hydrant 1

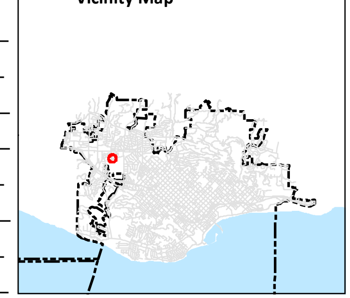
Hydrant #: FH-C05-010
Make:
Main Size:
Static PSI: 124 psi
Residual PSI: 100 psi

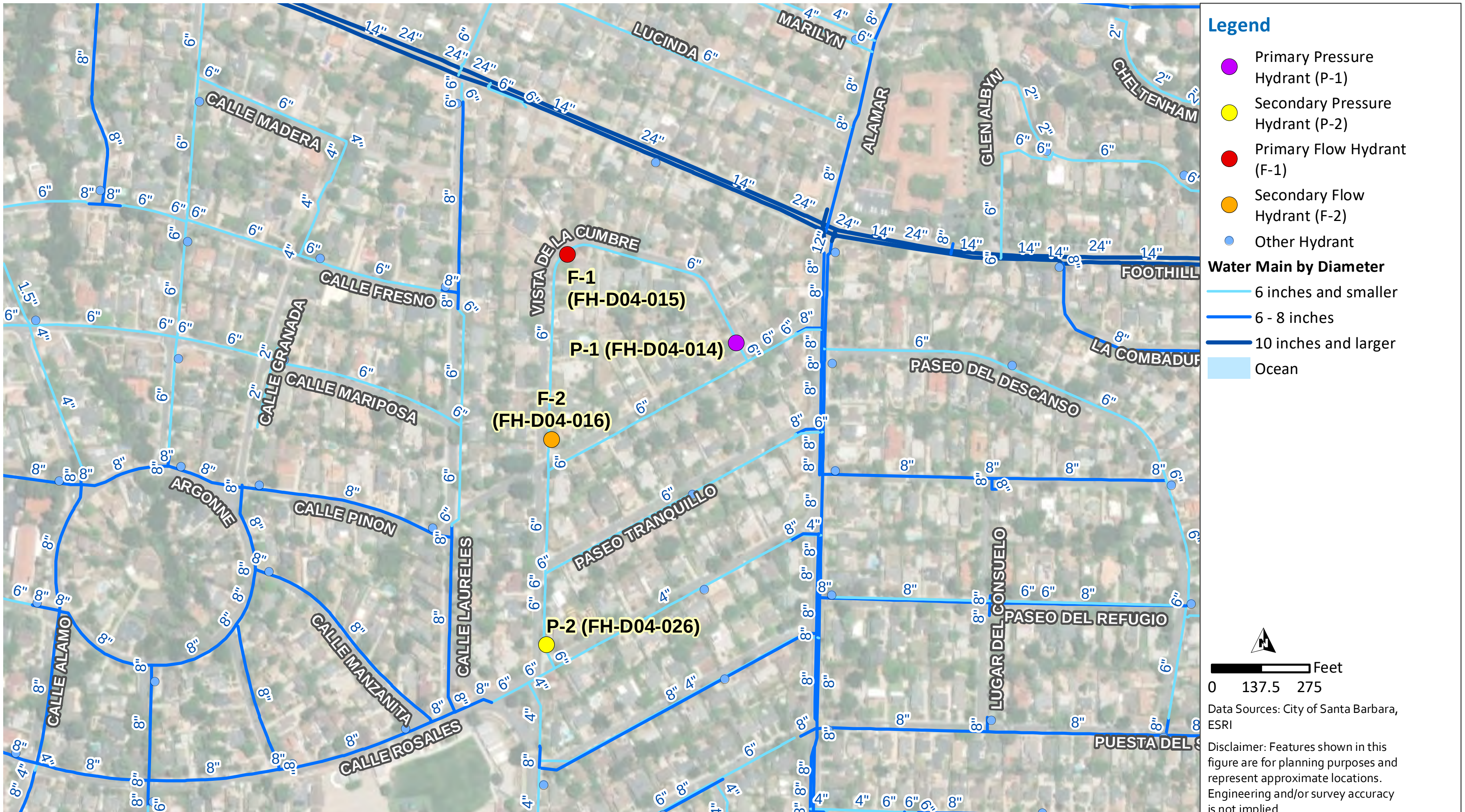
Pressure Hydrant 2

Hydrant #: FH-C06-010
Make:
Main Size:
Static PSI: 98 psi
Residual PSI: 75 psi

Hydrant #: FH-C06-009
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1108 gpm
Duration:

Vicinity Map





Test Location: Vista Del La Cumbre

Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant

Hydrant #: FH-D04-015
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1013 gpm
Duration:

Pressure Hydrant 1

Hydrant #: FH-D04-014
Make:
Main Size:
Static PSI: 82 psi
Residual PSI: 55 psi

Pressure Hydrant 2

Hydrant #: FH-D04-026
Make:
Main Size:
Static PSI: 95 psi
Residual PSI: 95 psi

Hydrant #: FH-D04-016
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM:
Duration:

Vicinity Map

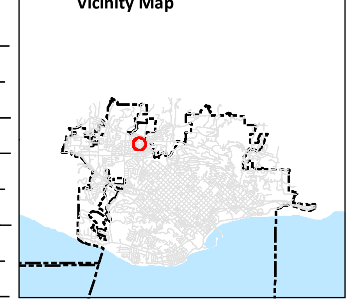
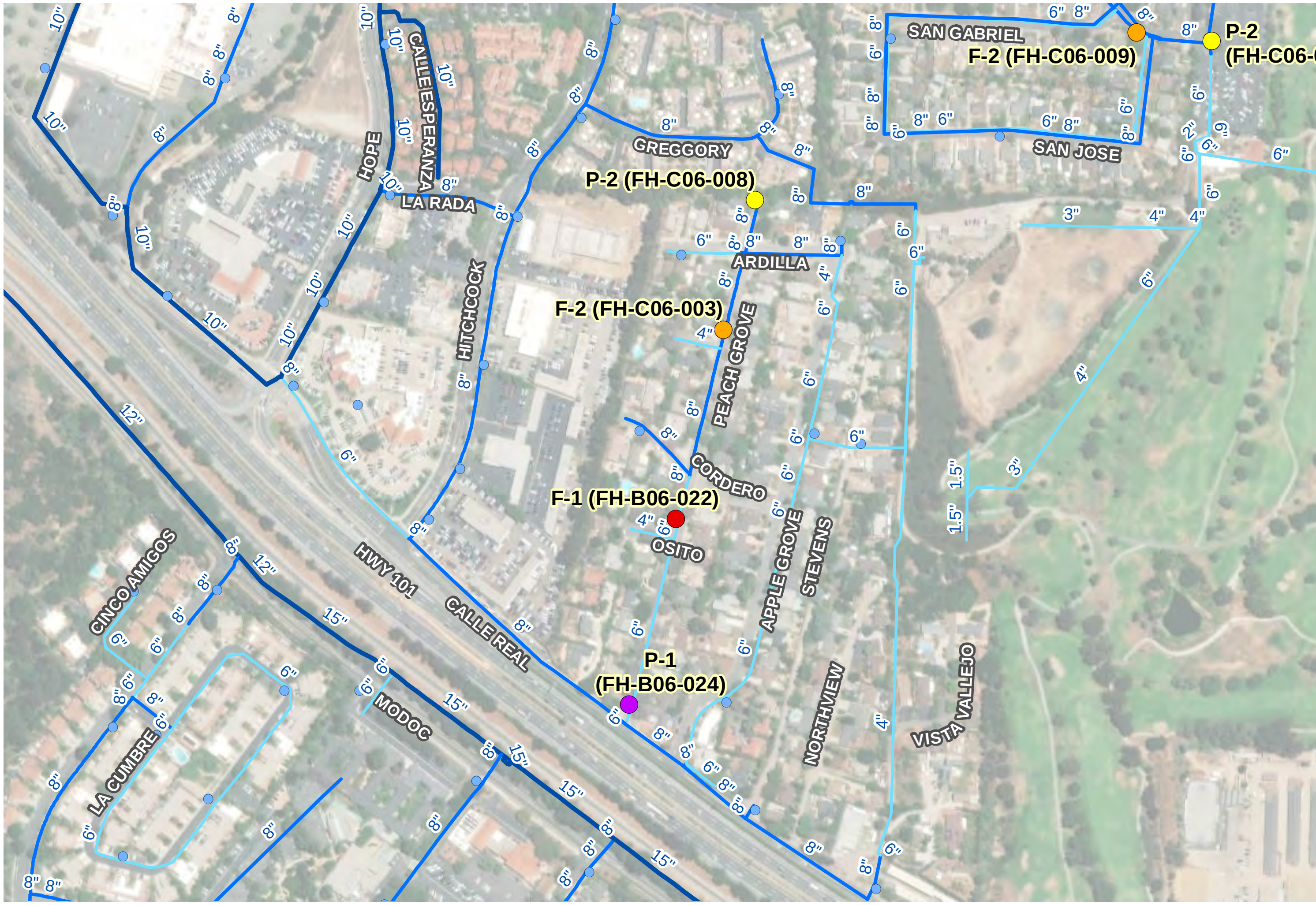


Figure 11 Fire Flow Test Site 11



Legend

- Primary Pressure Hydrant (P-1)
- Secondary Pressure Hydrant (P-2)
- Primary Flow Hydrant (F-1)
- Secondary Flow Hydrant (F-2)
- Other Hydrant

Water Main by Diameter

- 6 inches and smaller
- 6 - 8 inches
- 10 inches and larger
- Ocean

Feet
0 155 310

Data Sources: City of Santa Barbara, ESRI

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Test Location: Peach Grove and Osito

Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant

Hydrant #: FH-B06-022
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1285 gpm
Duration:

Pressure Hydrant 1

Hydrant #: FH-B06-024
Make:
Main Size:
Static PSI: 124 psi
Residual PSI: 115 psi

Pressure Hydrant 2

Hydrant #: FH-C06-008
Make:
Main Size:
Static PSI: 120 psi
Residual PSI: 100 psi

Hydrant #: FH-C06-003
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM:
Duration:

Vicinity Map

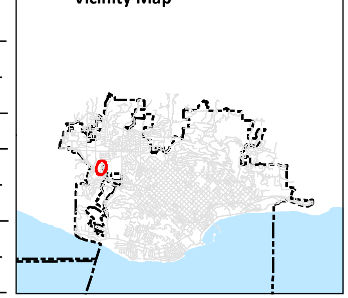
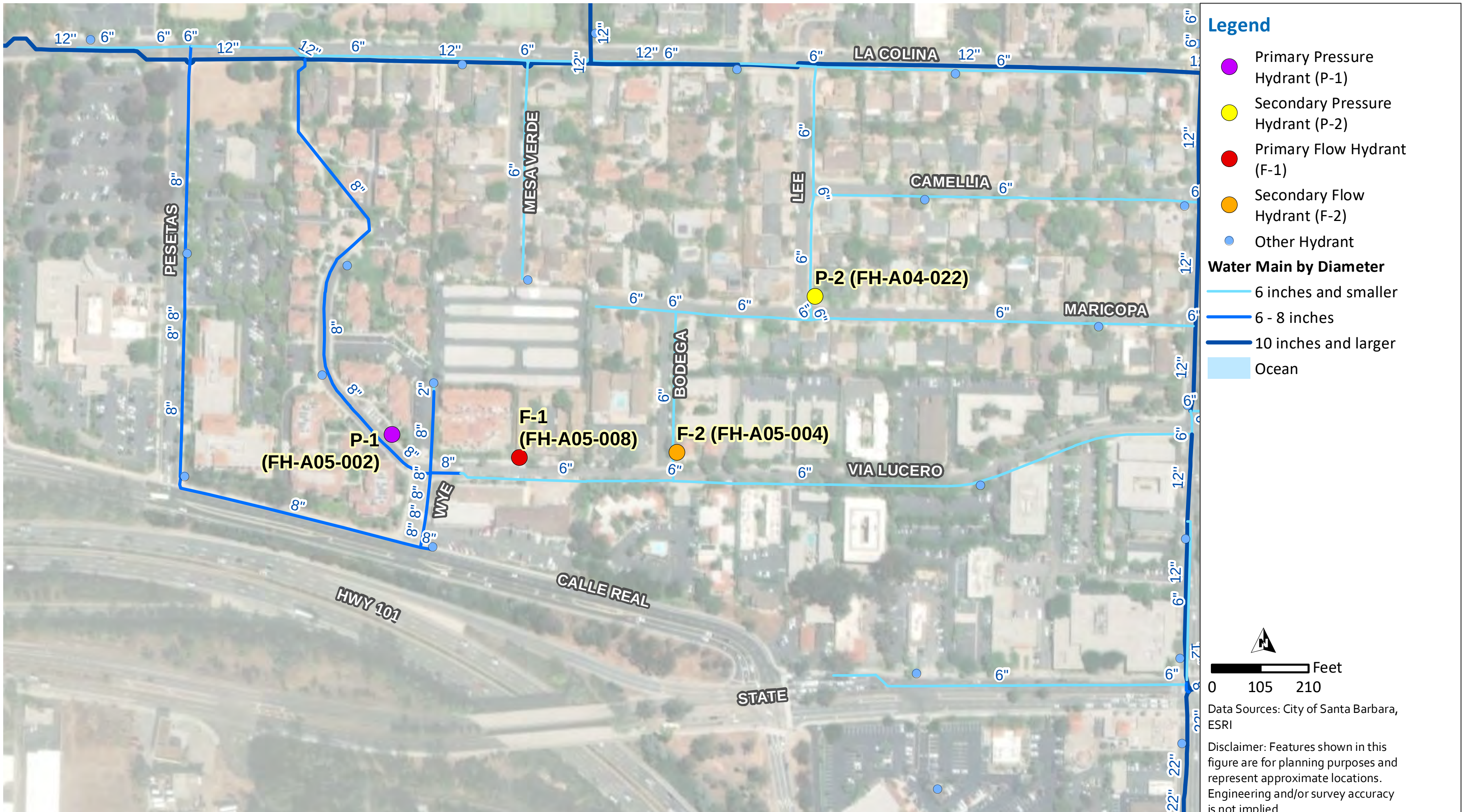


Figure 12 Fire Flow Test Site 12



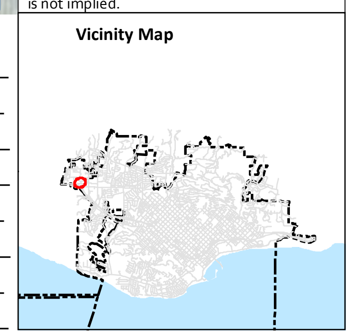
Test Location: Via Lucero and Bodega

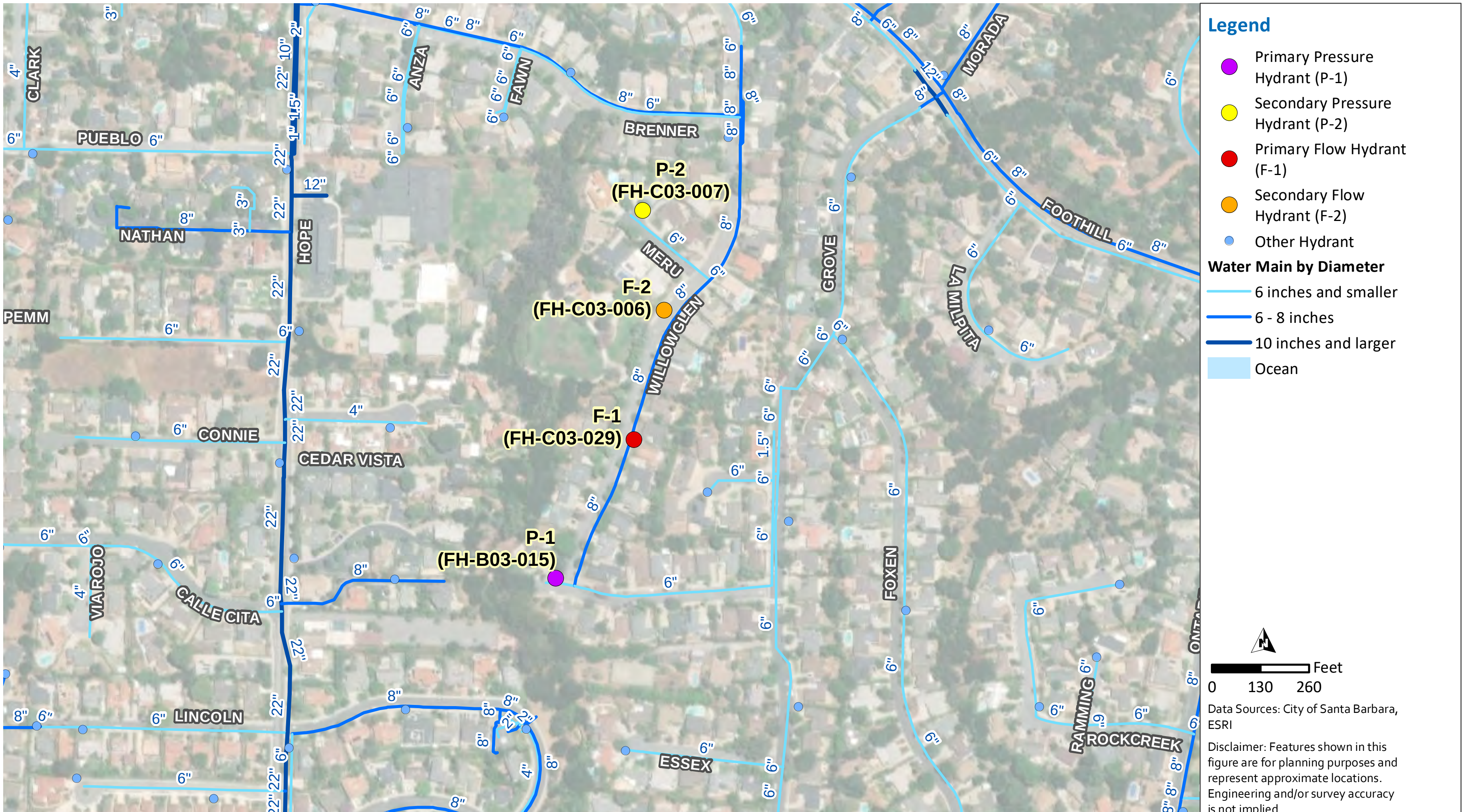
Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant	Pressure Hydrant 1	Pressure Hydrant 2	
Hydrant #: FH-A05-008	Hydrant #: FH-A05-002	Hydrant #: FH-A04-022	Hydrant #: FH-A05-004
Make:	Make:	Make:	Make:
Main Size:	Main Size:	Main Size:	Main Size:
Static PSI:	Static PSI: 105 psi	Static PSI: 110 psi	Static PSI:
Residual PSI:	Residual PSI: 95 psi	Residual PSI: 100 psi	Residual PSI:
Pitot PSI:			Pitot PSI:
Flow GPM: 1218 gpm			Flow GPM:
Duration:			Duration:





Test Location: Willowglen and Meru

Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant

Hydrant #: FH-C03-029
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1068 gpm
Duration:

Pressure Hydrant 1

Hydrant #: FH-B03-015
Make:
Main Size:
Static PSI: 165 psi
Residual PSI: 70 psi

Pressure Hydrant 2

Hydrant #: FH-C03-007
Make:
Main Size:
Static PSI: 155 psi
Residual PSI: 65 psi

Hydrant #: FH-C03-006
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM:
Duration:

Vicinity Map

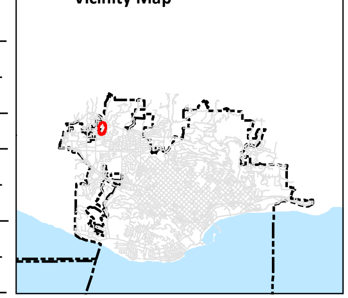


Figure 14 **Fire Flow Test Site 14**

Legend

- Primary Pressure Hydrant (P-1)
- Secondary Pressure Hydrant (P-2)
- Primary Flow Hydrant (F-1)
- Secondary Flow Hydrant (F-2)
- Other Hydrant

Water Main by Diameter

- 6 inches and smaller
- 6 - 8 inches
- 10 inches and larger
- Ocean

Feet
0 115 230

Data Sources: City of Santa Barbara, ESRI

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Test Location: Santa Teresita and Francisco

Date/Time: ____

Temperature: ____

Notes/Observations: ____

Flowing Hydrant

Hydrant #: FH-D01-001
Make: ____
Main Size: ____
Static PSI: ____
Residual PSI: ____
Pitot PSI: ____
Flow GPM: 1330 gpm
Duration: ____

Pressure Hydrant 1

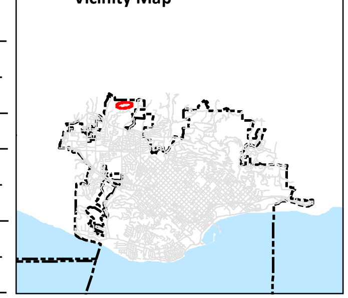
Hydrant #: FH-D02-001
Make: ____
Main Size: ____
Static PSI: 110 psi
Residual PSI: 95 psi

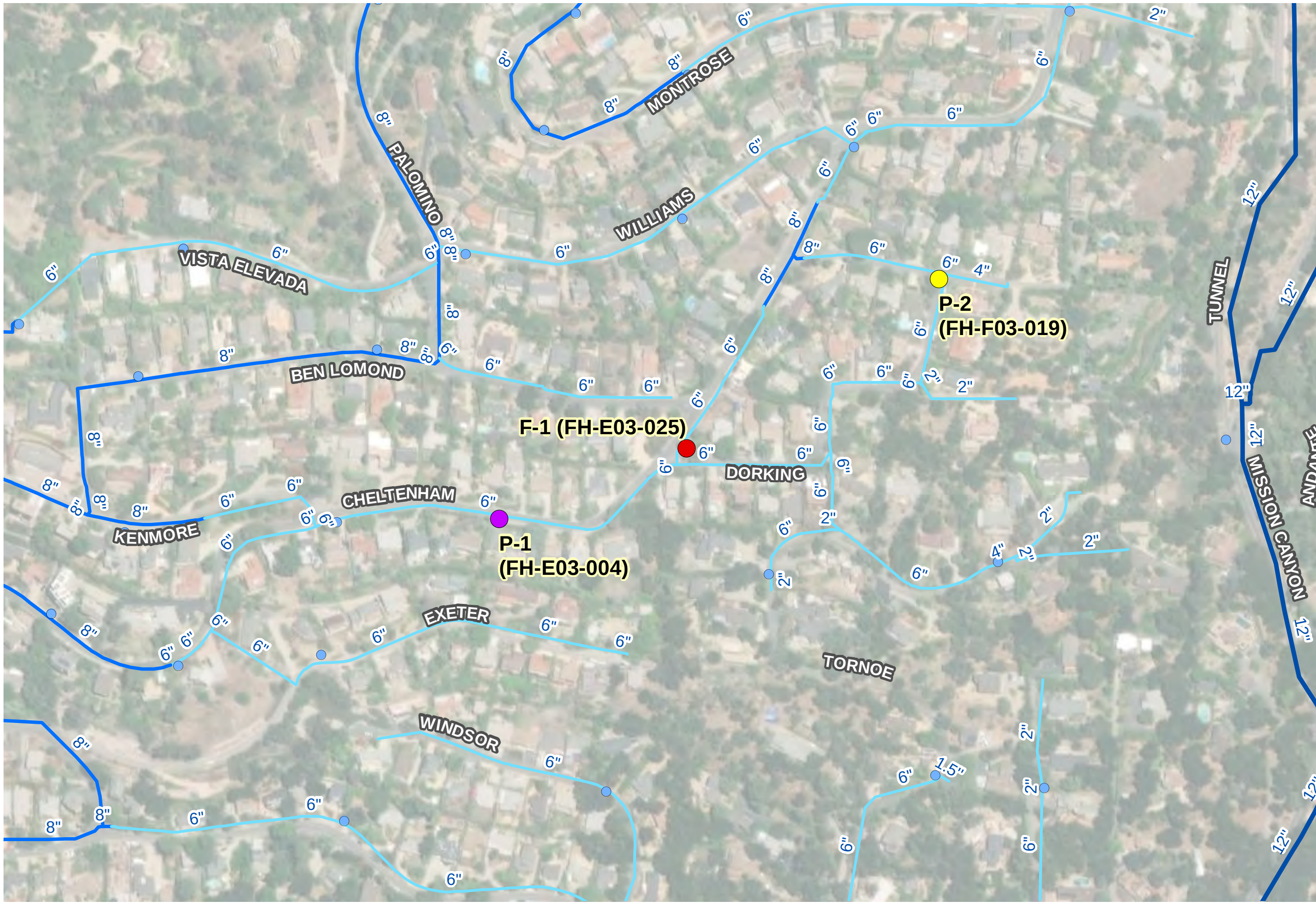
Pressure Hydrant 2

Hydrant #: FH-C02-005
Make: ____
Main Size: ____
Static PSI: 170 psi
Residual PSI: 150 psi

Hydrant #: FH-D01-002
Make: ____
Main Size: ____
Static PSI: ____
Residual PSI: ____
Pitot PSI: ____
Flow GPM: ____
Duration: ____

Vicinity Map





Legend

- Primary Pressure Hydrant (P-1)
- Secondary Pressure Hydrant (P-2)
- Primary Flow Hydrant (F-1)
- Secondary Flow Hydrant (F-2)
- Other Hydrant

Water Main by Diameter

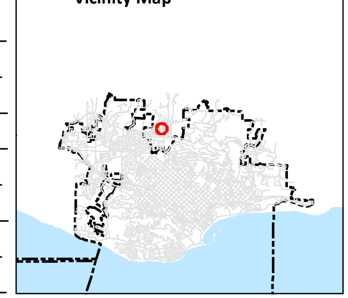
- 6 inches and smaller
- 6 - 8 inches
- 10 inches and larger
- Ocean

Feet
0 120 240

Data Sources: City of Santa Barbara, ESRI

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Vicinity Map



Test Location: Cheltenham and Kenmore
Date/Time:
Temperature:
Notes/Observations:

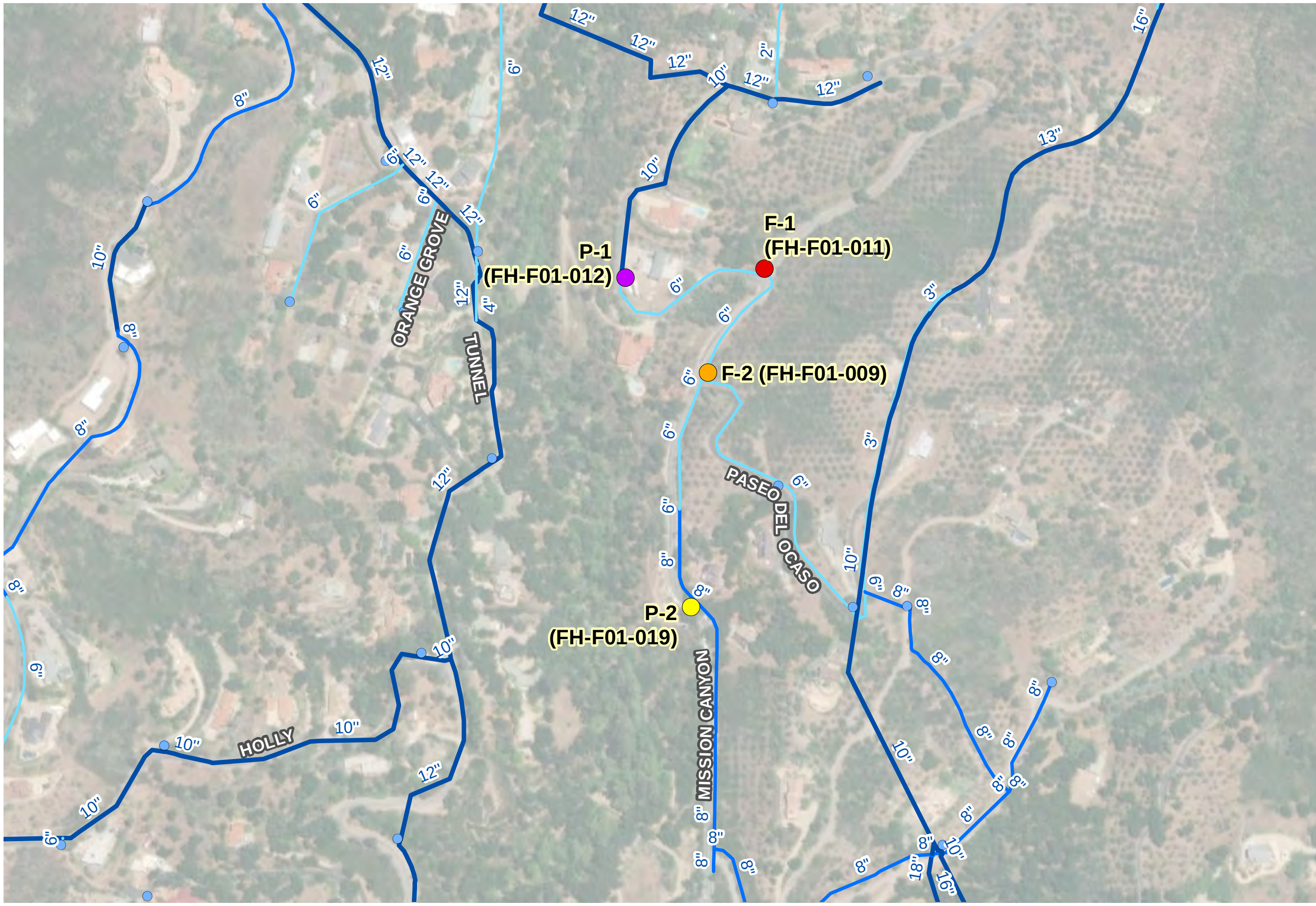
Flowing Hydrant
Hydrant #: FH-E03-025
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1330 gpm
Duration:

Pressure Hydrant 1
Hydrant #: FH-E03-004
Make:
Main Size:
Static PSI: 135 psi
Residual PSI: 100 psi

Pressure Hydrant 2
Hydrant #: FH-F03-019
Make:
Main Size:
Static PSI: 120 psi
Residual PSI: 85 psi

Hydrant #:
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM:
Duration:

Figure 16 Fire Flow Test Site 16



Legend

- Primary Pressure Hydrant (P-1)
- Secondary Pressure Hydrant (P-2)
- Primary Flow Hydrant (F-1)
- Secondary Flow Hydrant (F-2)
- Other Hydrant

Water Main by Diameter

- 6 inches and smaller
- 6 - 8 inches
- 10 inches and larger
- Ocean

Feet
0 140 280

Data Sources: City of Santa Barbara, ESRI

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Test Location: Mission Canyon and Paseo Del Ocaso

Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant

Hydrant #: FH-F01-011
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1241 gpm
Duration:

Pressure Hydrant 1

Hydrant #: FH-F01-012
Make:
Main Size:
Static PSI: 140 psi
Residual PSI: 110 psi

Pressure Hydrant 2

Hydrant #: FH-F01-019
Make:
Main Size:
Static PSI: 175 psi
Residual PSI: 130 psi

Hydrant #: FH-F01-009
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM:
Duration:

Vicinity Map

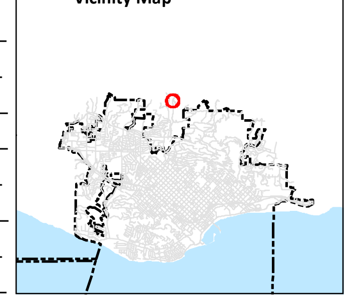
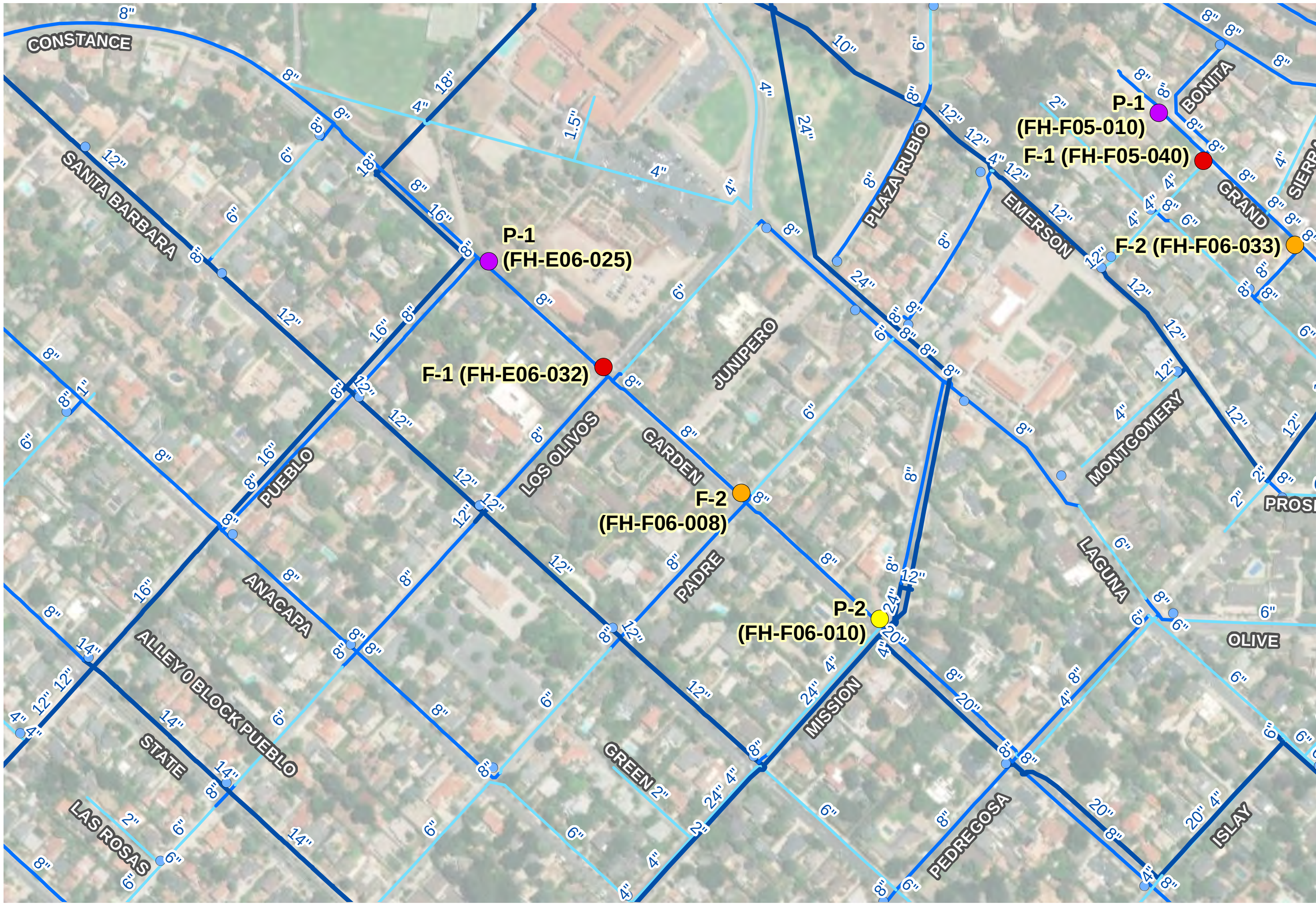


Figure 17 Fire Flow Test Site 17



Legend

- Primary Pressure Hydrant (P-1)
- Secondary Pressure Hydrant (P-2)
- Primary Flow Hydrant (F-1)
- Secondary Flow Hydrant (F-2)
- Other Hydrant

Water Main by Diameter

- 6 inches and smaller
- 6 - 8 inches
- 10 inches and larger
- Ocean

Feet
0 145 290

Data Sources: City of Santa Barbara, ESRI

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Test Location: Garden and Los Olivos

Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant

Hydrant #: FH-E06-032
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1218 gpm
Duration:

Pressure Hydrant 1

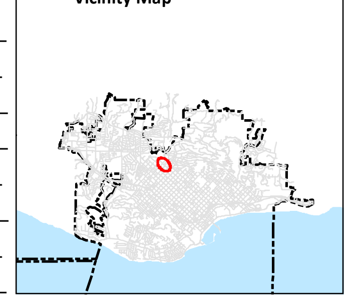
Hydrant #: FH-E06-025
Make:
Main Size:
Static PSI: 90 psi
Residual PSI: 85 psi

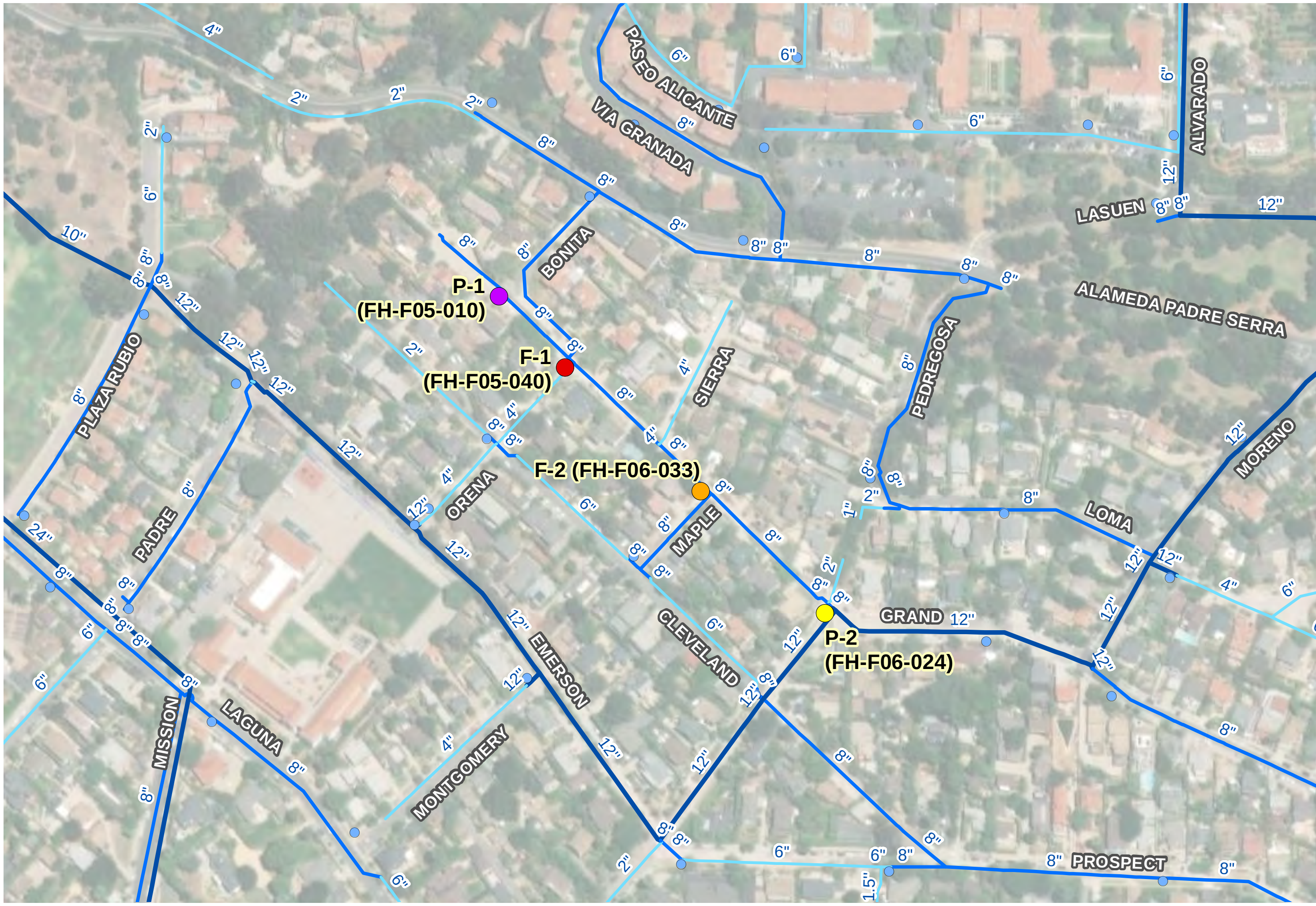
Pressure Hydrant 2

Hydrant #: FH-F06-010
Make:
Main Size:
Static PSI: 110 psi
Residual PSI: 110 psi

Hydrant #: FH-F06-008
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1286 gpm
Duration:

Vicinity Map





Legend

- Primary Pressure Hydrant (P-1)
- Secondary Pressure Hydrant (P-2)
- Primary Flow Hydrant (F-1)
- Secondary Flow Hydrant (F-2)
- Other Hydrant

Water Main by Diameter

- 6 inches and smaller
- 6 - 8 inches
- 10 inches and larger
- Ocean

Feet
0 100 200

Data Sources: City of Santa Barbara, ESRI

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Test Location: Grand and Maple

Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant	Pressure Hydrant 1	Pressure Hydrant 2	
Hydrant #: FH-F05-040	Hydrant #: FH-F05-010	Hydrant #: FH-F06-024	Hydrant #: FH-F06-033
Make:	Make:	Make:	Make:
Main Size:	Main Size:	Main Size:	Main Size:
Static PSI:	Static PSI: 120 psi	Static PSI: 140 psi	Static PSI:
Residual PSI:	Residual PSI: 98 psi	Residual PSI: 136 psi	Residual PSI:
Pitot PSI:			Pitot PSI:
Flow GPM: 1308 gpm			Flow GPM:
Duration:			Duration:

Vicinity Map

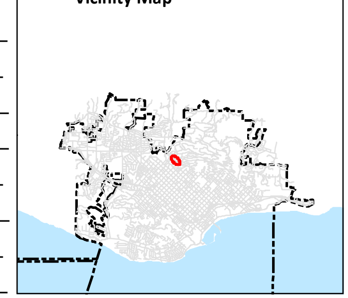


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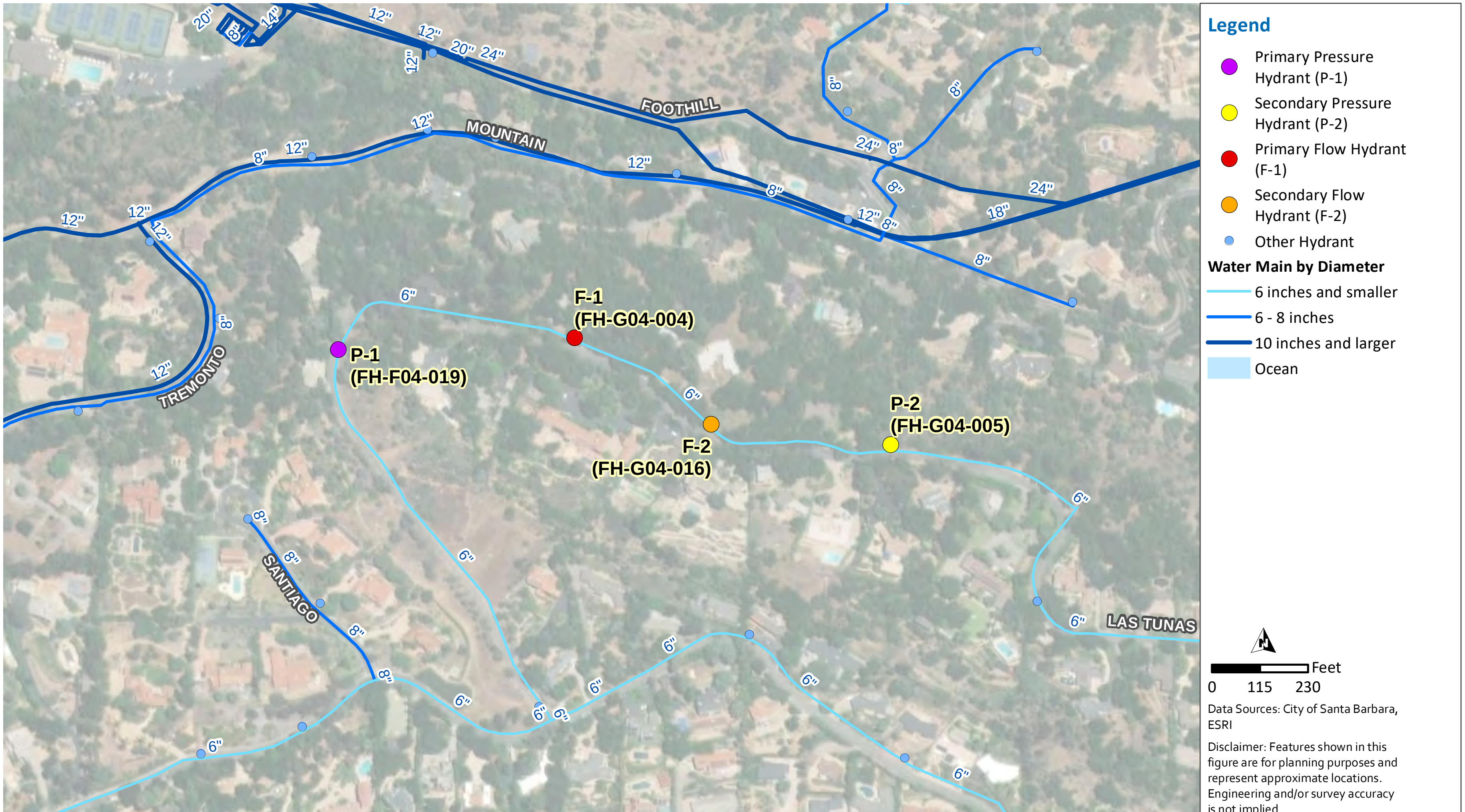
Figure 19 Fire Flow Test Site 19



Test Location: Las Tunas	Flowing Hydrant	Pressure Hydrant 1	Pressure Hydrant 2	
	Hydrant #: FH-G04-004	Hydrant #: FH-F04-019	Hydrant #: FH-G04-005	Hydrant #: FH-G04-016
Date/Time:	Make:	Make:	Make:	Make:
Temperature:	Main Size:	Main Size:	Main Size:	Main Size:
Notes/Observations:	Static PSI:	Static PSI: 160 psi	Static PSI: 130 psi	Static PSI:
	Residual PSI:	Residual PSI: 100 psi	Residual PSI: 69 psi	Residual PSI:
	Pitot PSI:			Pitot PSI:
	Flow GPM: 956 gpm			Flow GPM:
	Duration:			Duration:

Vicinity Map

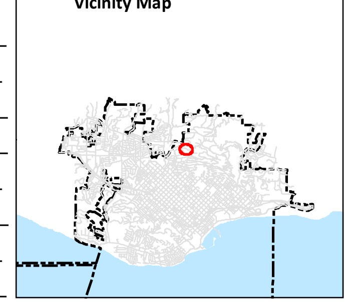
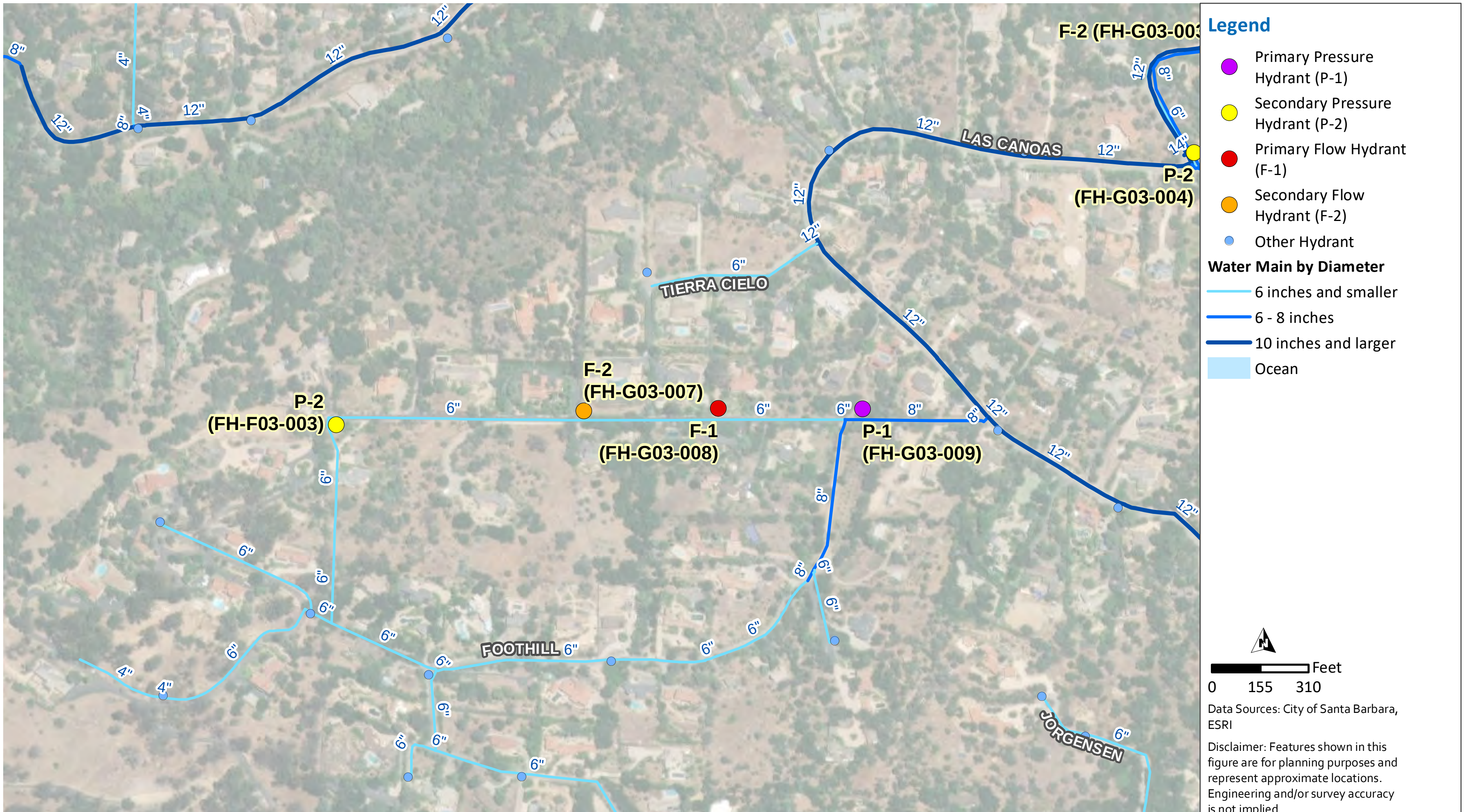


Figure 20 Fire Flow Test Site 20



Test Location: Las Canoas Ln

Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant

Hydrant #: FH-G03-008
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1013 gpm
Duration:

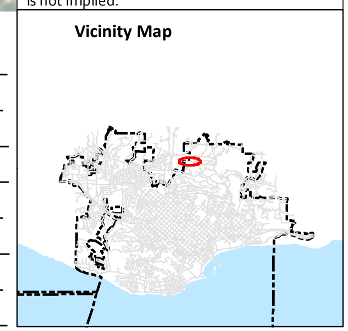
Pressure Hydrant 1

Hydrant #: FH-G03-009
Make:
Main Size:
Static PSI: 107 psi
Residual PSI: 85 psi

Pressure Hydrant 2

Hydrant #: FH-F03-003
Make:
Main Size:
Static PSI: 110 psi
Residual PSI: 77 psi

Hydrant #: FH-G03-007
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM:
Duration:



Test Location: Las Canoas

Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant

Hydrant #: FH-H02-005

Make:

Main Size:

Static PSI:

Residual PSI:

Pitot PSI:

Flow GPM: 707 gpm

Duration:

Pressure Hydrant 1

Hydrant #: FH-H02-009

Make:

Main Size:

Static PSI: 90 psi

Residual PSI: 25 psi

Pressure Hydrant 2

Hydrant #: FH-G03-004

Make:

Main Size:

Static PSI:

Residual PSI:

Hydrant #: FH-G03-003

Make:

Main Size:

Static PSI:

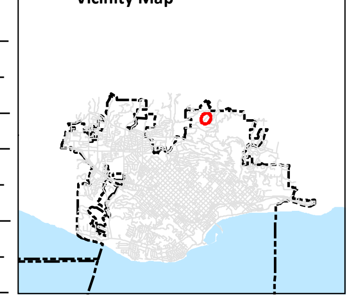
Residual PSI:

Pitot PSI:

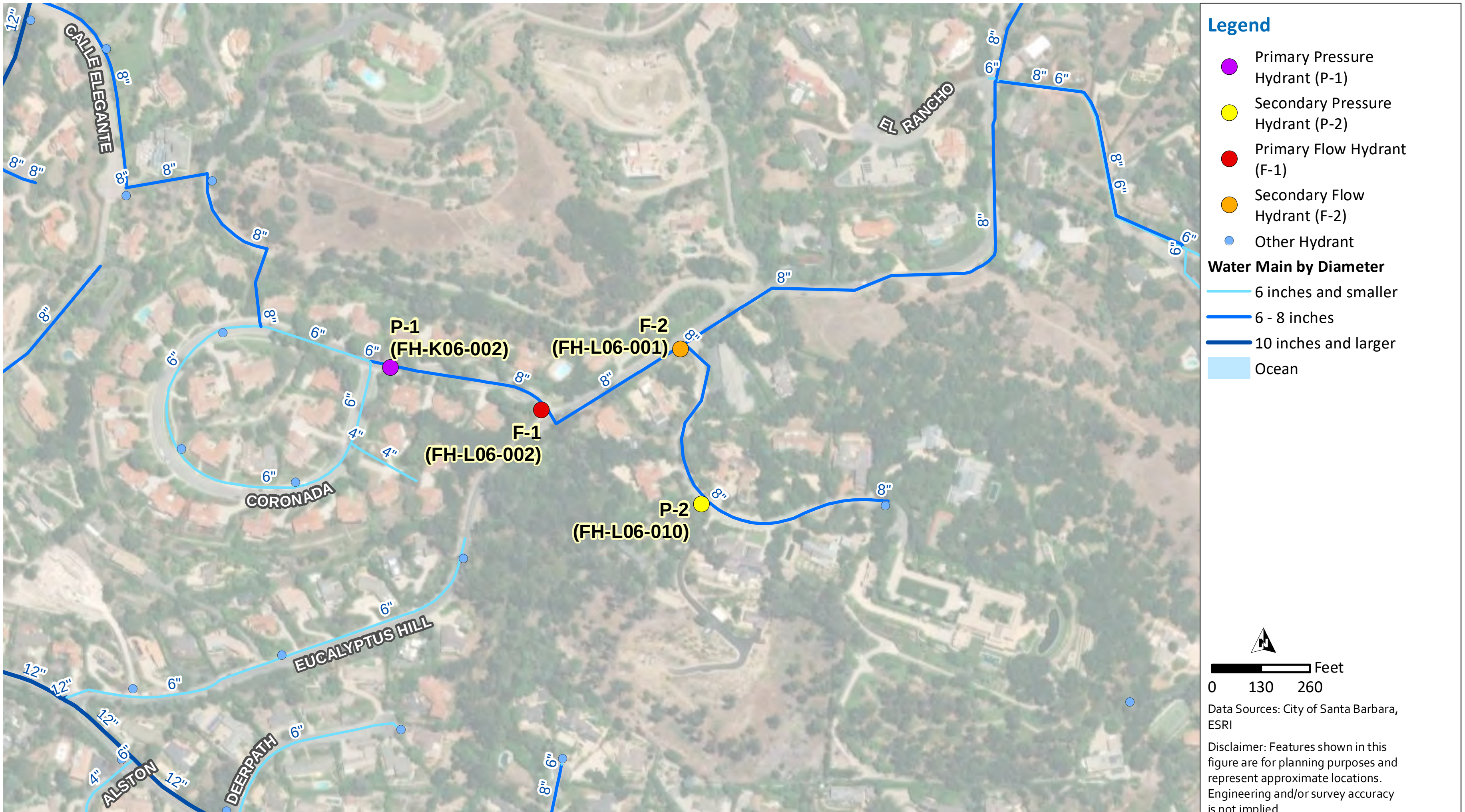
Flow GPM:

Duration:

Vicinity Map



Last Revised: January 28, 2020 Carollo/Documents/Client/CA/Santa&space;Barbara/11370A00/GIS/FireHydrantTestingDetails_Filled_Out_Sheets.mxd



Test Location: Eucalyptus Hill and Coronada
____
Date/Time: ______________________
Temperature: ______________________
Notes/Observations: ______________________
____
____
____
____

Flowing Hydrant
Hydrant #: FH-L06-002
Make: ______________
Main Size: ______________
Static PSI: ______________
Residual PSI: ______________
Pitot PSI: ______________
Flow GPM: 999 gpm
Duration: ______________

Pressure Hydrant 1
Hydrant #: FH-K06-002
Make: ______________
Main Size: ______________
Static PSI: 120 psi
Residual PSI: 60 psi

Pressure Hydrant 2
Hydrant #: FH-L06-010
Make: ______________
Main Size: ______________
Static PSI: 125 psi
Residual PSI: 81 psi

Hydrant #: FH-L06-001
Make: ______________
Main Size: ______________
Static PSI: ______________
Residual PSI: ______________
Pitot PSI: ______________
Flow GPM: ______________
Duration: ______________

Vicinity Map

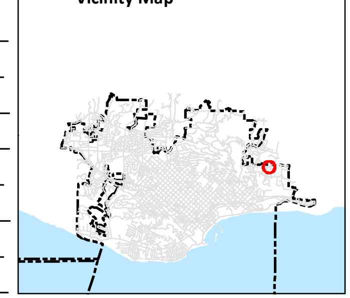
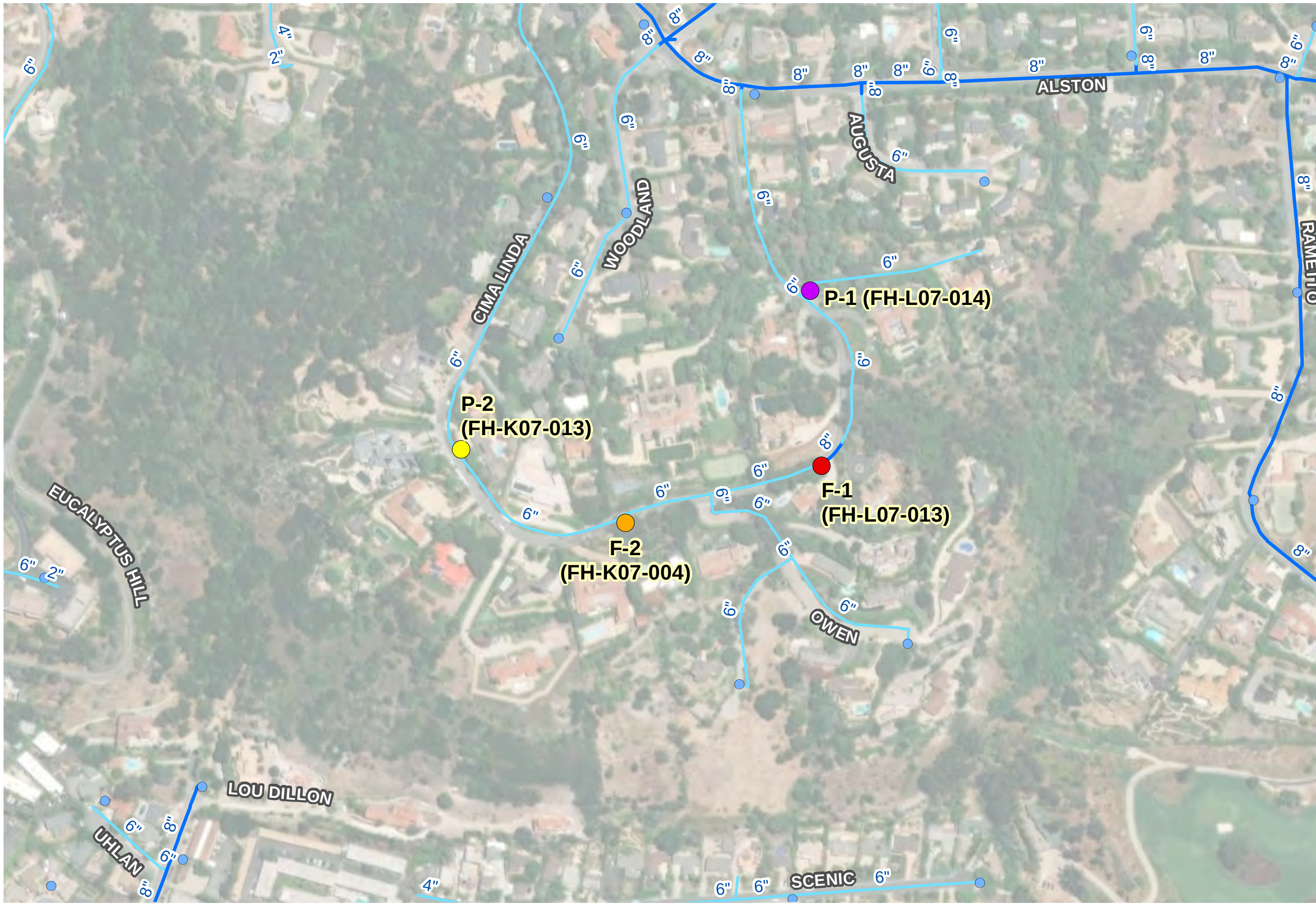


Figure 23 Fire Flow Test Site 23



Legend

- Primary Pressure Hydrant (P-1)
- Secondary Pressure Hydrant (P-2)
- Primary Flow Hydrant (F-1)
- Secondary Flow Hydrant (F-2)
- Other Hydrant

Water Main by Diameter

- 6 inches and smaller
- 6 - 8 inches
- 10 inches and larger
- Ocean

Feet
0 130 260

Data Sources: City of Santa Barbara, ESRI

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Test Location: Cima Linda

Date/Time:

Temperature:

Notes/Observations:

Flowing Hydrant

Hydrant #: FH-L07-013
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM: 1158 gpm
Duration:

Pressure Hydrant 1

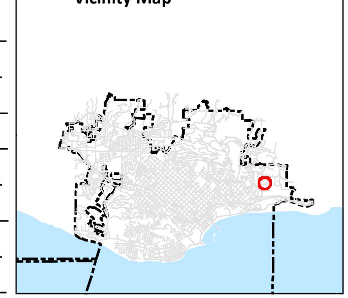
Hydrant #: FH-L07-014
Make:
Main Size:
Static PSI: 135 psi
Residual PSI: 80 psi

Pressure Hydrant 2

Hydrant #: FH-K07-013
Make:
Main Size:
Static PSI: 145 psi
Residual PSI: 84 psi

Hydrant #: FH-K07-004
Make:
Main Size:
Static PSI:
Residual PSI:
Pitot PSI:
Flow GPM:
Duration:

Vicinity Map



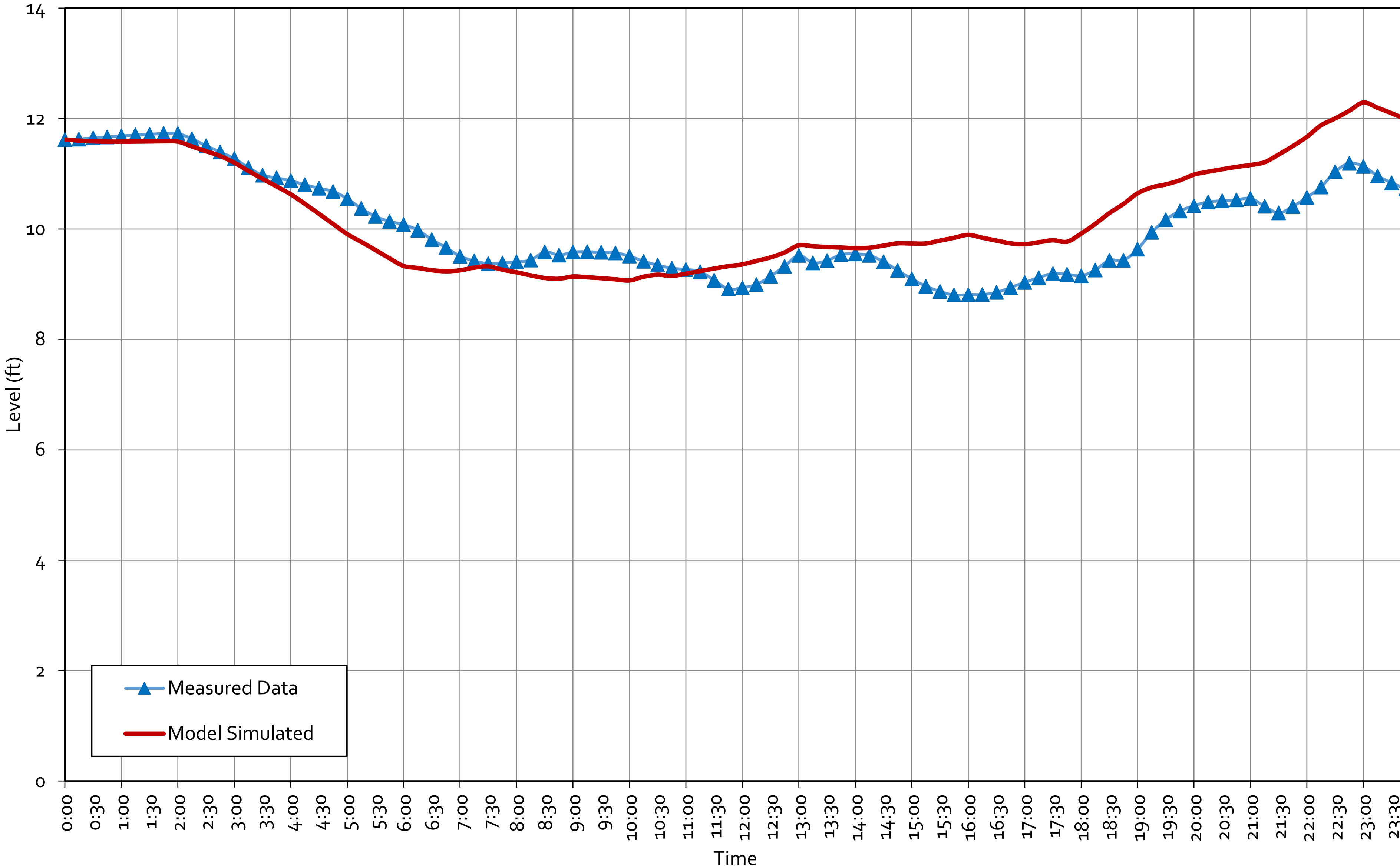
Last Revised: January 28, 2020 Carollo/Documents/Client/CA/Santa&space;Barbara/11370A00/GIS/FireHydrantTestingDetails_Filled_Out_Sheets.mxd

Appendix 1B

EXTENDED PERIOD SIMULATION CALIBRATION RESULTS

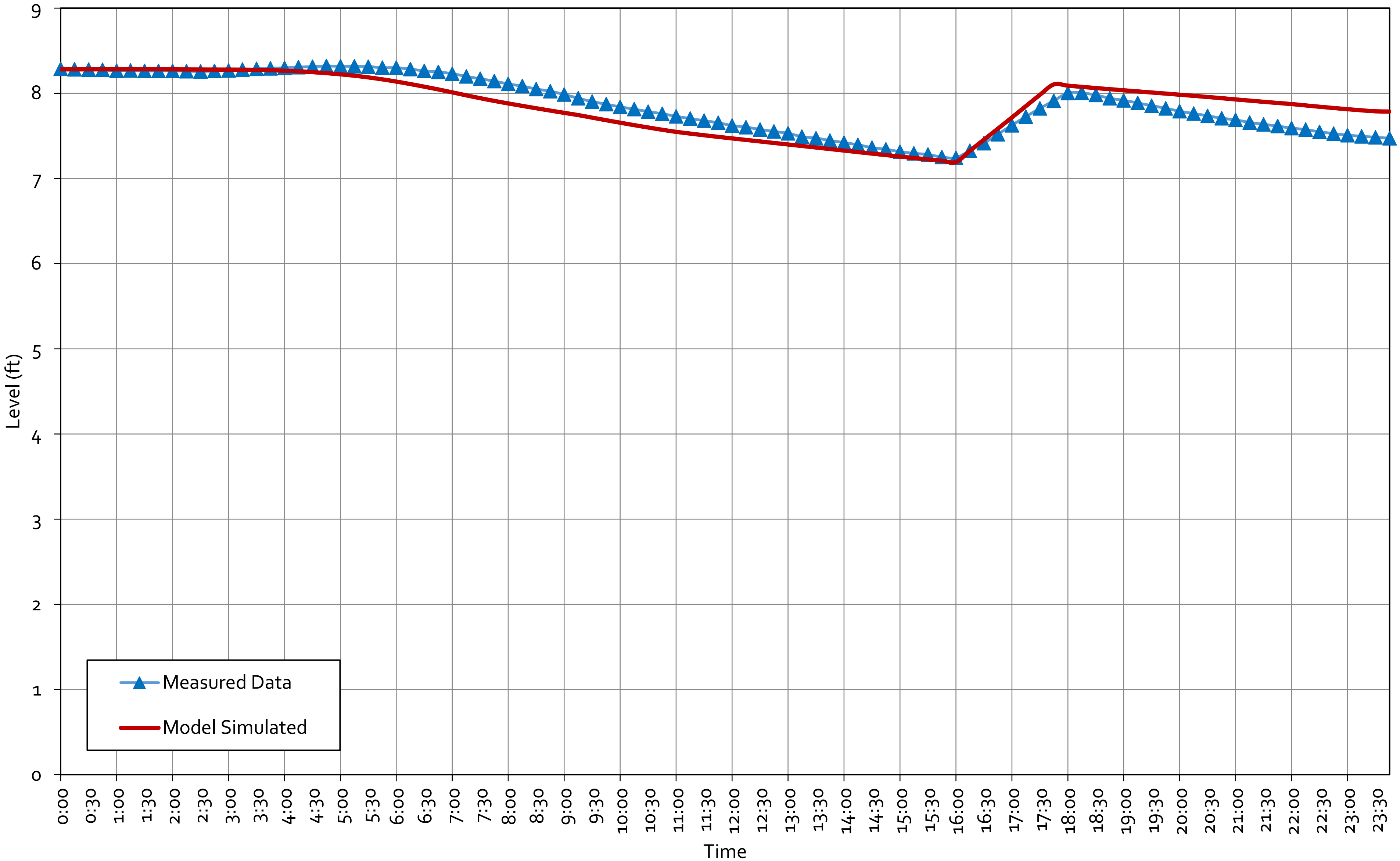
Water Distribution Infrastructure Plan

EPS CALIBRATION - CATER CLEARWELL



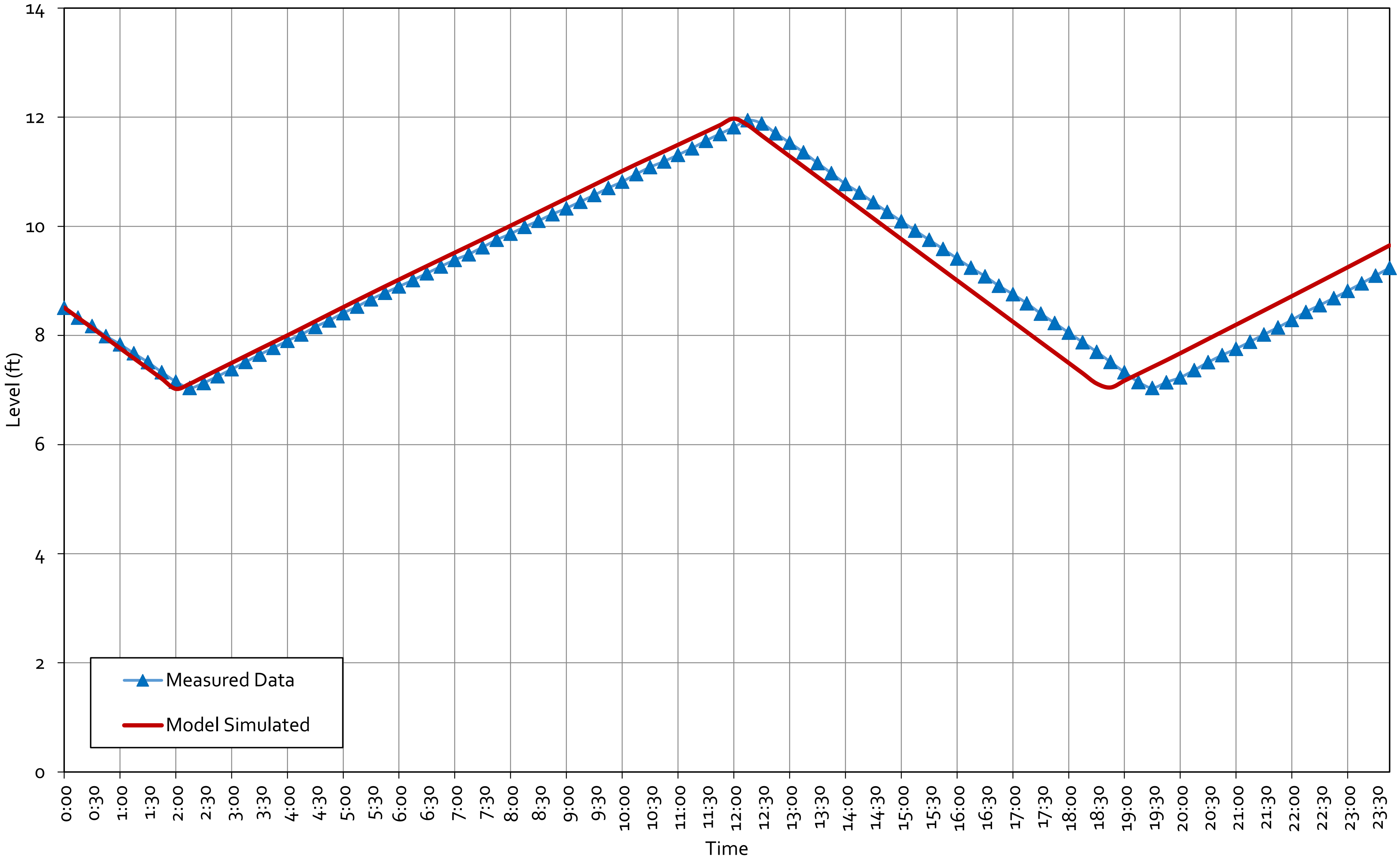
Water Distribution Infrastructure Plan

EPS CALIBRATION - VIC TRACE RESERVOIR



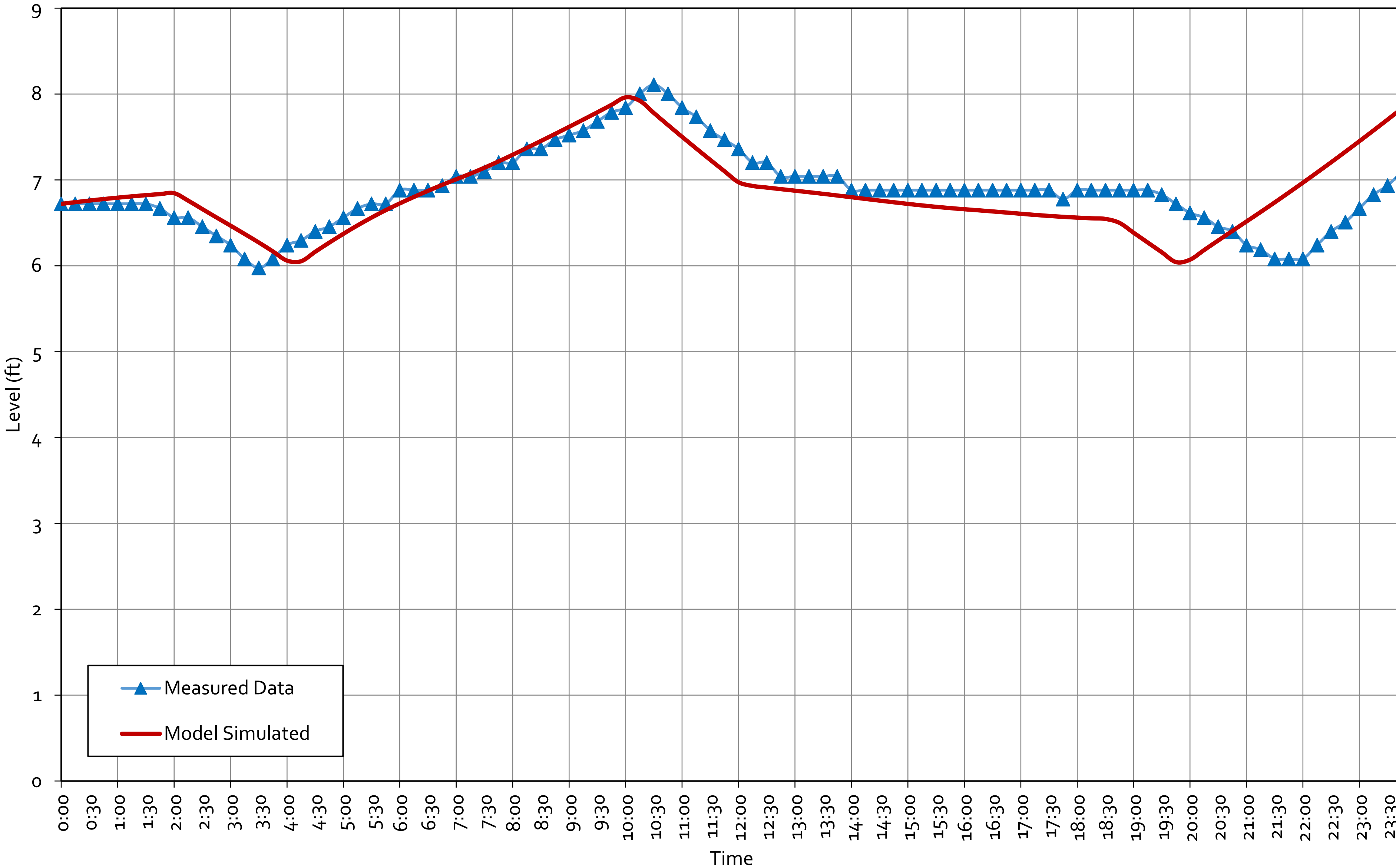
Water Distribution Infrastructure Plan

EPS CALIBRATION - SKOFIELD RESERVOIR



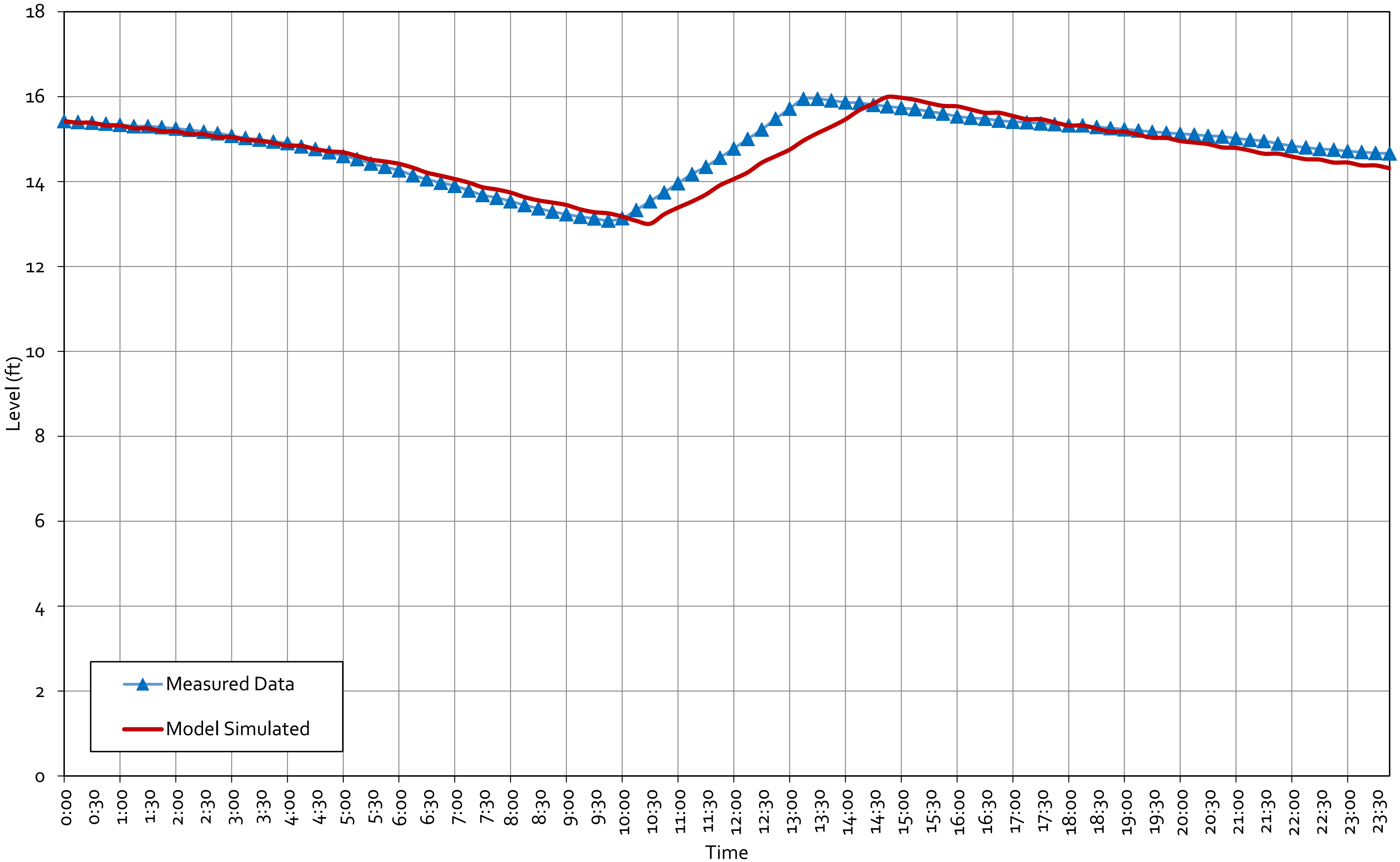
Water Distribution Infrastructure Plan

EPS CALIBRATION - EL CIELITO RESERVOIR



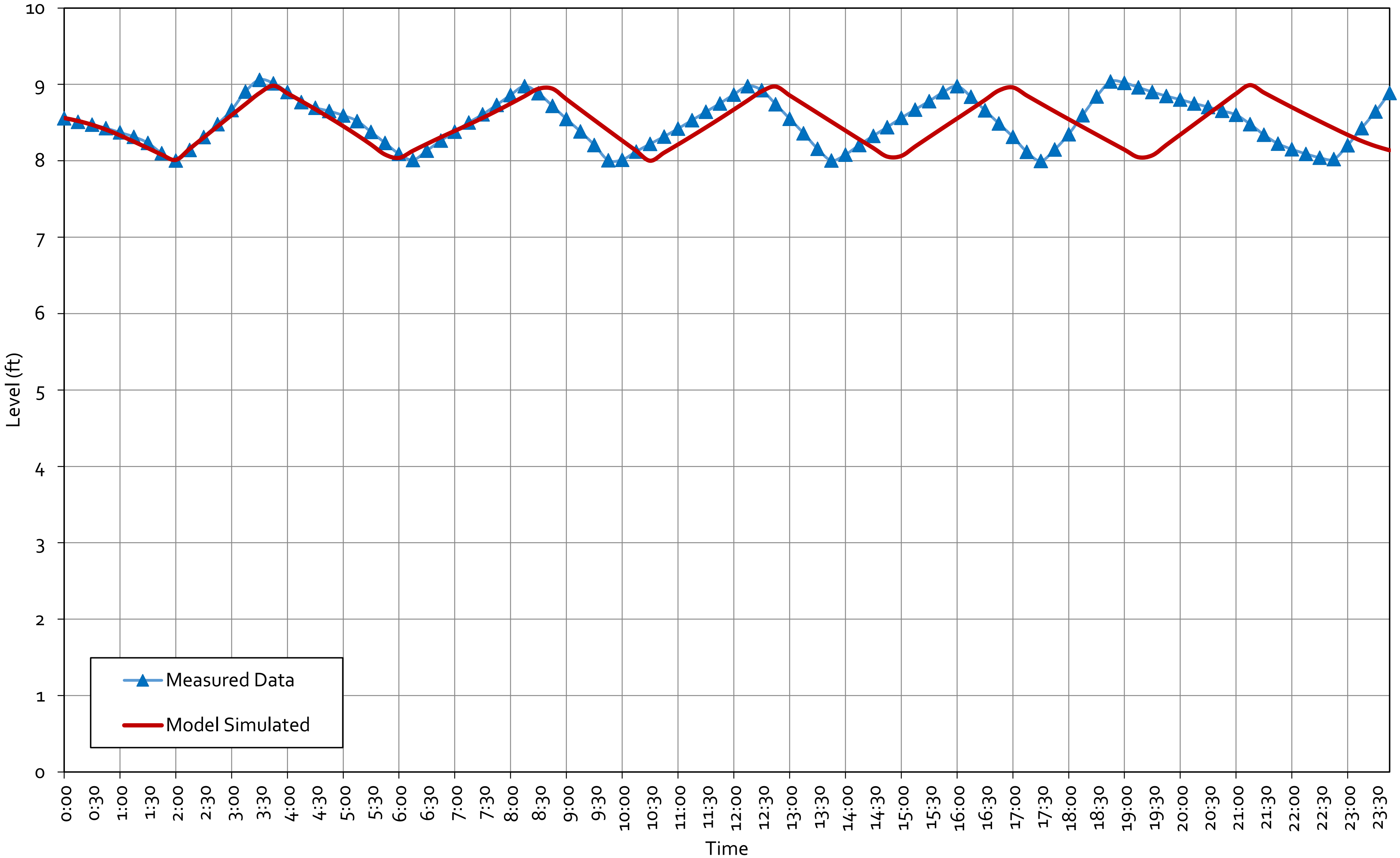
Water Distribution Infrastructure Plan

EPS CALIBRATION - EAST RESERVOIR



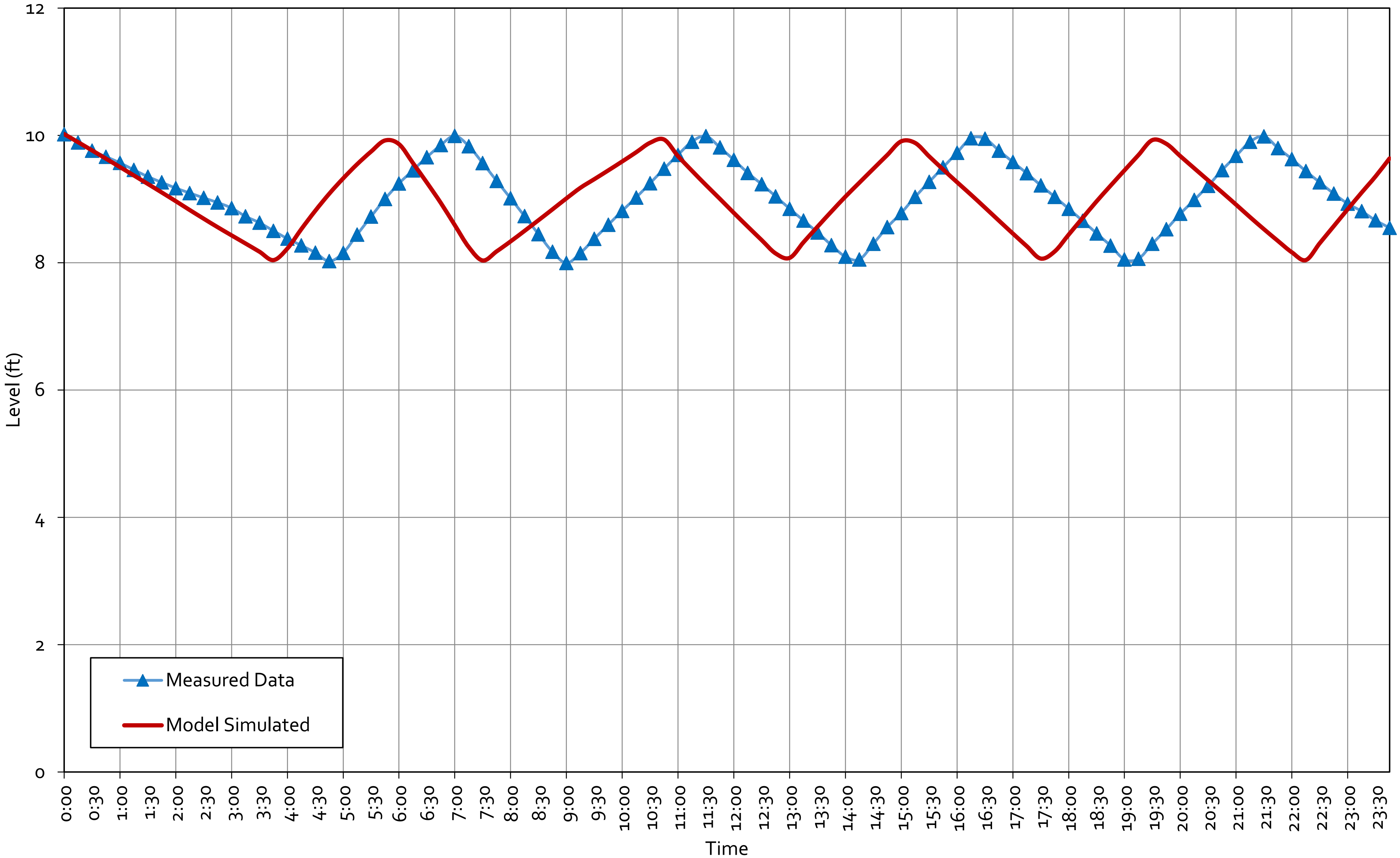
Water Distribution Infrastructure Plan

EPS CALIBRATION - LA VISTA RESERVOIR



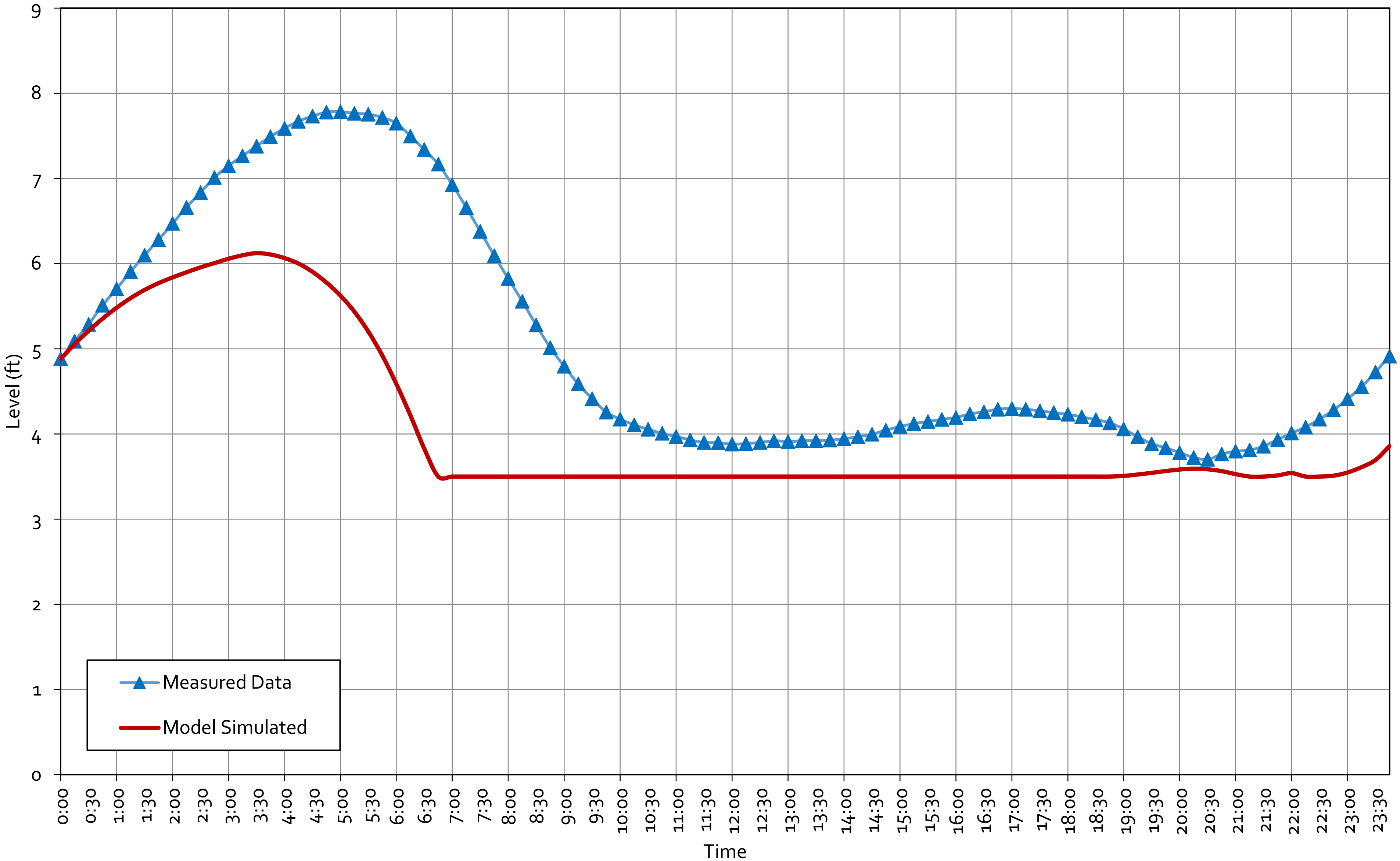
Water Distribution Infrastructure Plan

EPS CALIBRATION - RESERVOIR #2



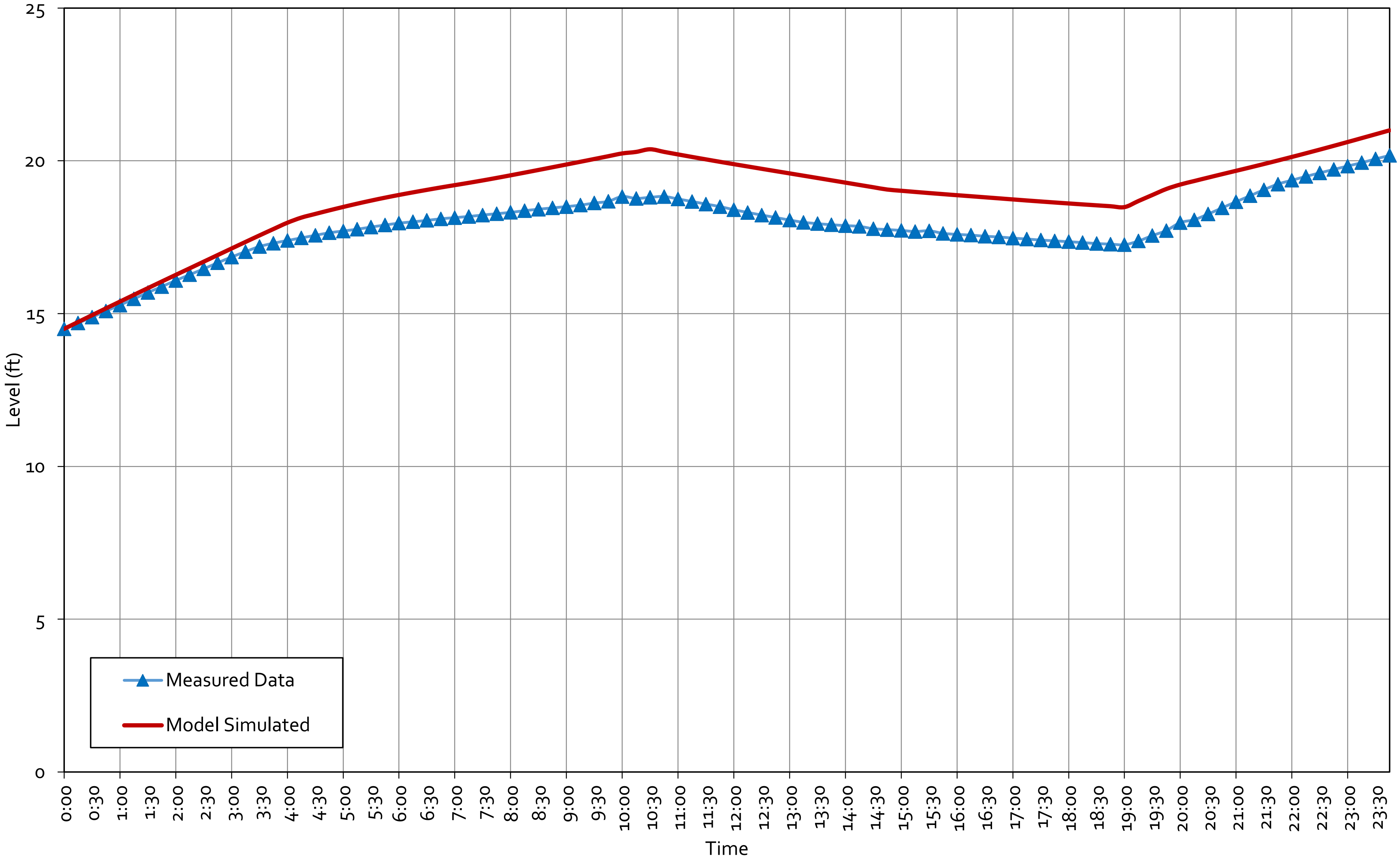
Water Distribution Infrastructure Plan

EPS CALIBRATION - RESERVOIR #1



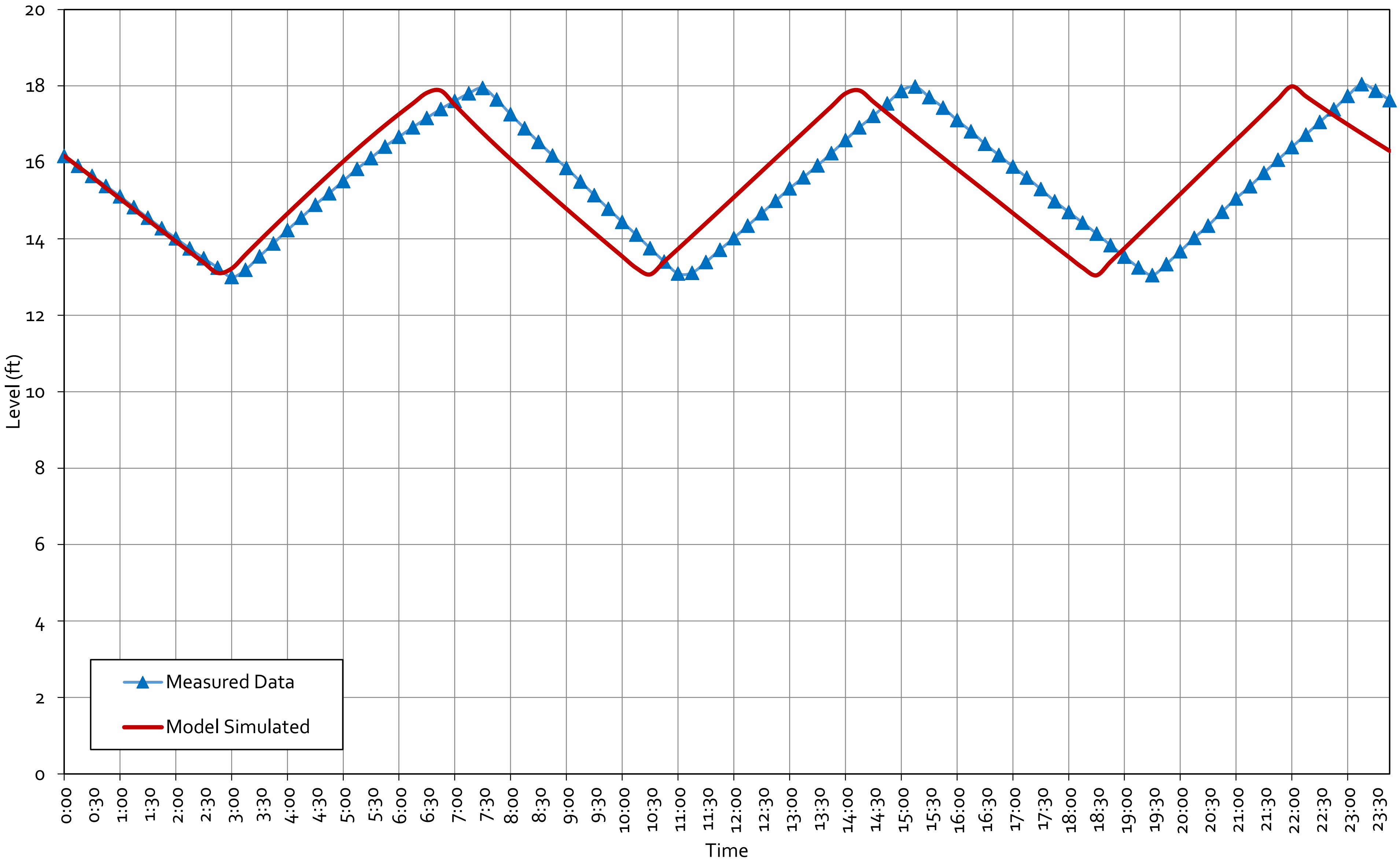
Water Distribution Infrastructure Plan

EPS CALIBRATION - MCLAUGHLIN RESERVOIR (NEW SHEFFIELD RESERVOIR)



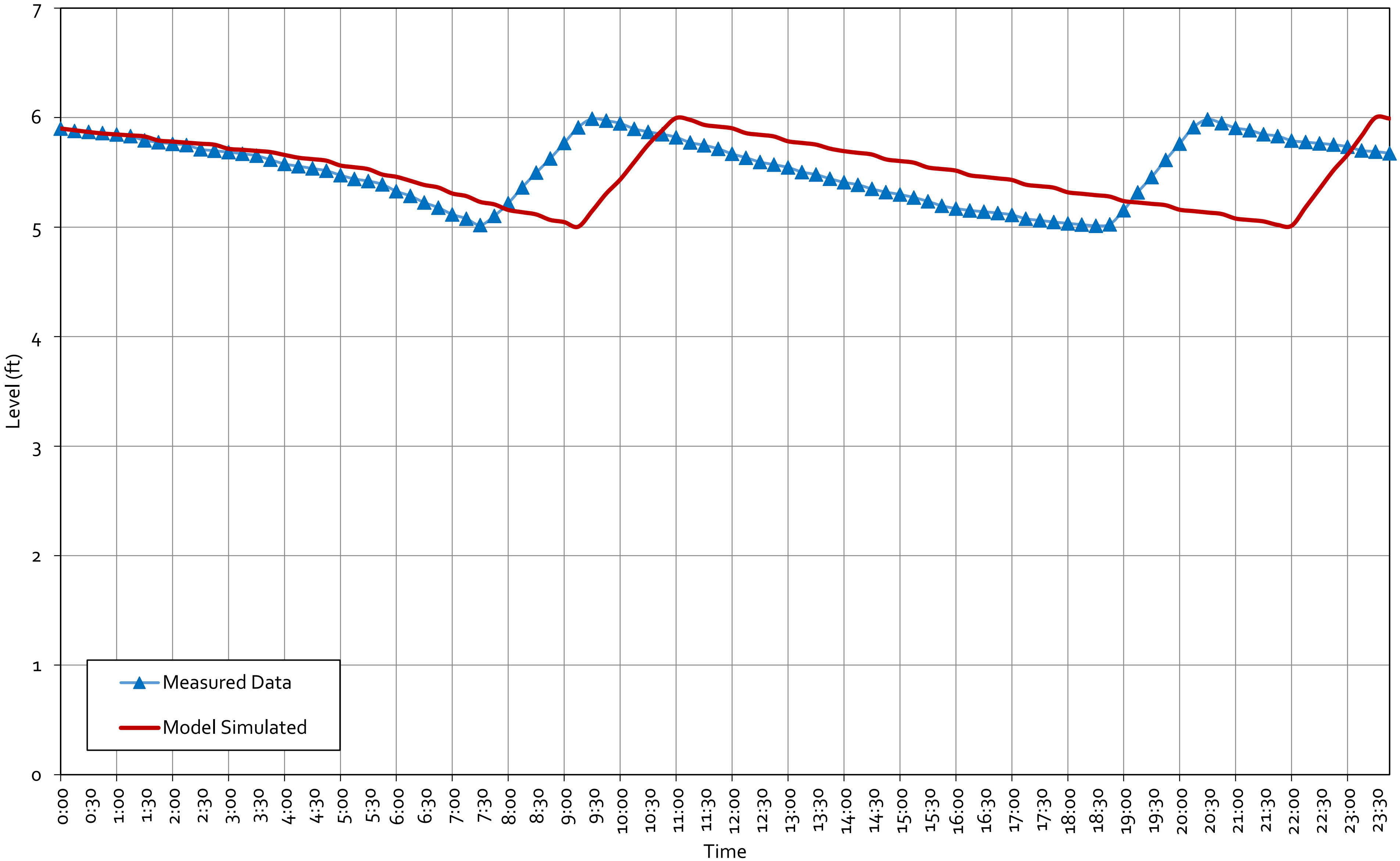
Water Distribution Infrastructure Plan

EPS CALIBRATION - TUNNEL ROAD RESERVOIR



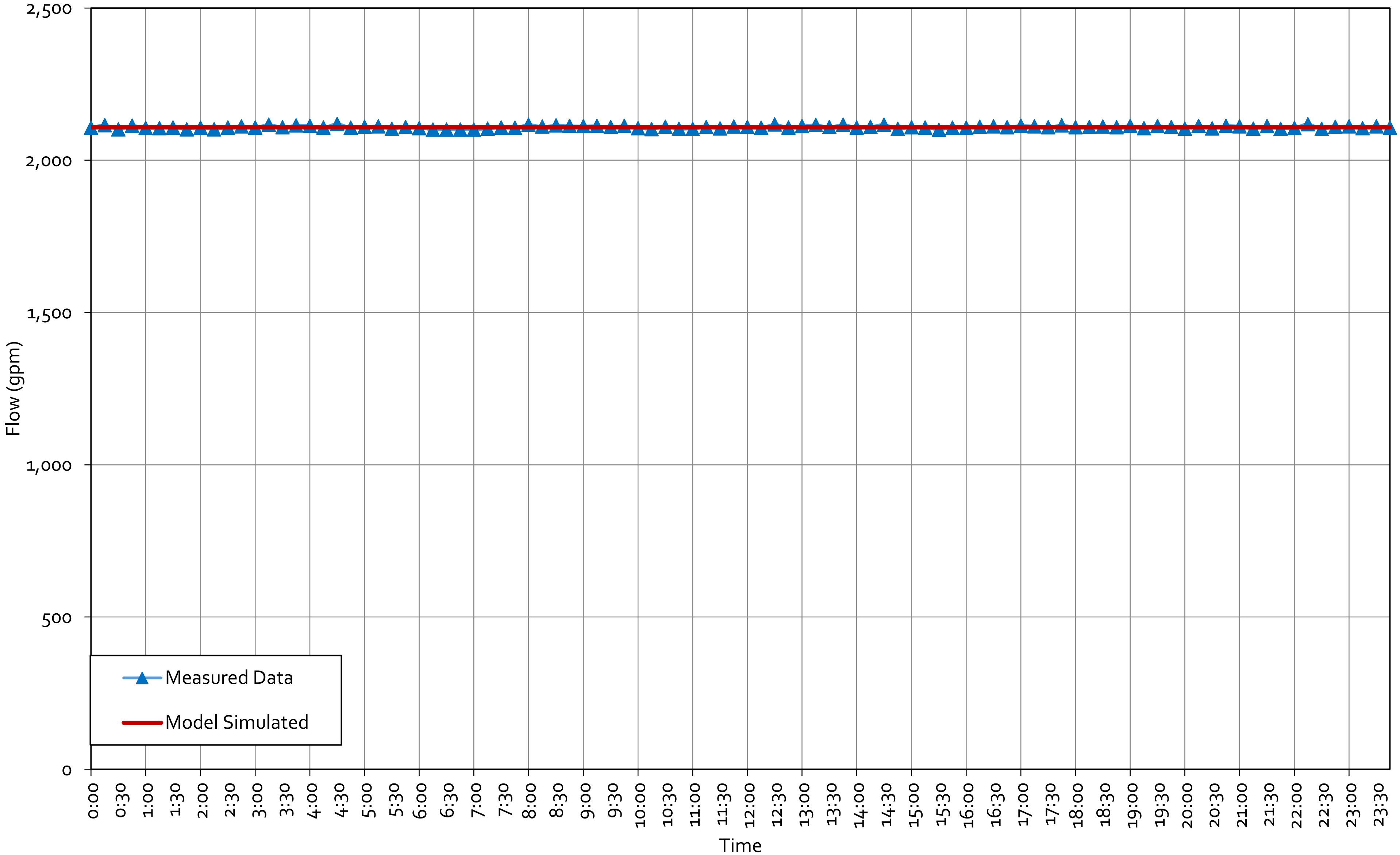
Water Distribution Infrastructure Plan

EPS CALIBRATION - HOPE RESERVOIR



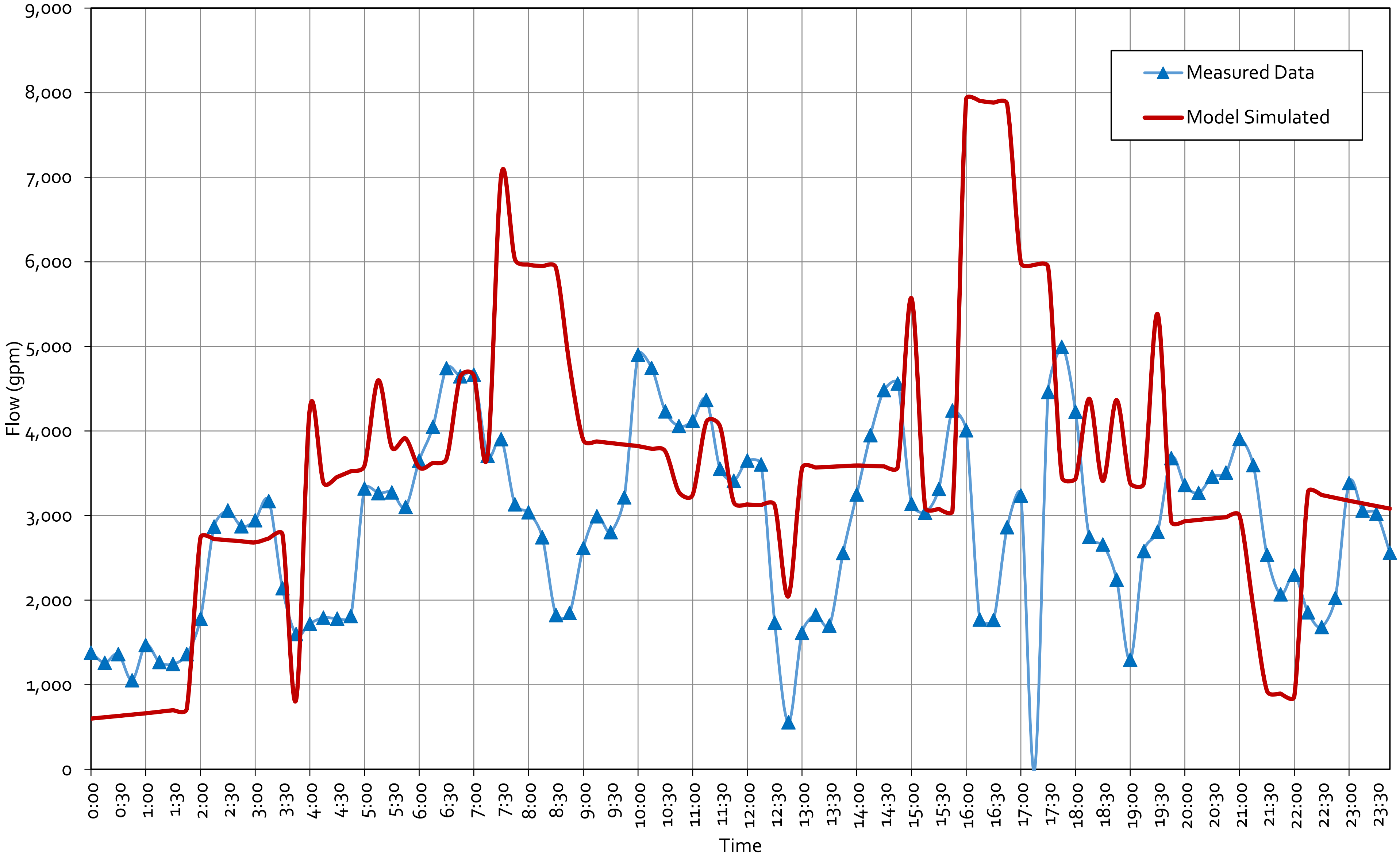
Water Distribution Infrastructure Plan

EPS CALIBRATION - DESAL PLANT FLOW



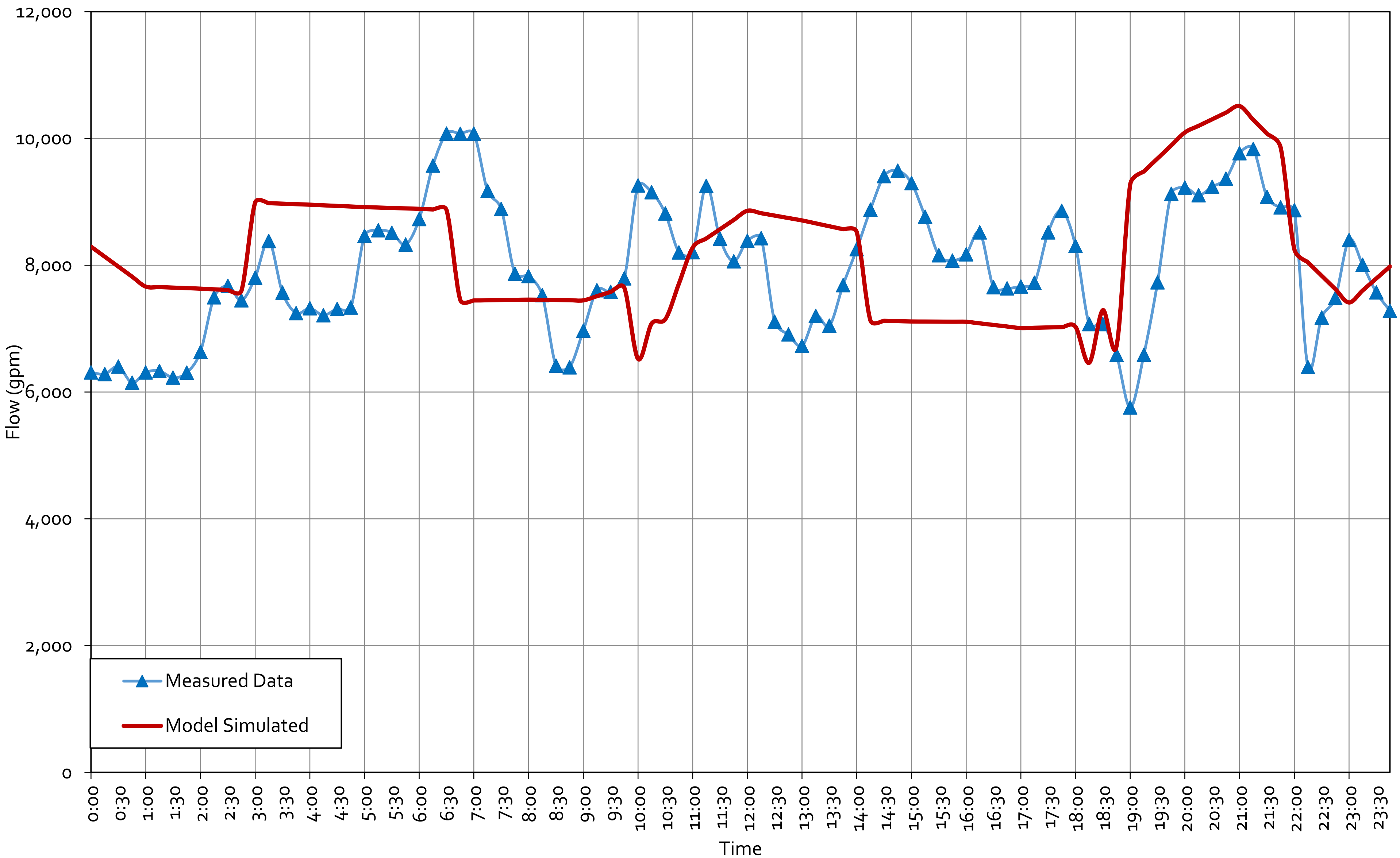
Water Distribution Infrastructure Plan

EPS CALIBRATION - CATER FLOW - 36" EFFLUENT



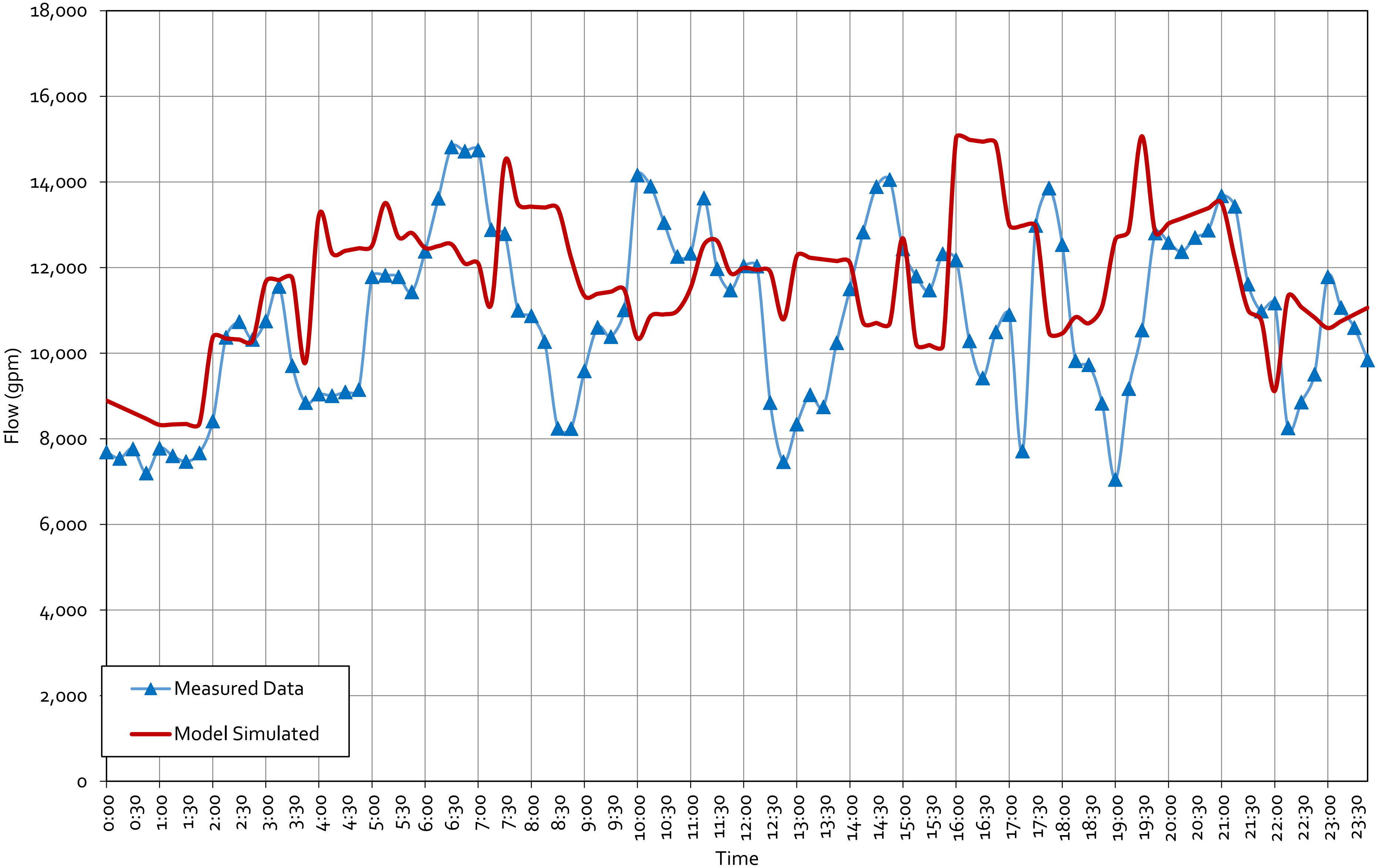
Water Distribution Infrastructure Plan

EPS CALIBRATION - CATER FLOW - 30" EFFLUENT



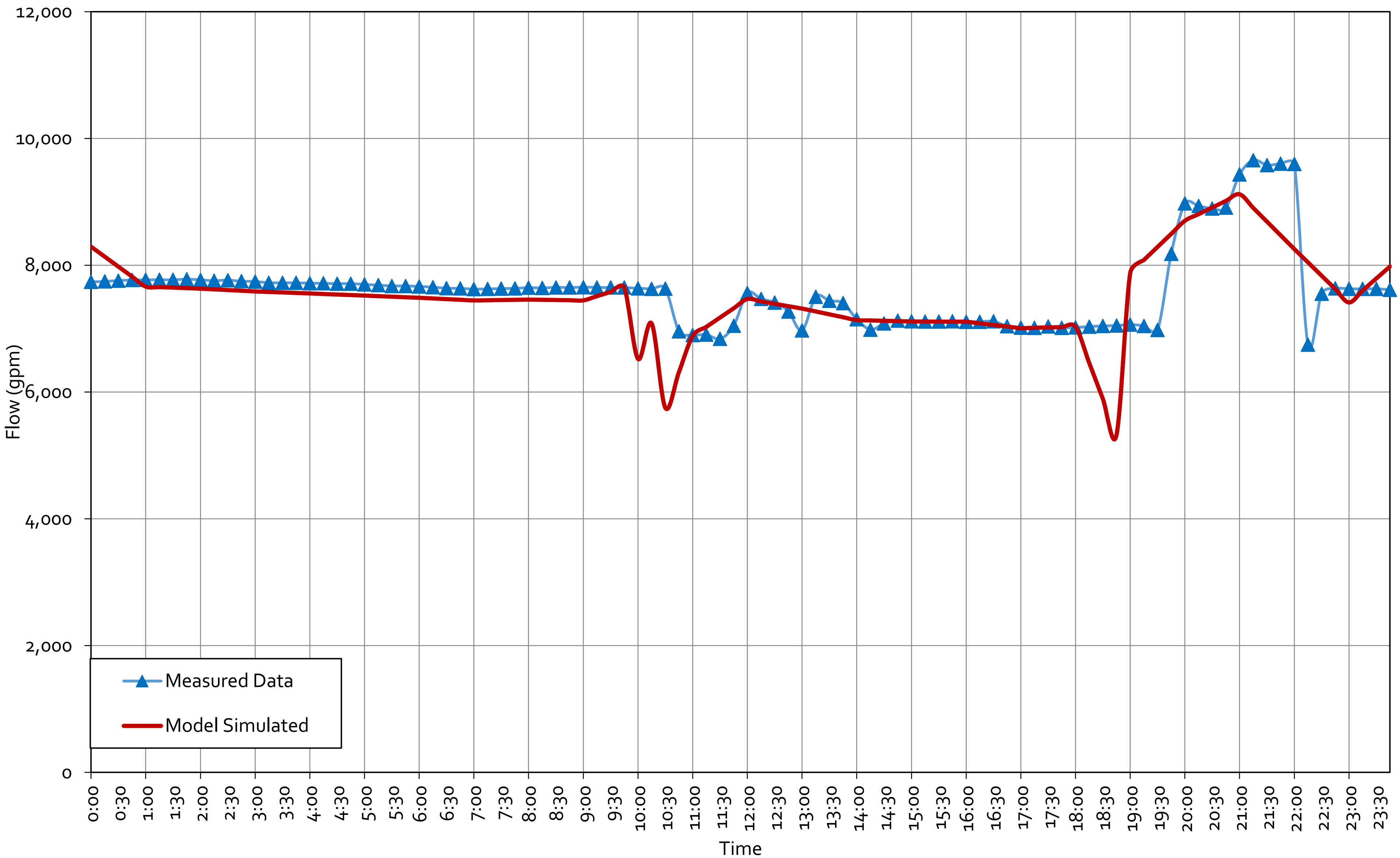
Water Distribution Infrastructure Plan

EPS CALIBRATION - CATER FLOW - 30" + 36" EFFLUENT



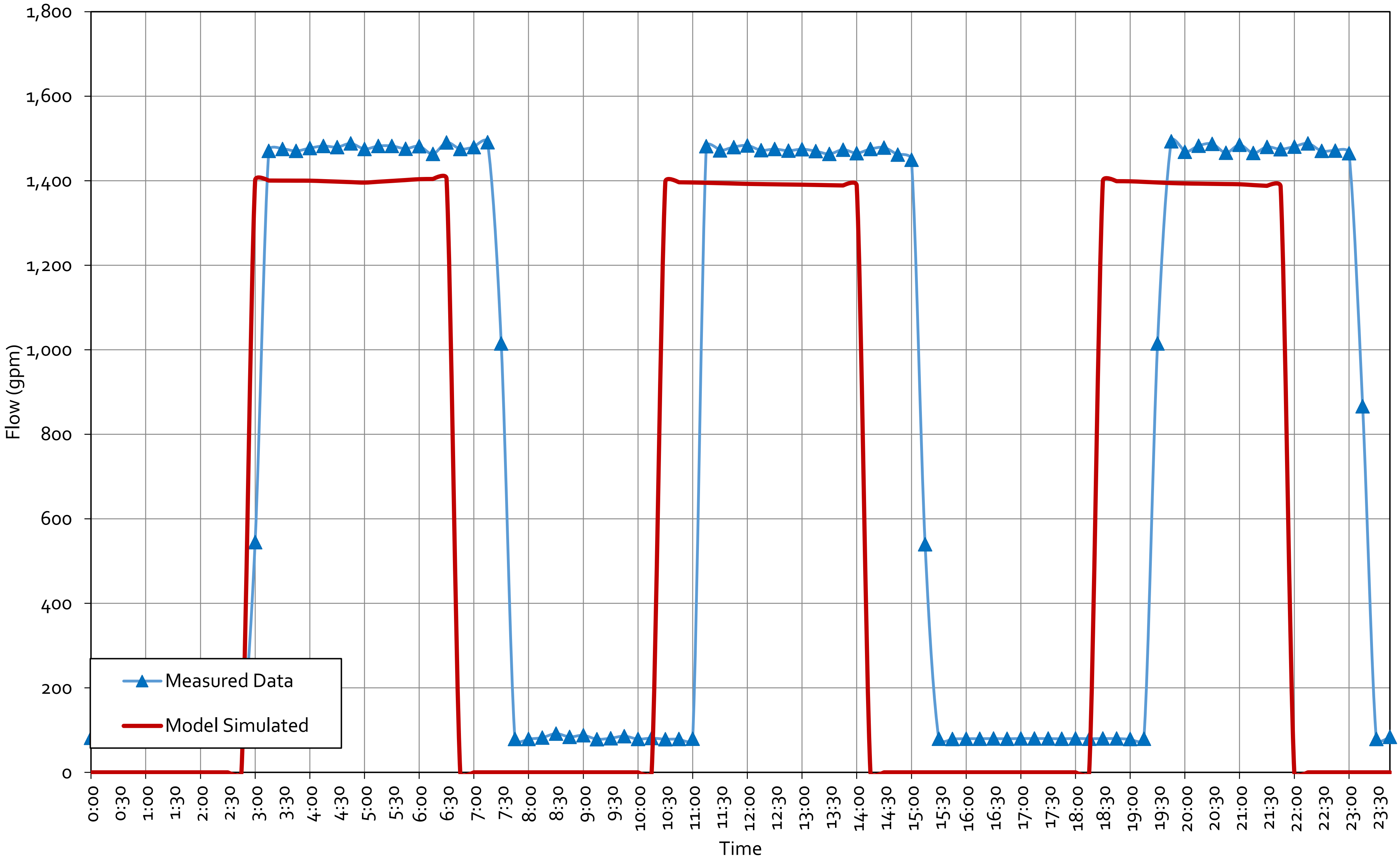
Water Distribution Infrastructure Plan

EPS CALIBRATION - SOUTH COAST CONDUIT



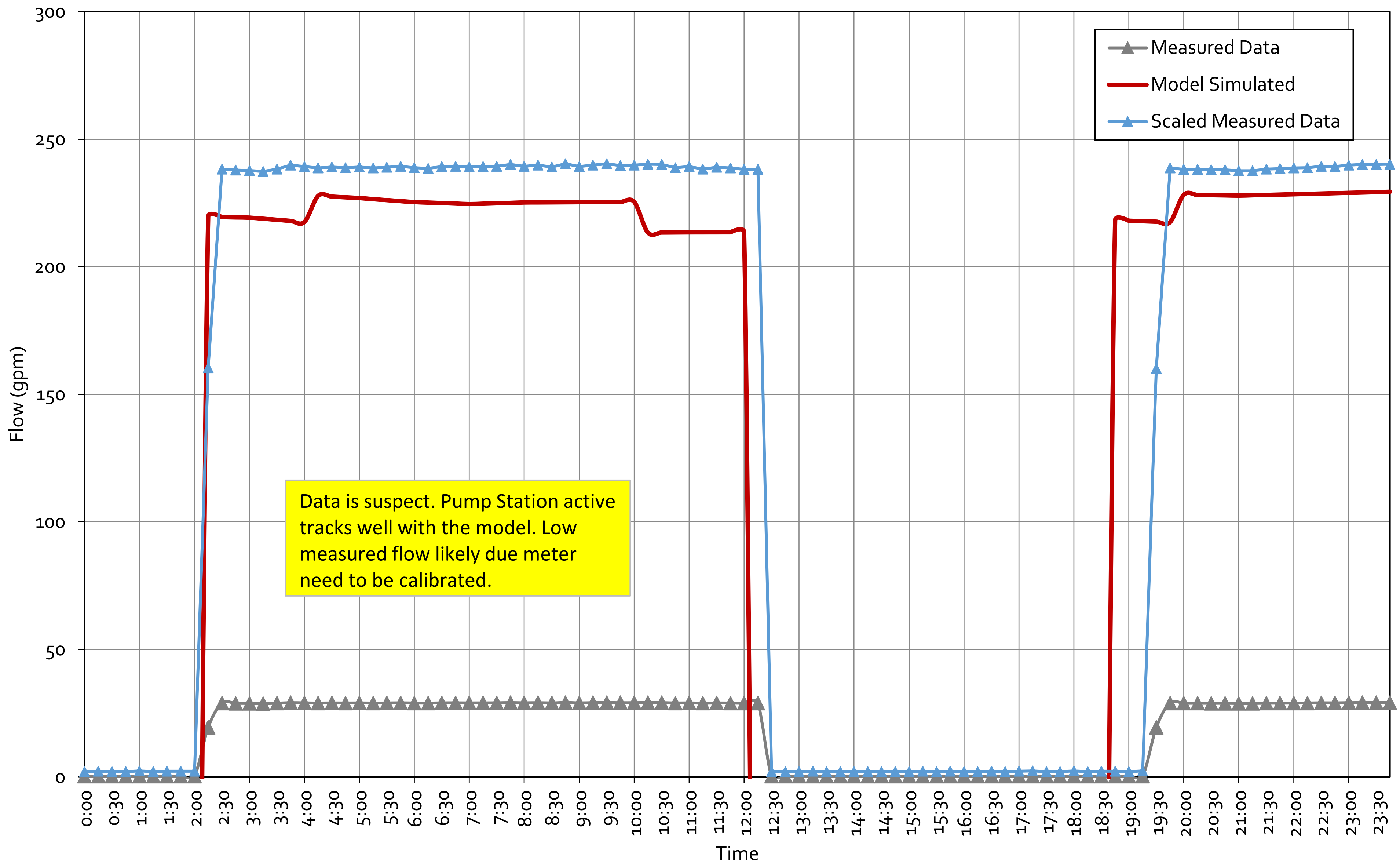
Water Distribution Infrastructure Plan

EPS CALIBRATION - CATER CROSS TIE PS FLOW



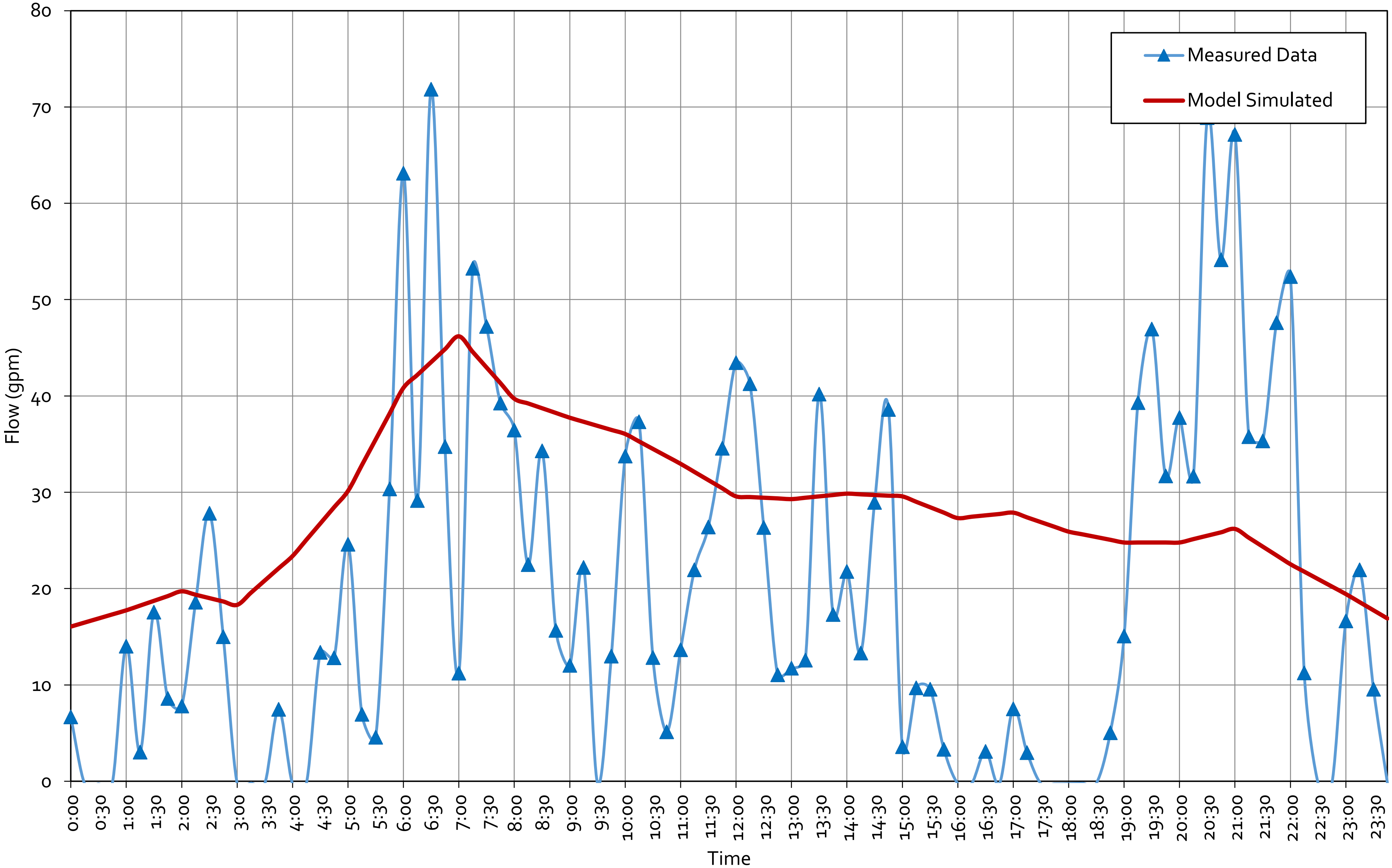
Water Distribution Infrastructure Plan

EPS CALIBRATION - SKOFIELD PS FLOW



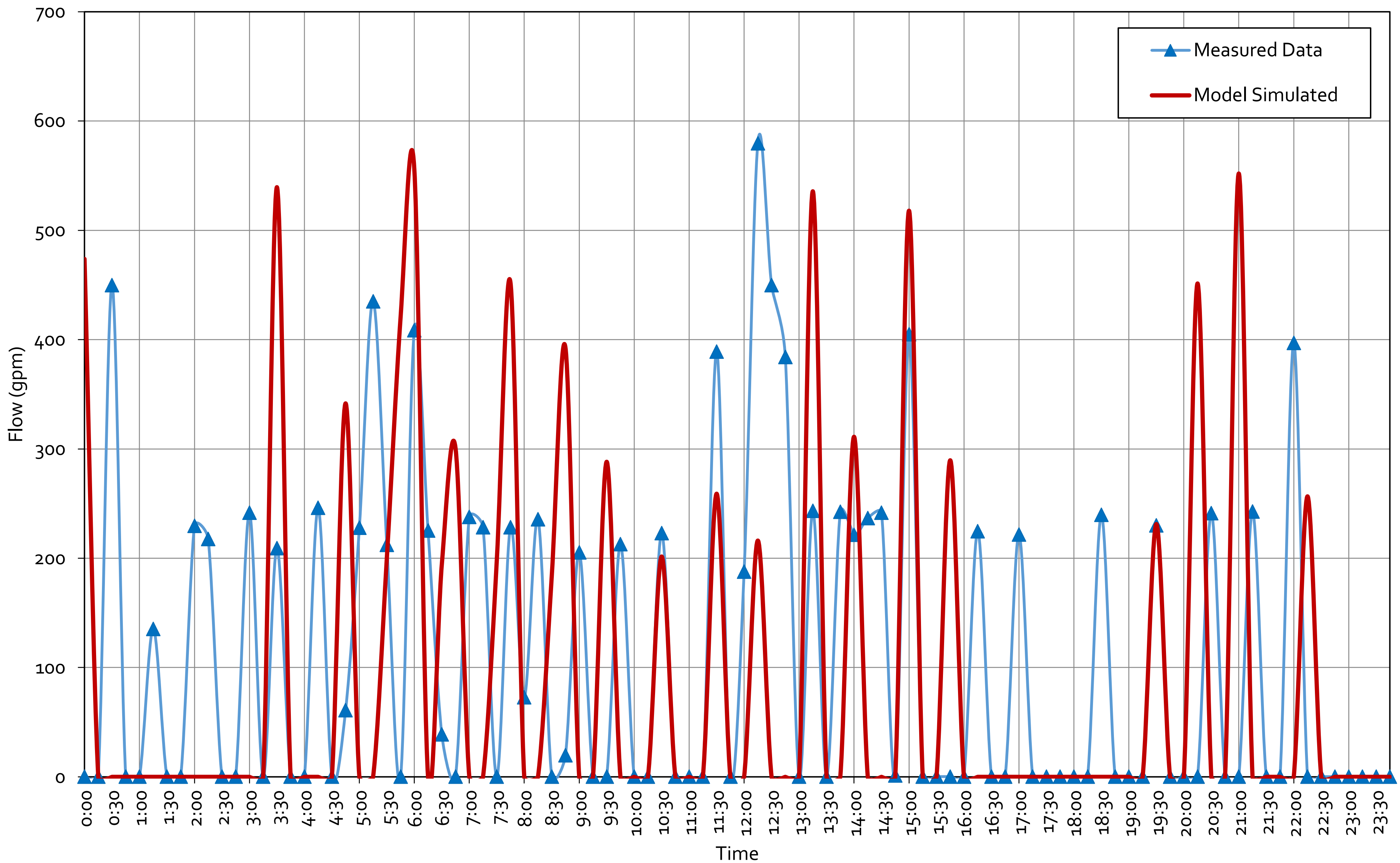
Water Distribution Infrastructure Plan

EPS CALIBRATION - CAMPANIL PS FLOW



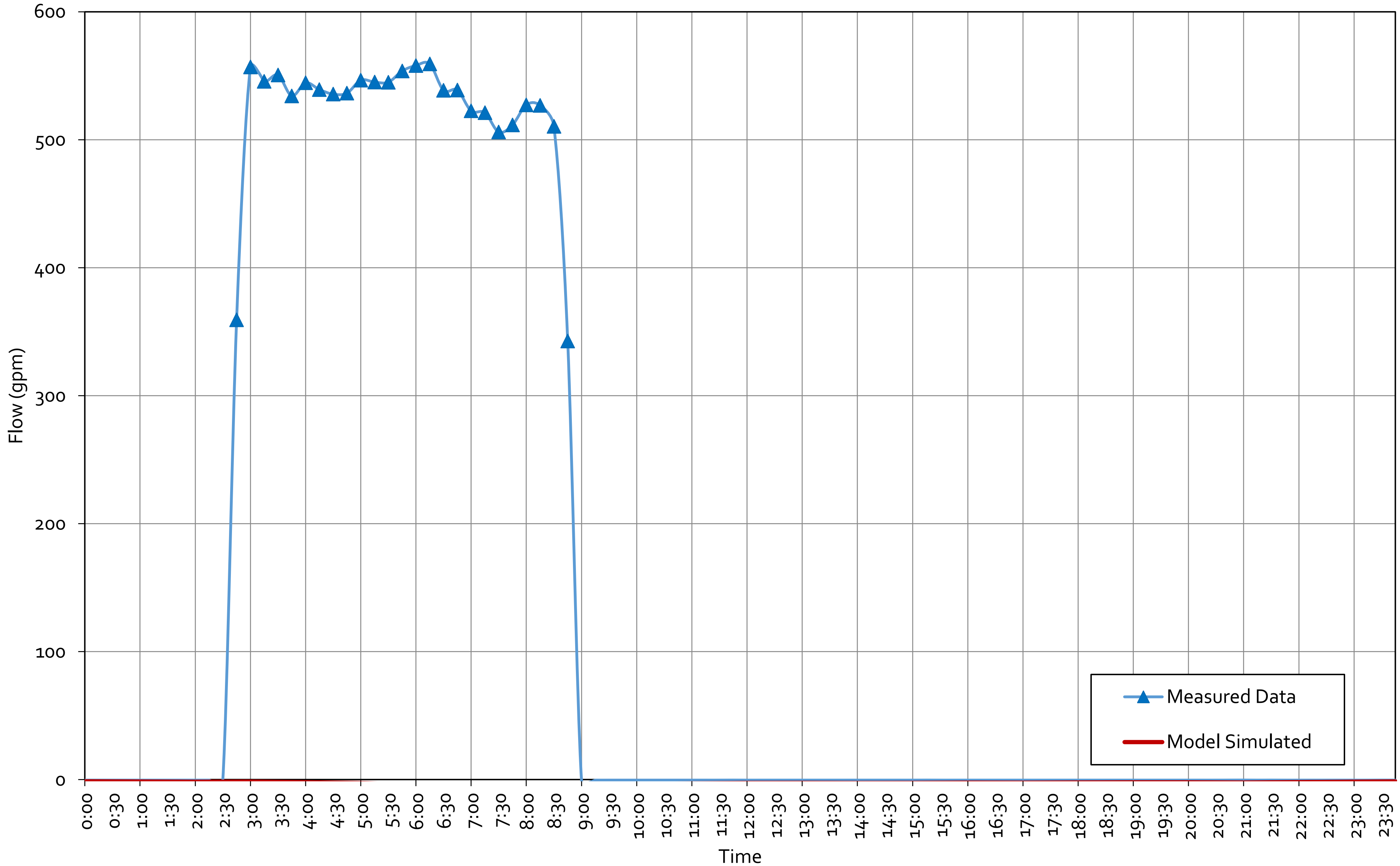
Water Distribution Infrastructure Plan

EPS CALIBRATION - BOTHIN PS FLOW



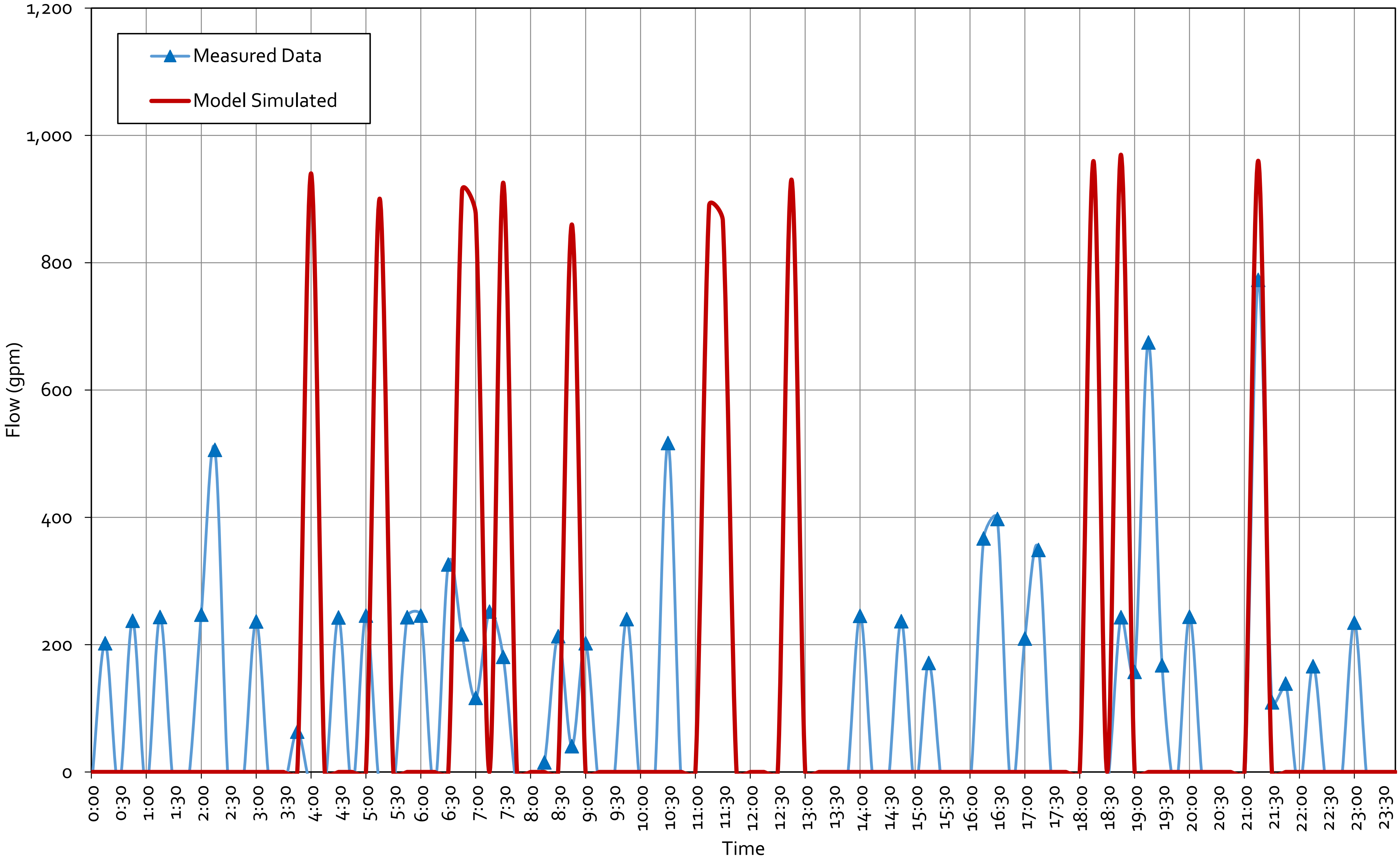
Water Distribution Infrastructure Plan

EPS CALIBRATION - PADRE PS FLOW



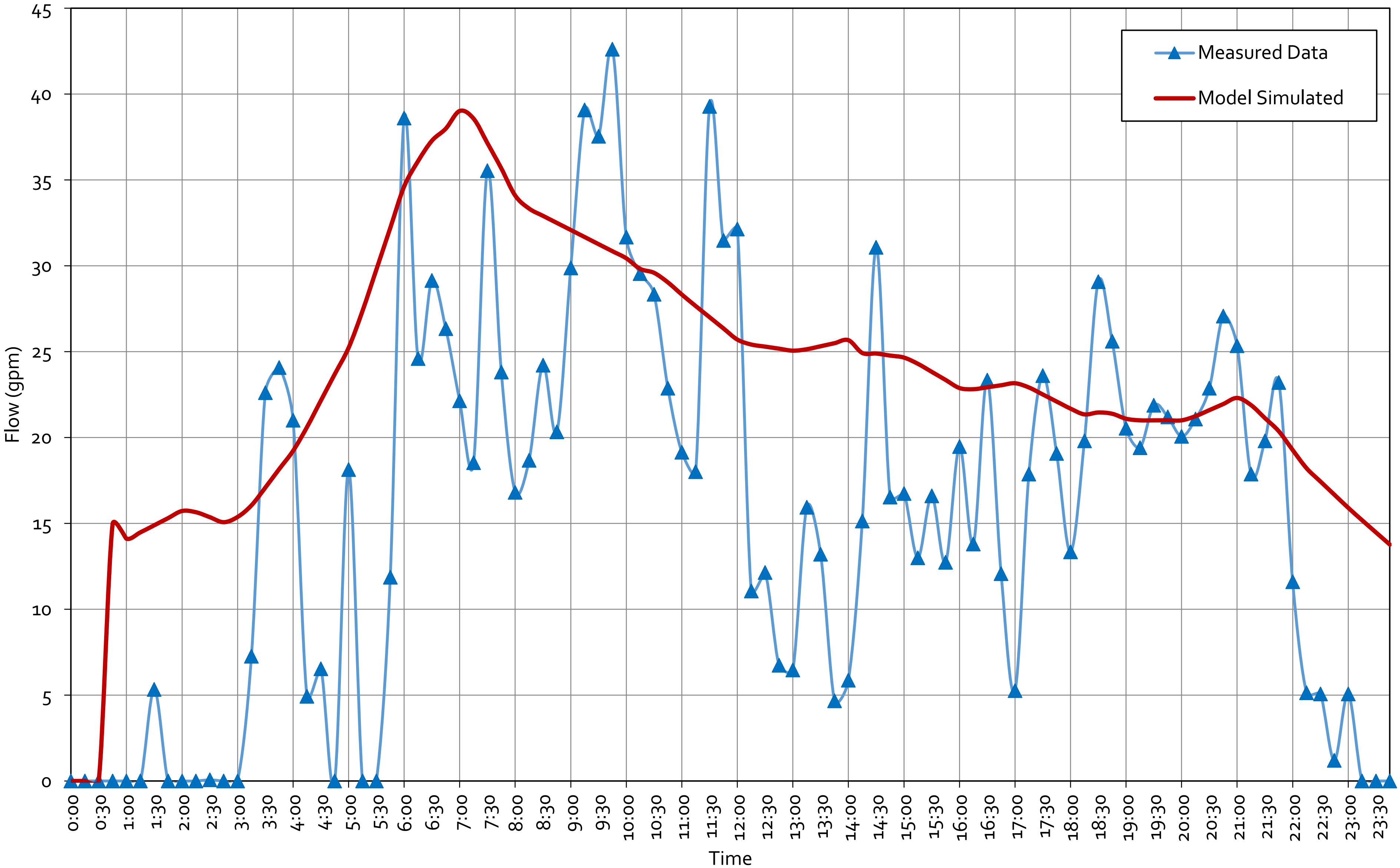
Water Distribution Infrastructure Plan

EPS CALIBRATION - ESCONDIDO PS FLOW



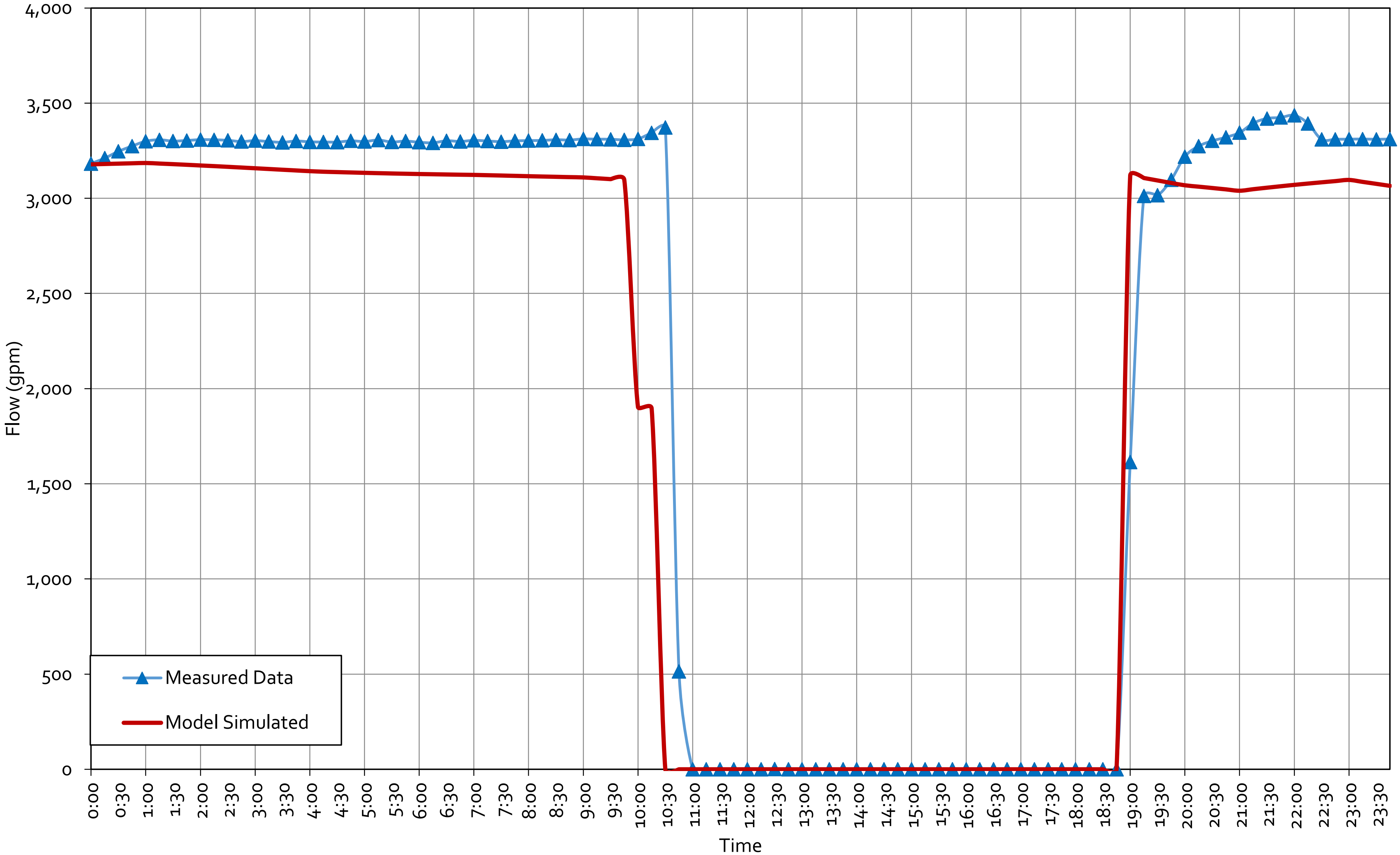
Water Distribution Infrastructure Plan

EPS CALIBRATION - TUNNEL PS FLOW



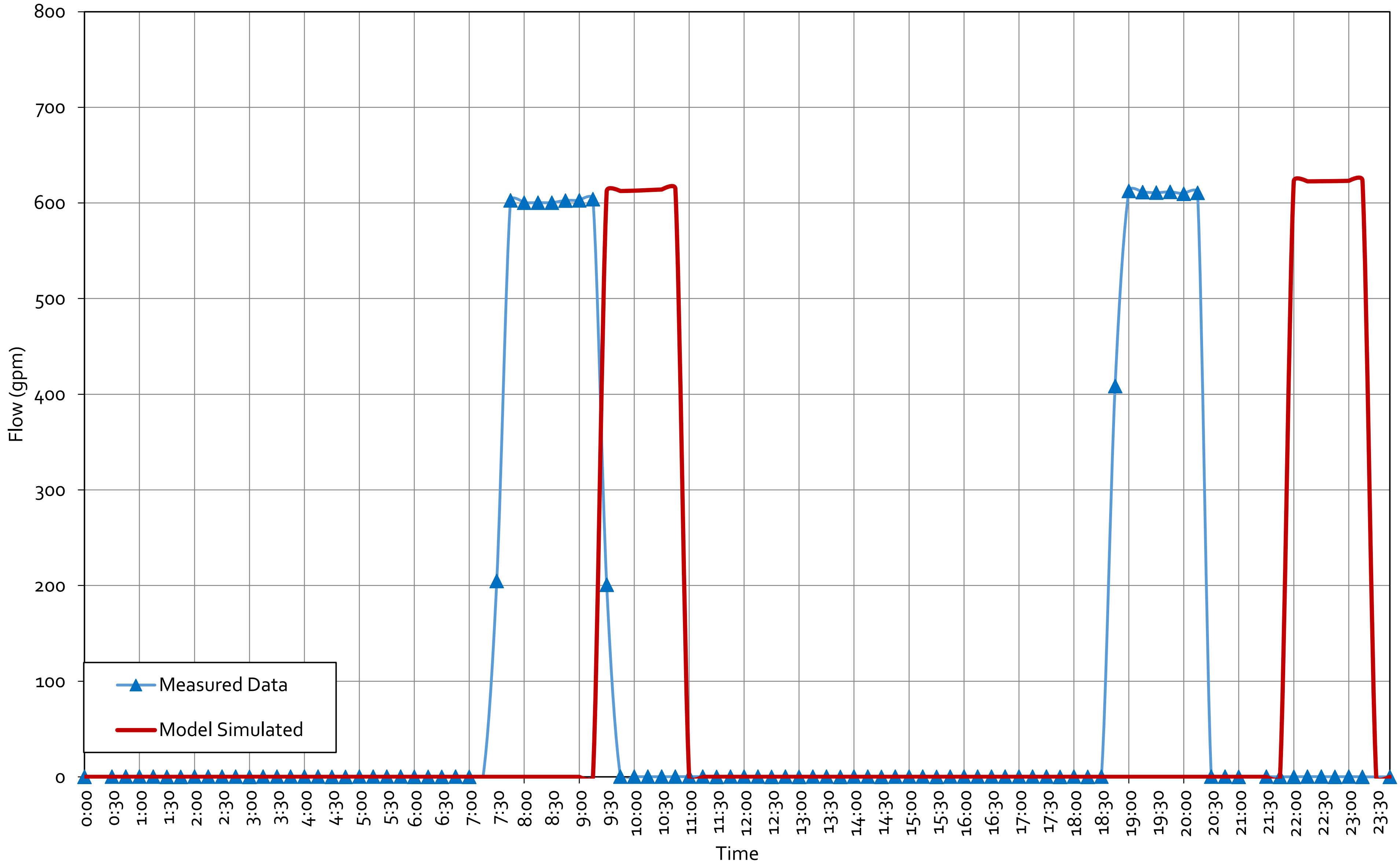
Water Distribution Infrastructure Plan

EPS CALIBRATION - SHEFFIELD PS FLOW



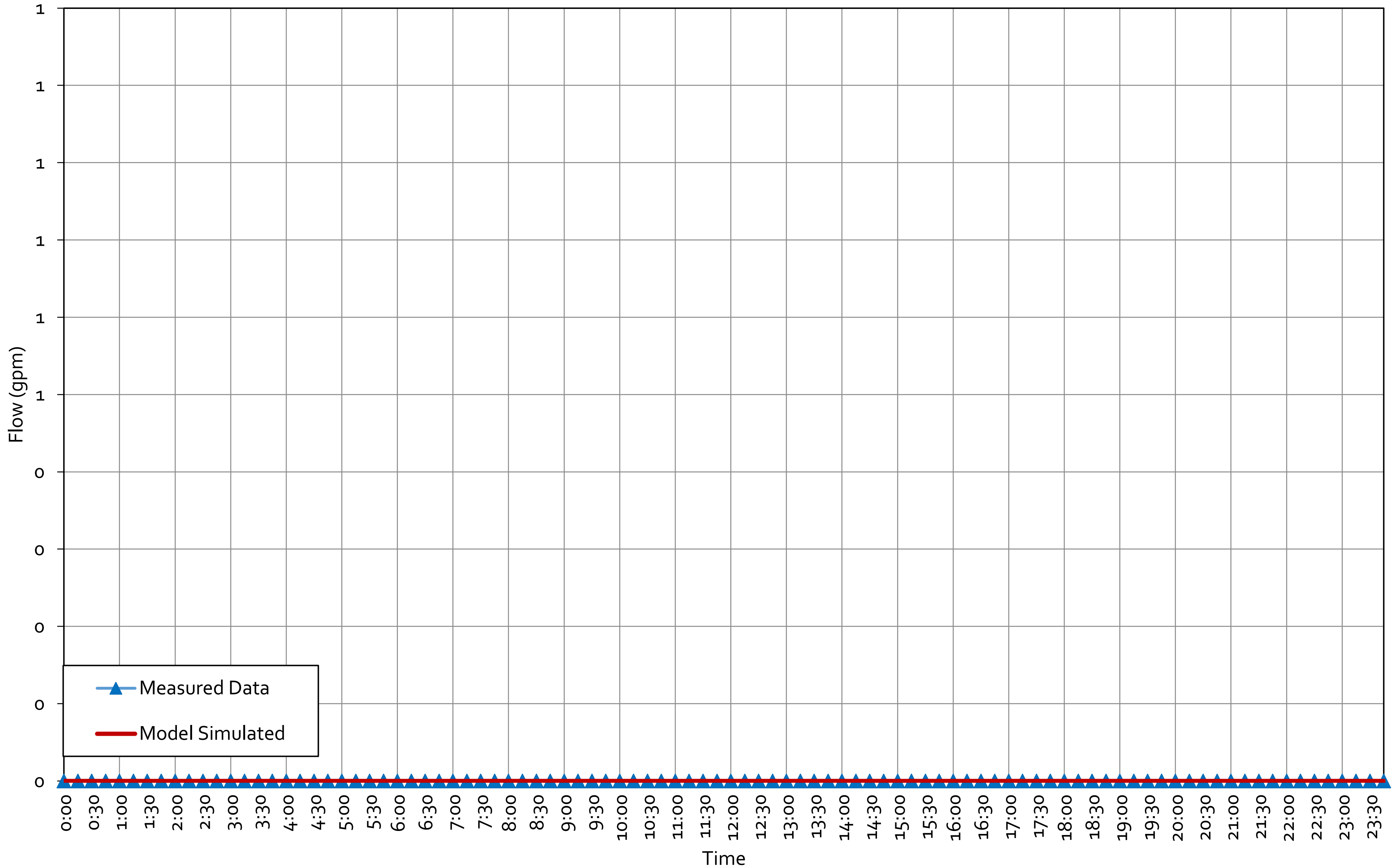
Water Distribution Infrastructure Plan

EPS CALIBRATION - CALLE LAS CALERAS PS FLOW



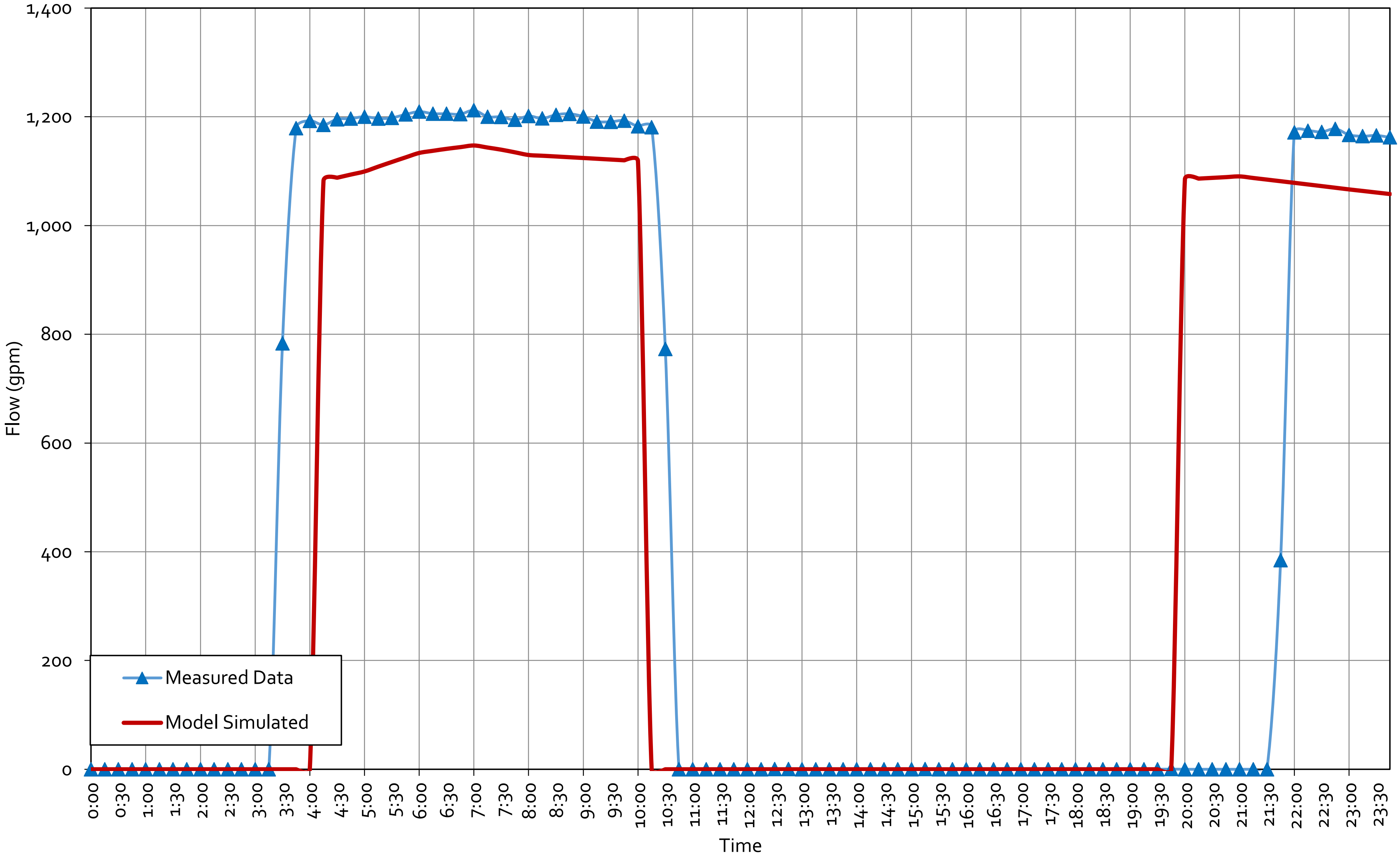
Water Distribution Infrastructure Plan

EPS CALIBRATION - ROCKY NOOK PS FLOW



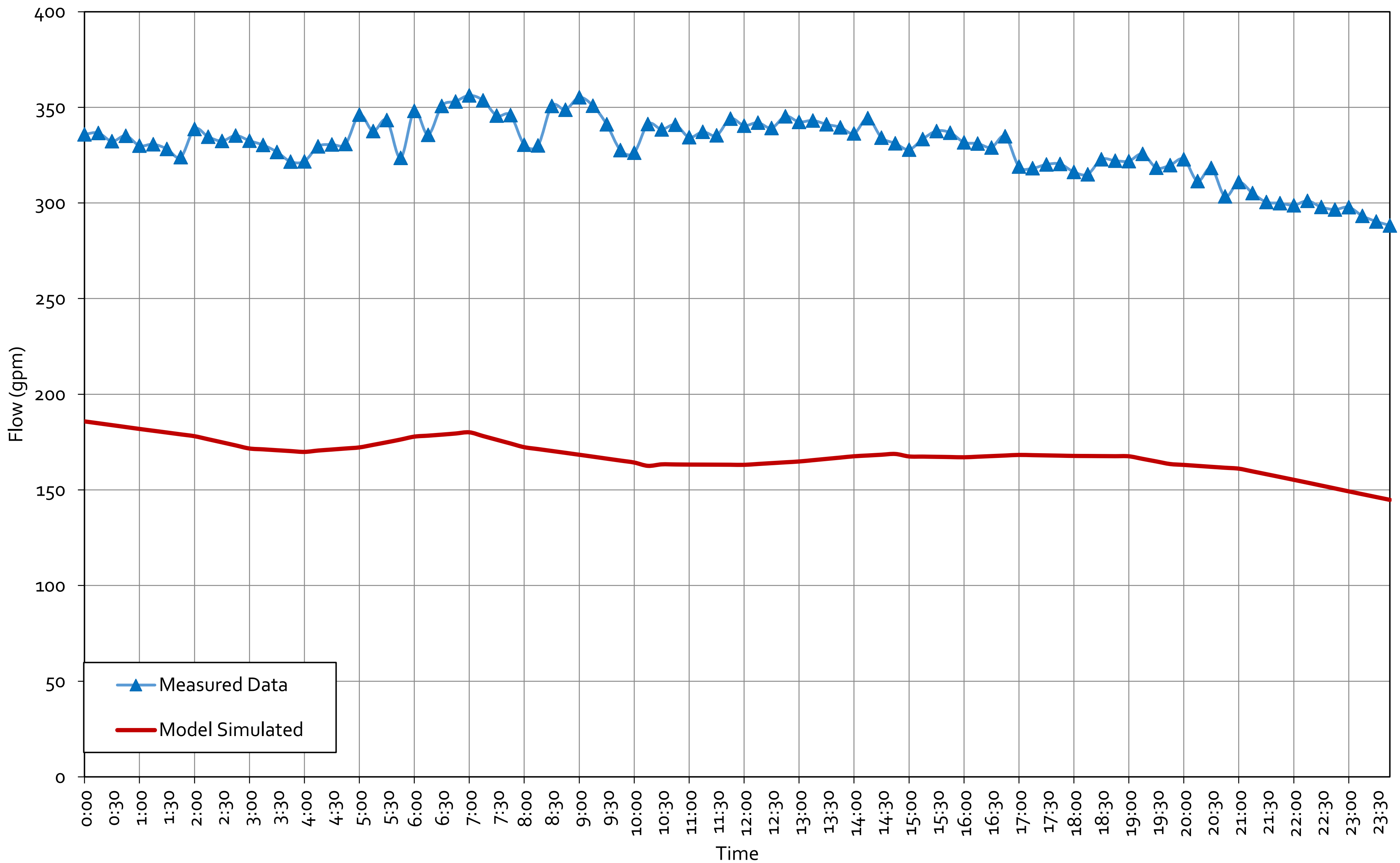
Water Distribution Infrastructure Plan

EPS CALIBRATION - EL CIELITO PS FLOW



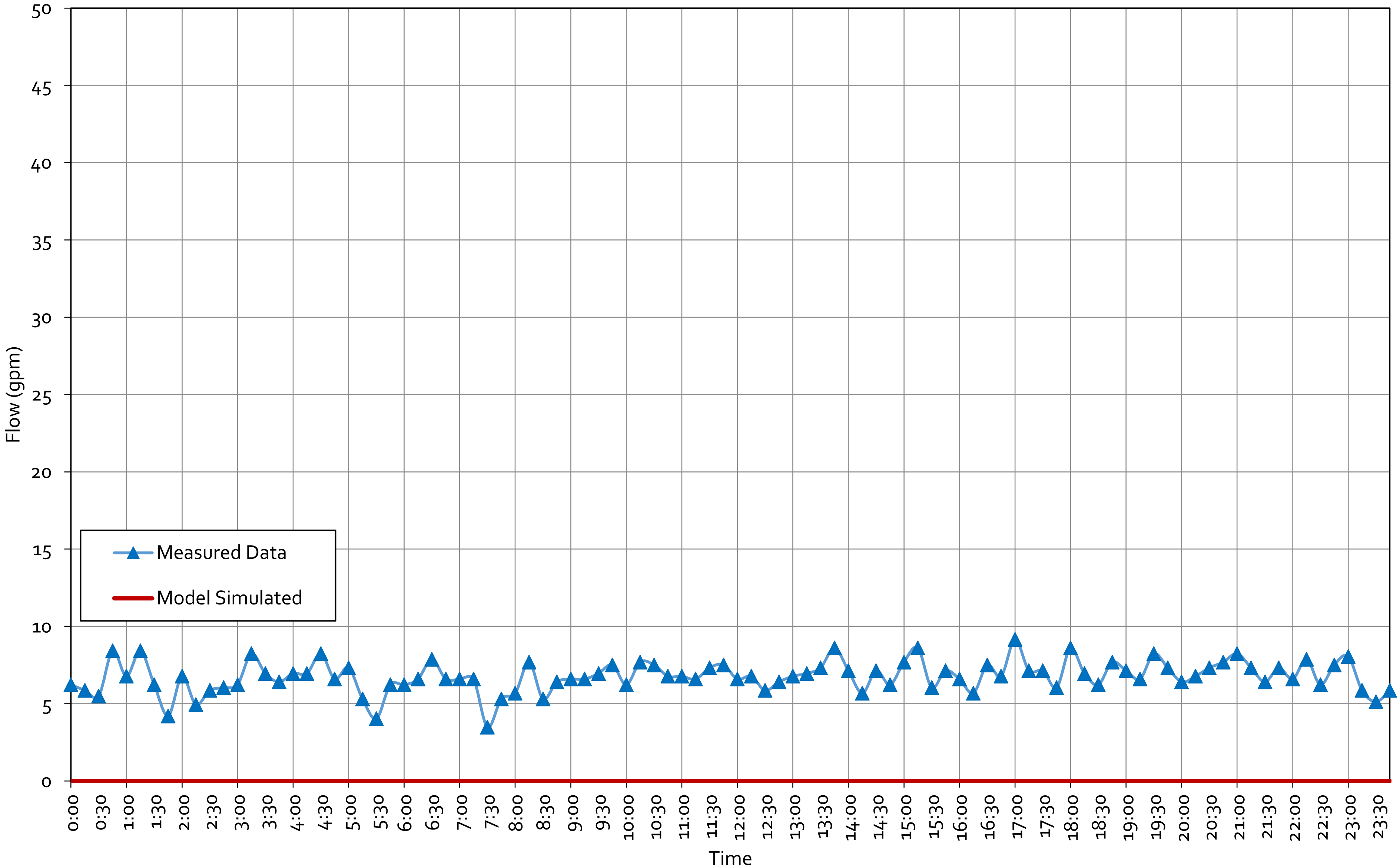
Water Distribution Infrastructure Plan

EPS CALIBRATION - ONTARE SHEFFIELD PRV FLOW



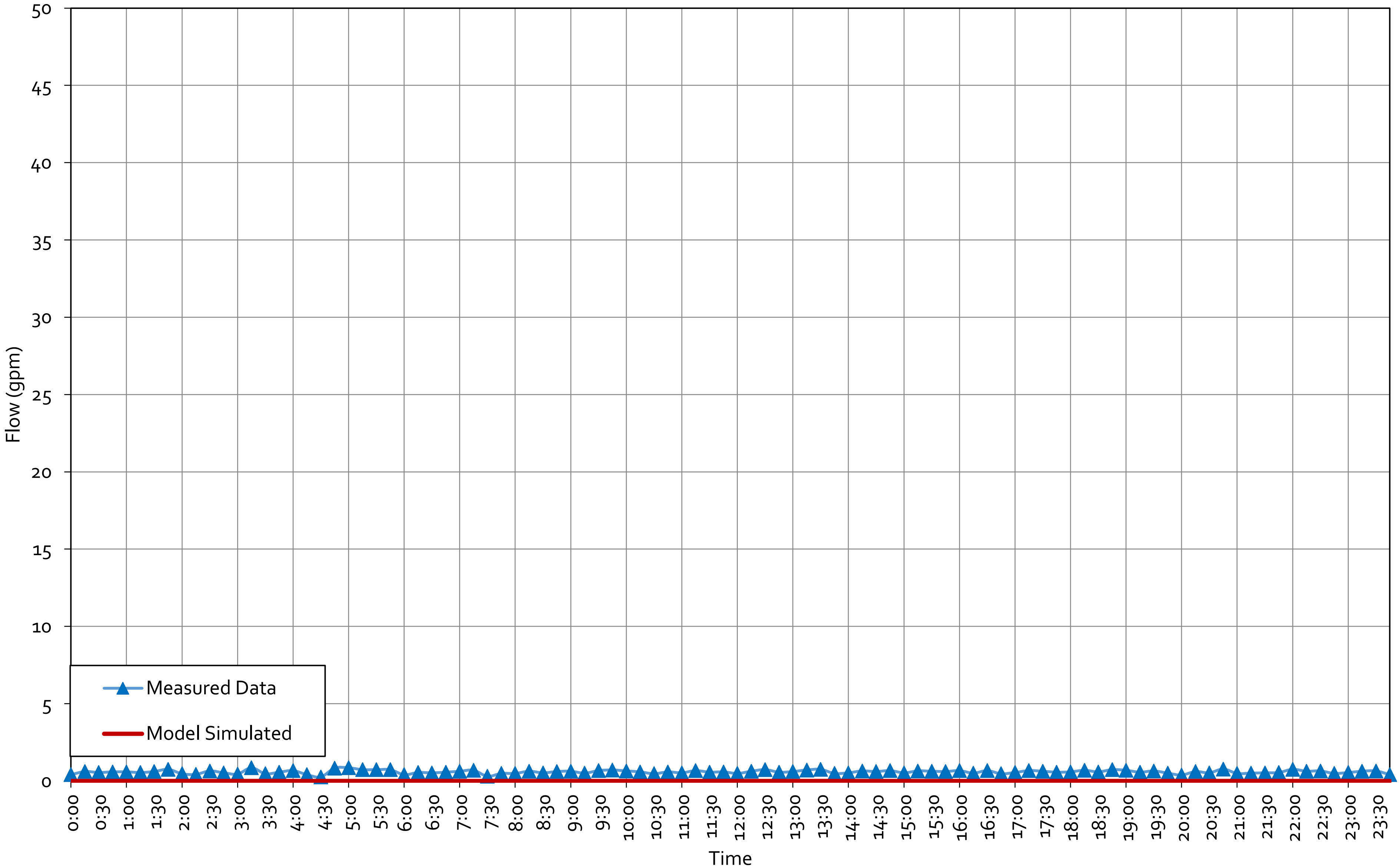
Water Distribution Infrastructure Plan

EPS CALIBRATION - GARDEN STREET PRV - 12" FLOW



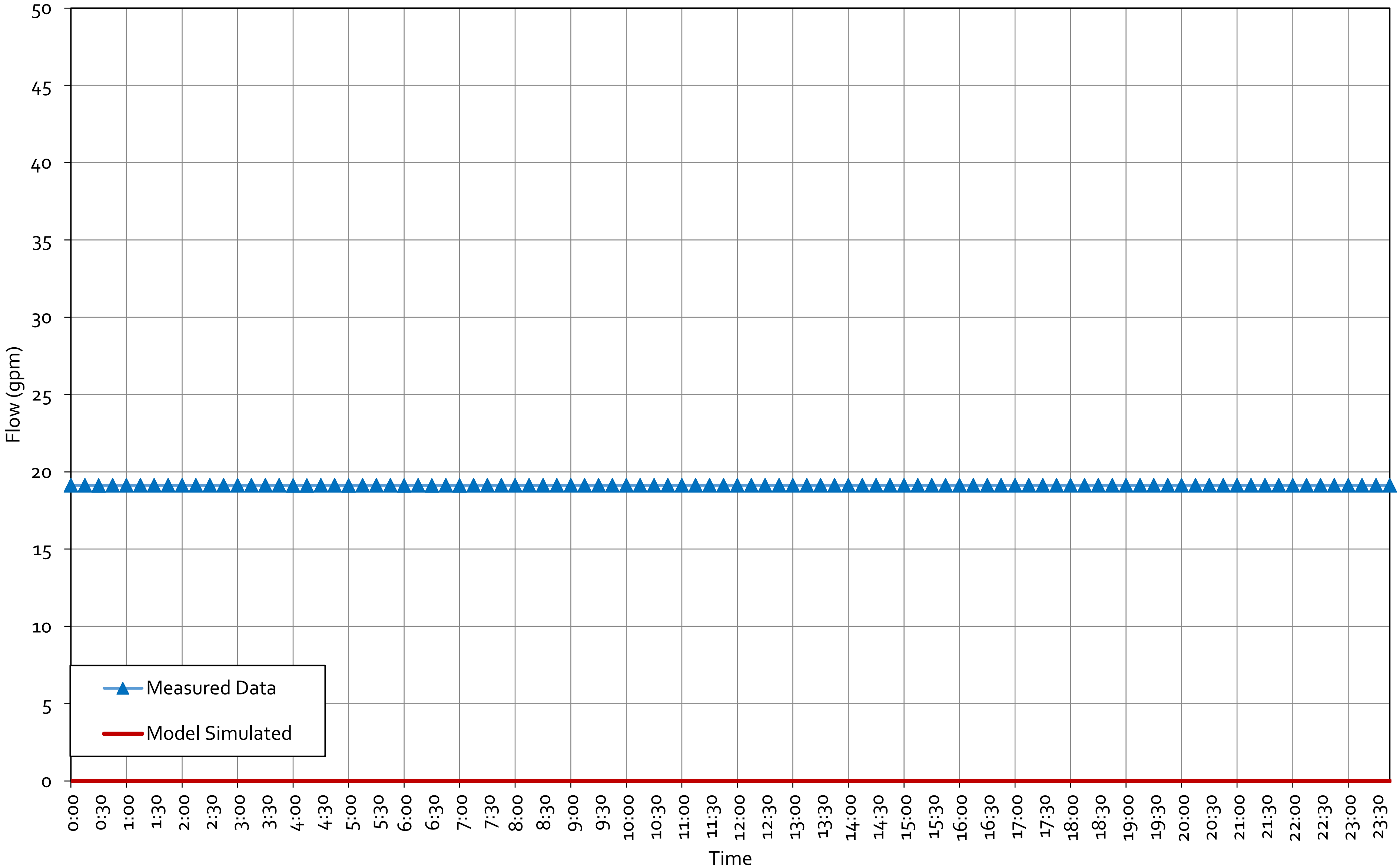
Water Distribution Infrastructure Plan

EPS CALIBRATION - GARDEN STREET PRV - 4" FLOW



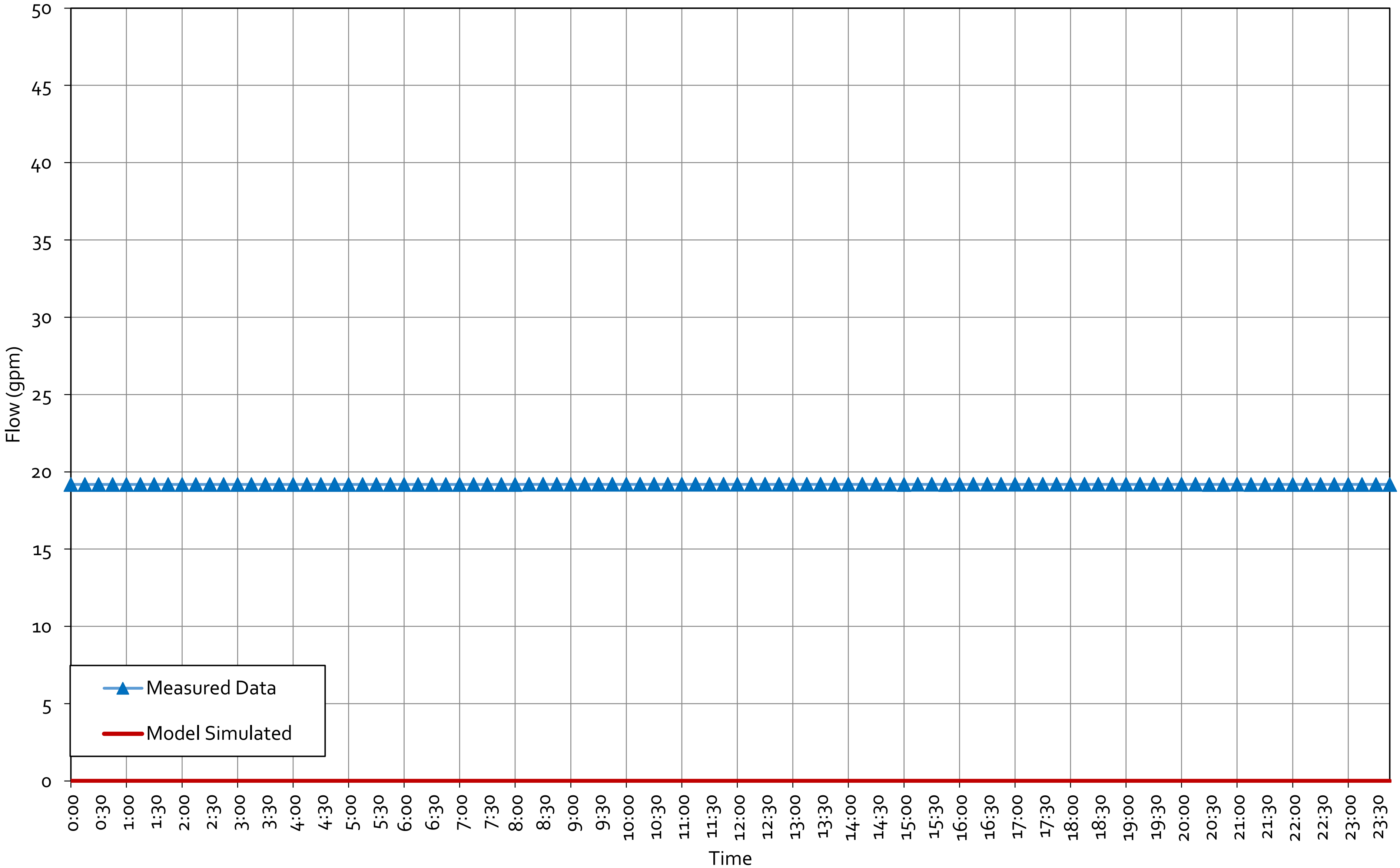
Water Distribution Infrastructure Plan

EPS CALIBRATION - ROBINS STREET PRV - 3" FLOW



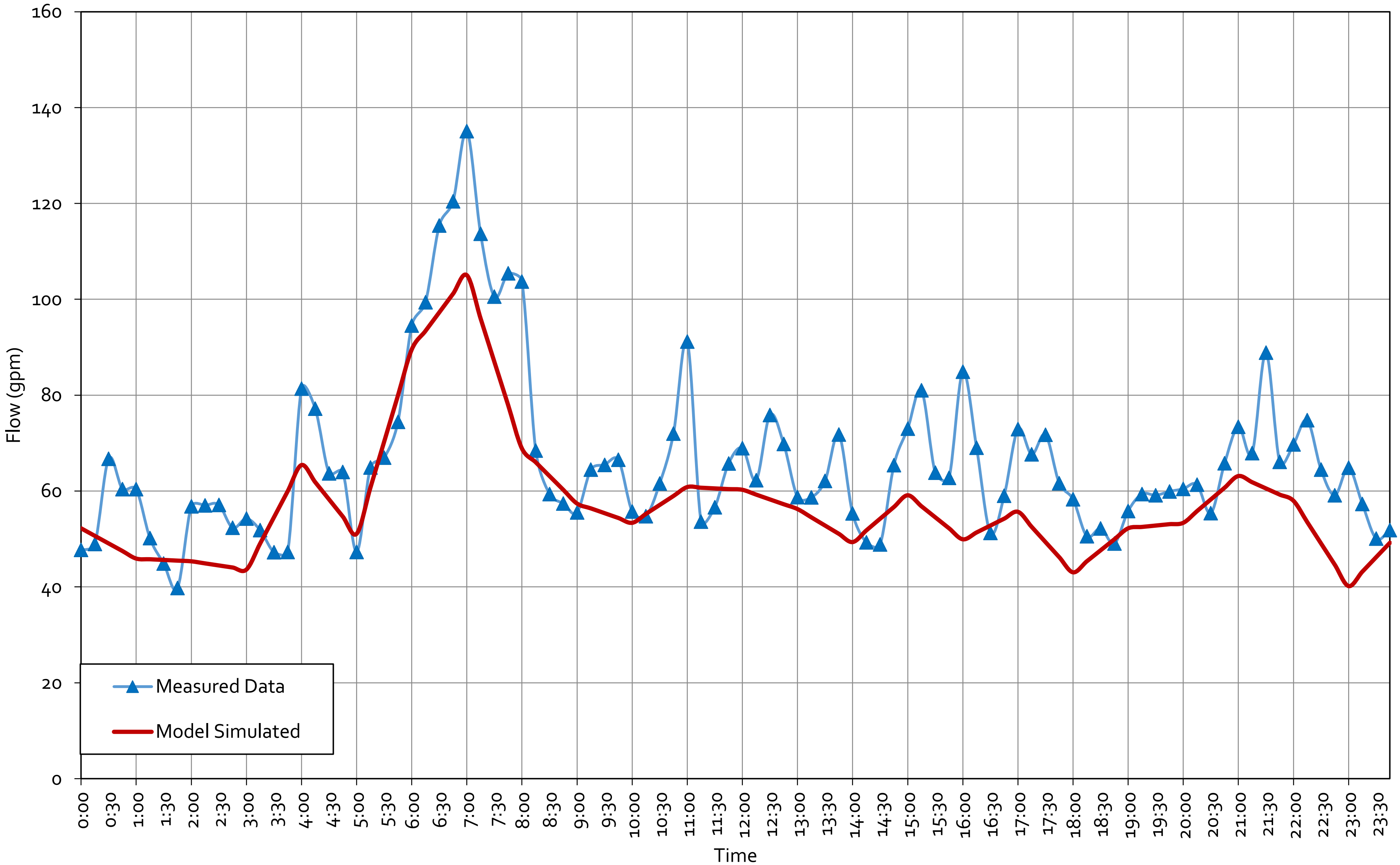
Water Distribution Infrastructure Plan

EPS CALIBRATION - ROBINS STREET PRV - 8" FLOW



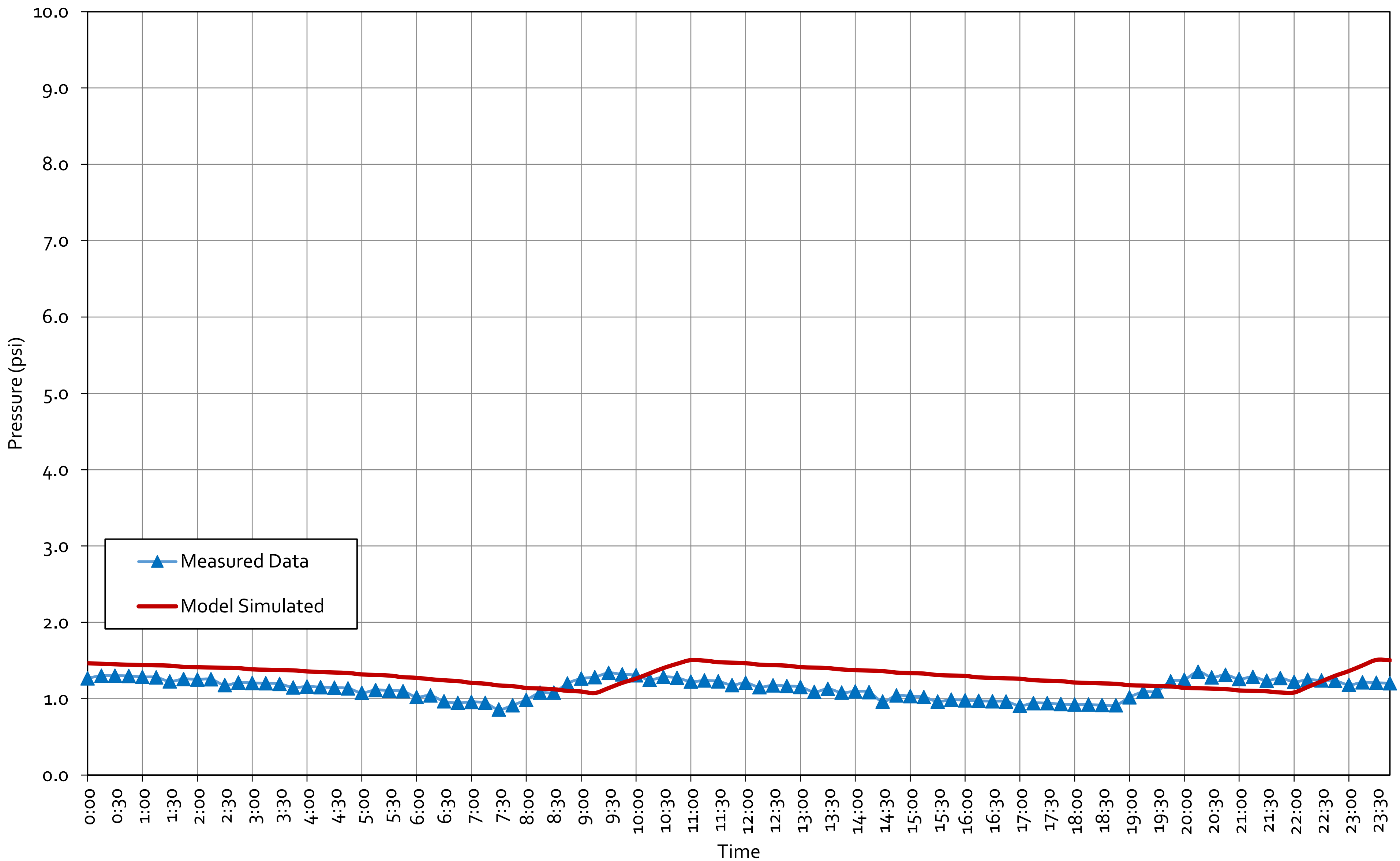
Water Distribution Infrastructure Plan

EPS CALIBRATION - ONTARE NORTHRIDGE PRV FLOW



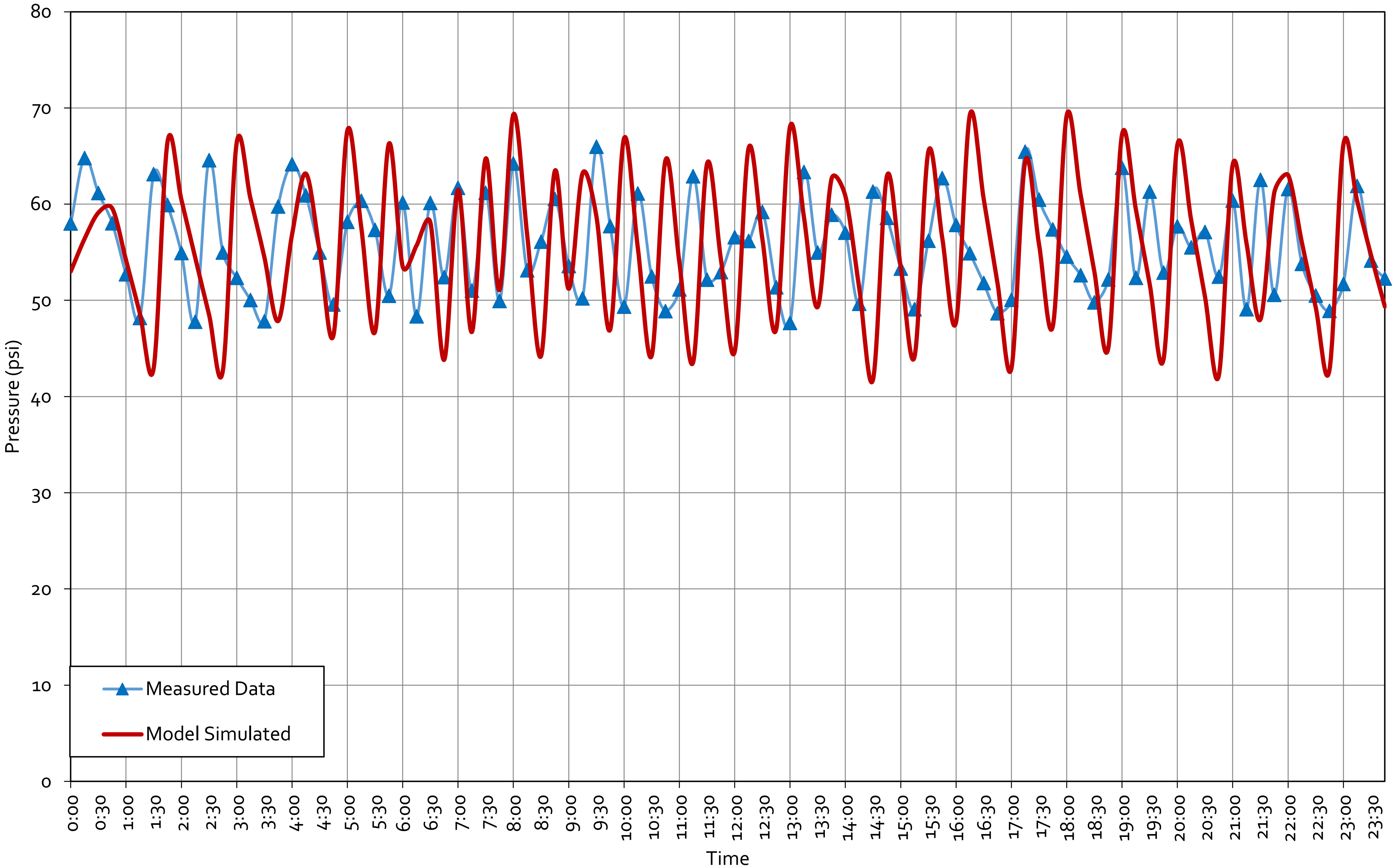
Water Distribution Infrastructure Plan

EPS CALIBRATION - CAMPANIL PS SUCTION PRESSURE



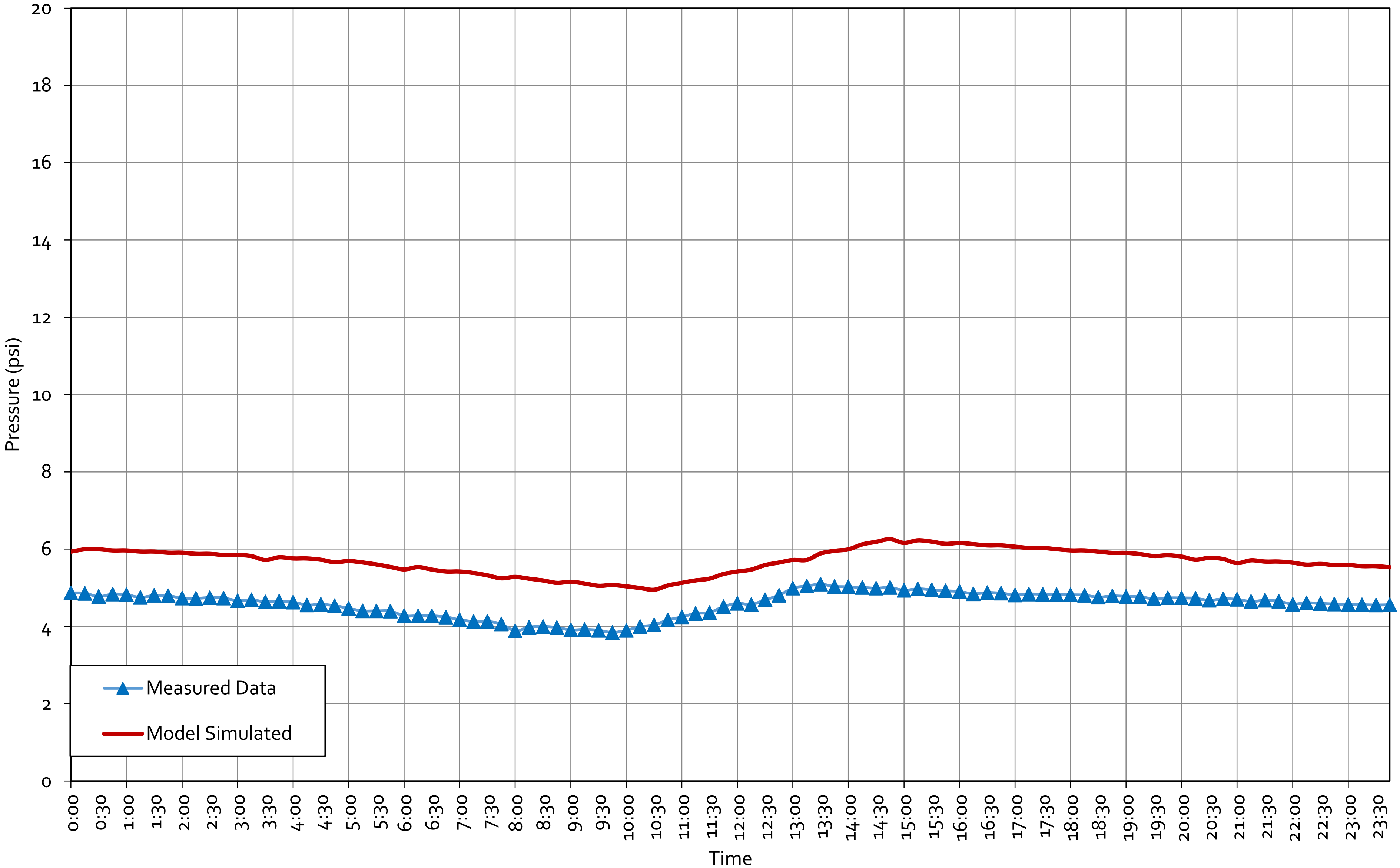
Water Distribution Infrastructure Plan

EPS CALIBRATION - CAMPANIL PS DISCHARGE PRESSURE



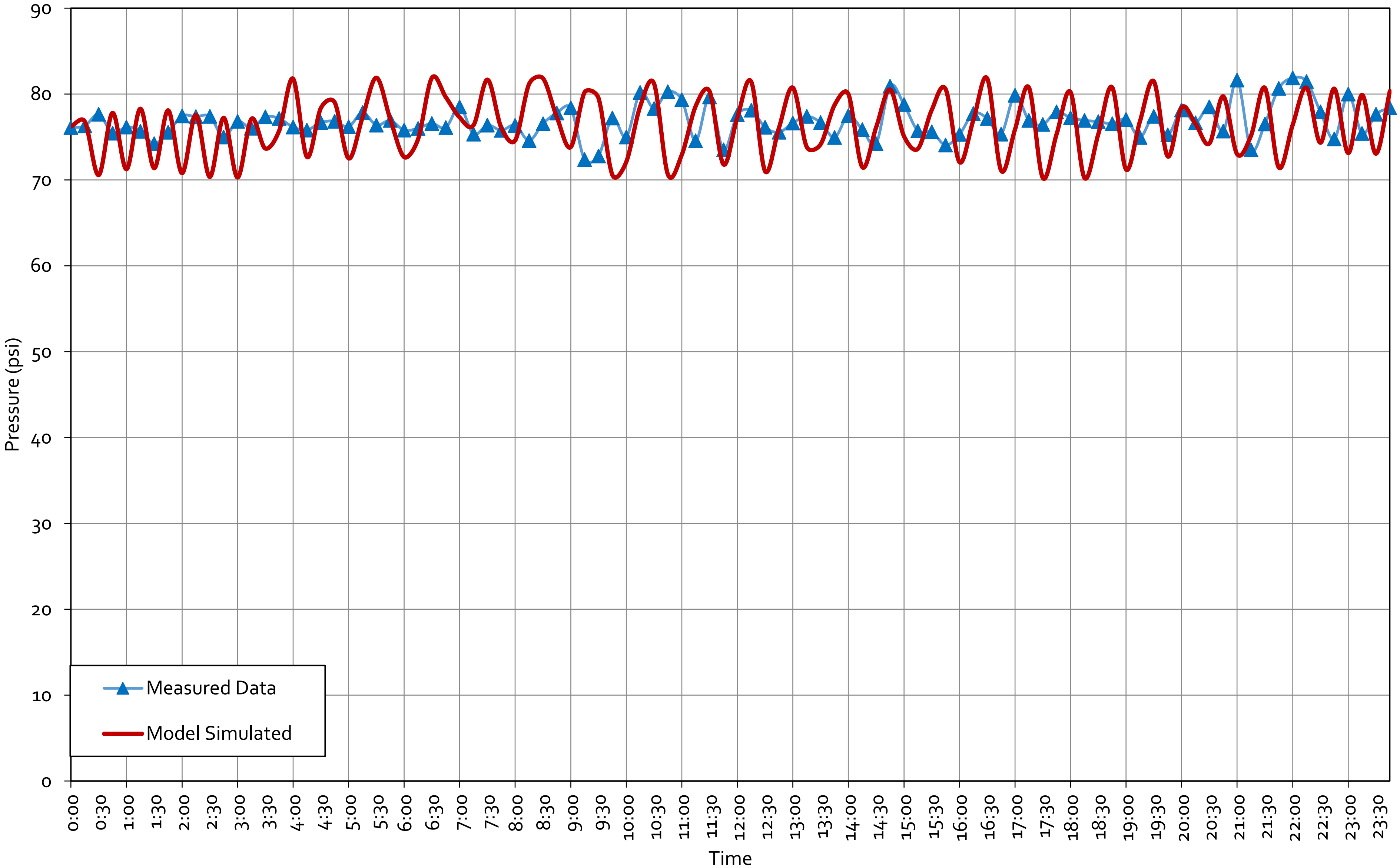
Water Distribution Infrastructure Plan

EPS CALIBRATION - BOTHIN PS SUCTION PRESSURE



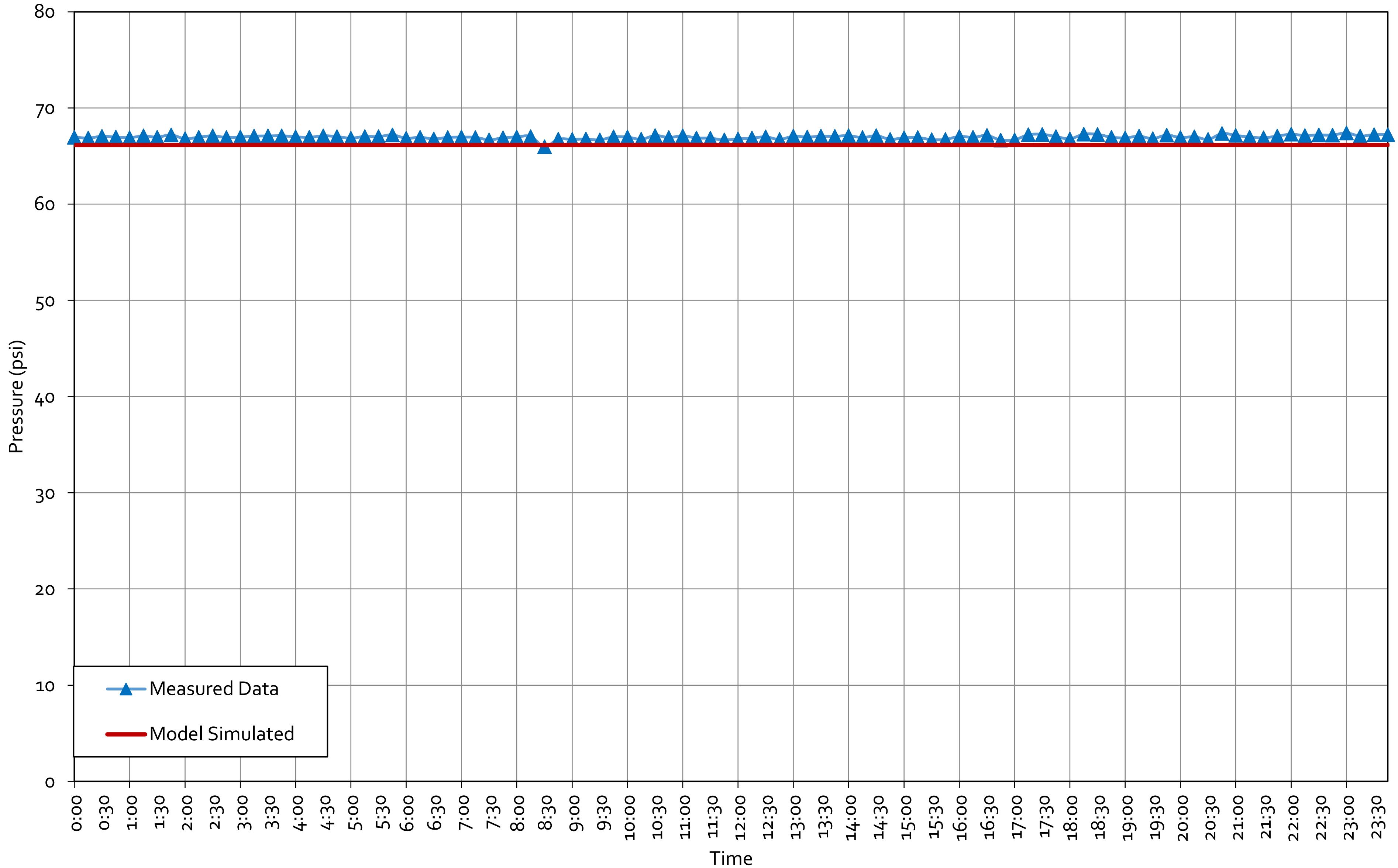
Water Distribution Infrastructure Plan

EPS CALIBRATION - BOTHIN PS DISCHARGE PRESSURE



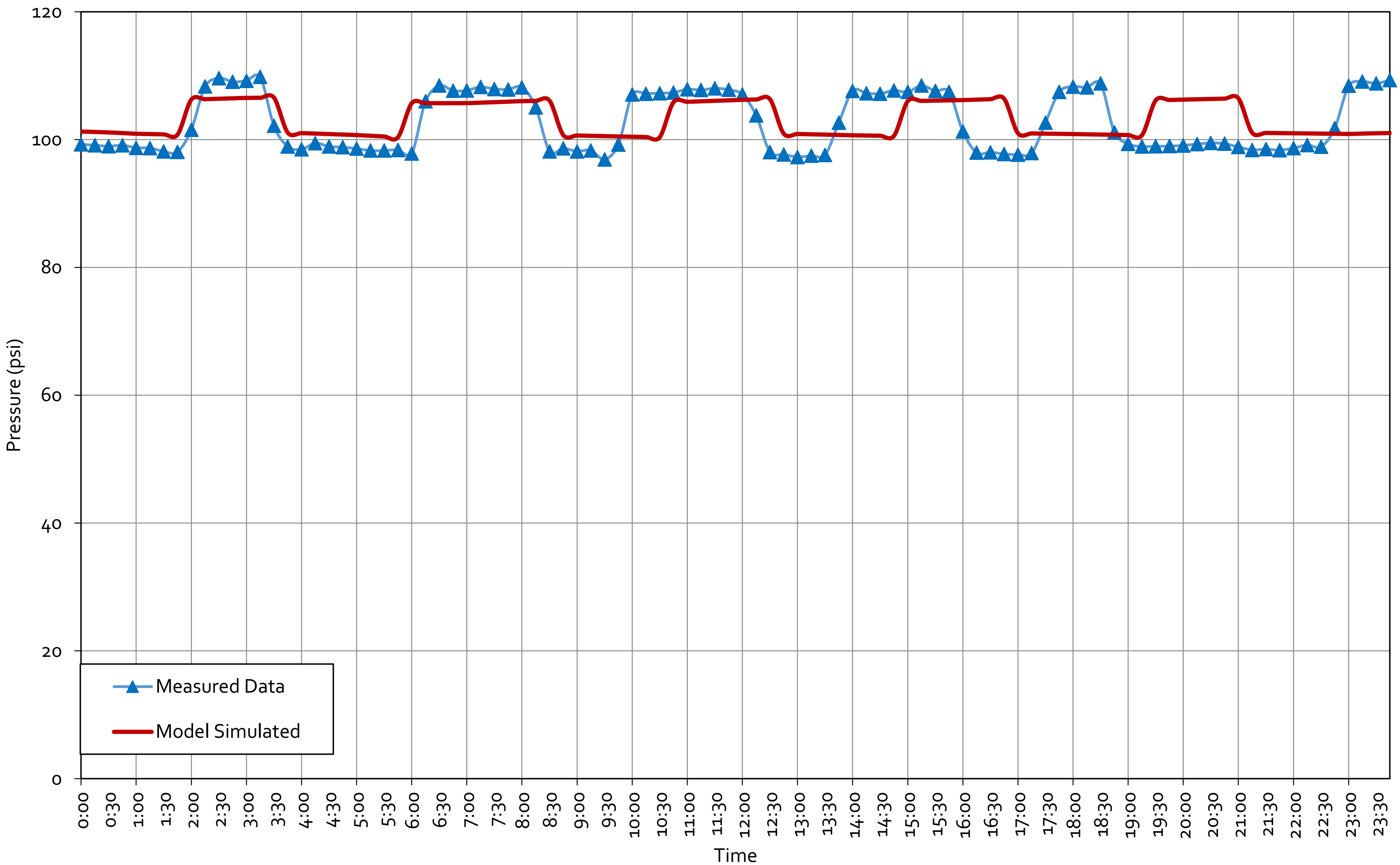
Water Distribution Infrastructure Plan

EPS CALIBRATION - ONTARE SHEFFIELD DOWNSTREAM PRESSURE



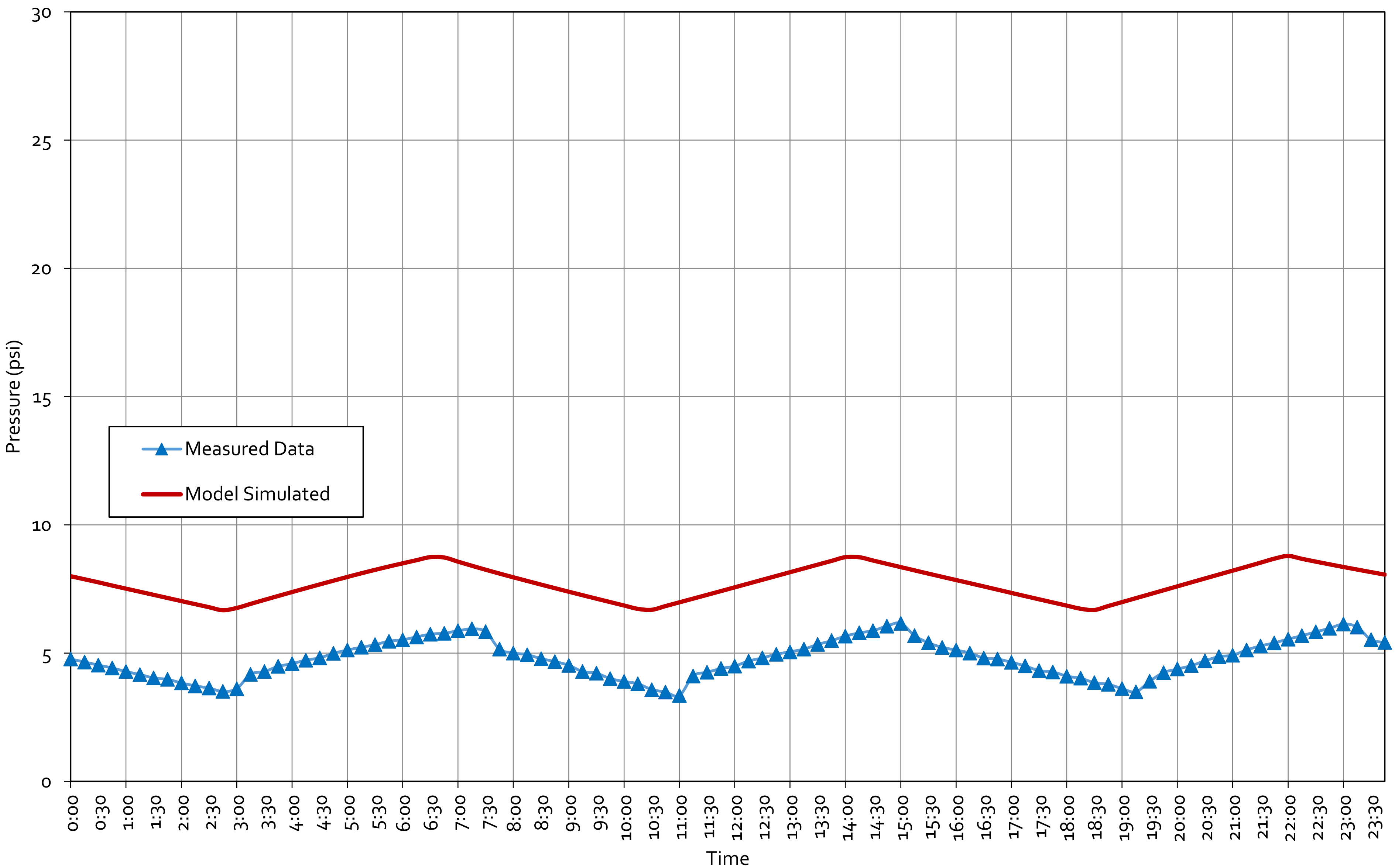
Water Distribution Infrastructure Plan

EPS CALIBRATION - STATE STREET DOWNSTREAM PRESSURE



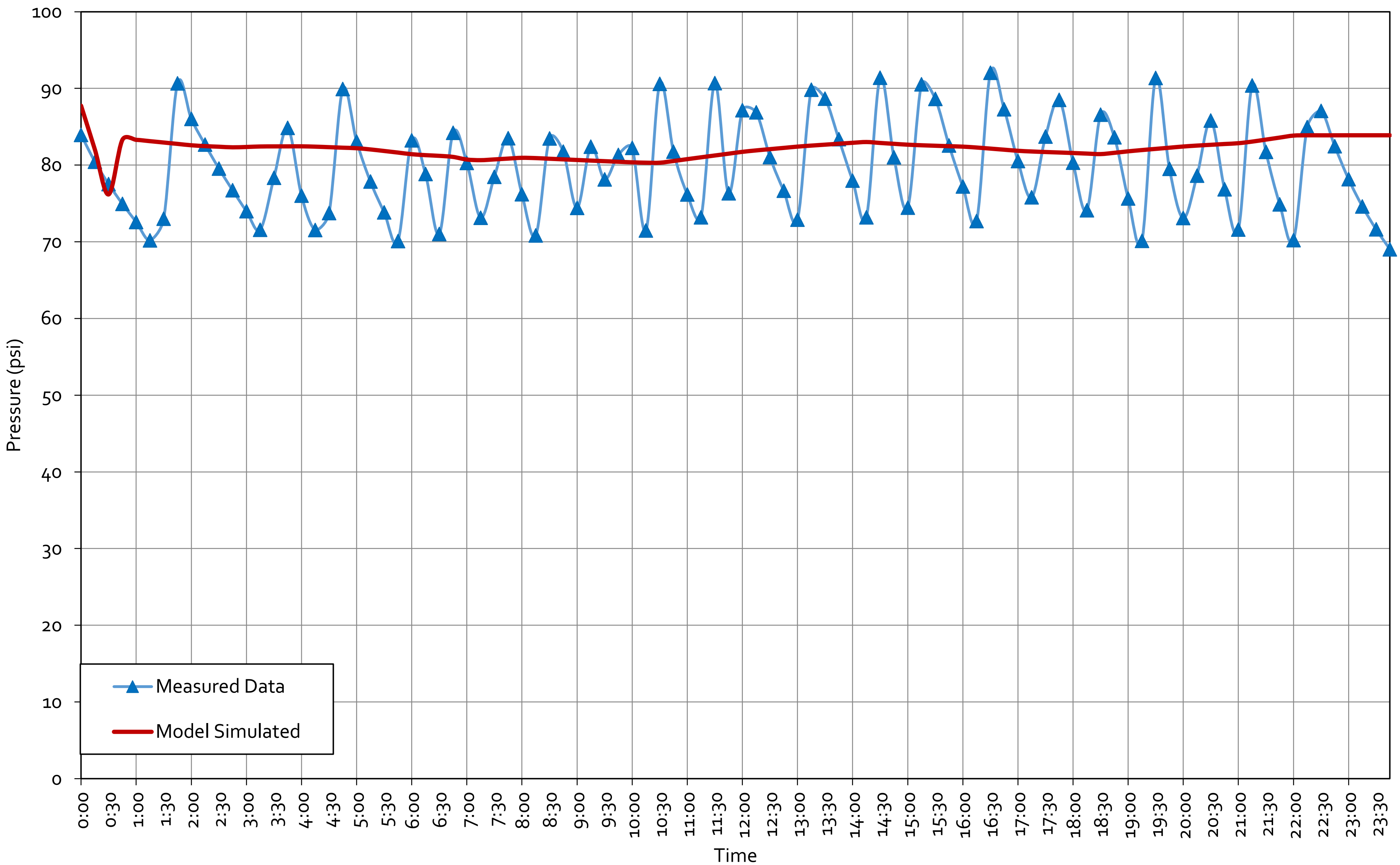
Water Distribution Infrastructure Plan

EPS CALIBRATION - TUNNEL PS SUCTION PRESSURE



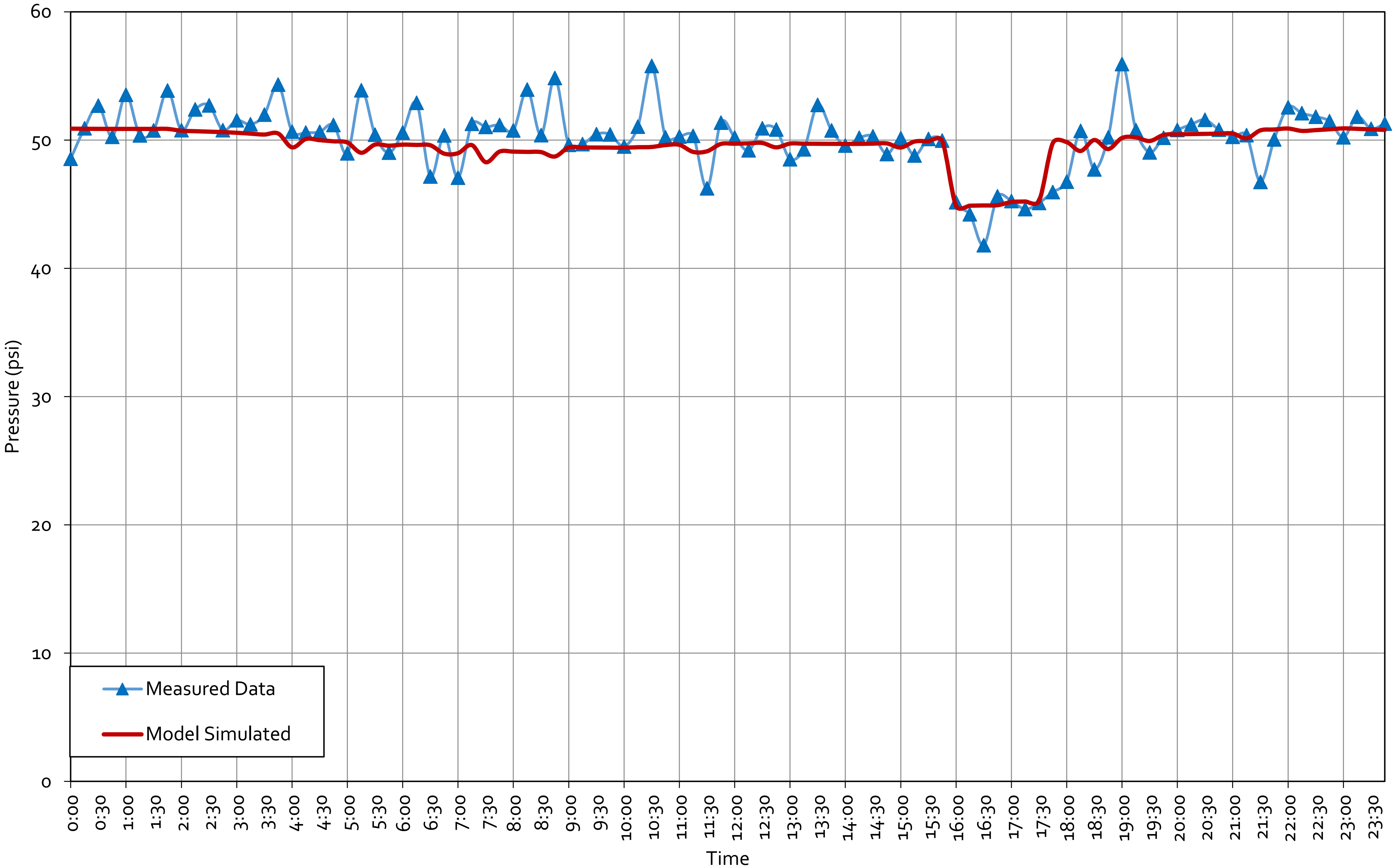
Water Distribution Infrastructure Plan

EPS CALIBRATION - TUNNEL PS DISCHARGE PRESSURE



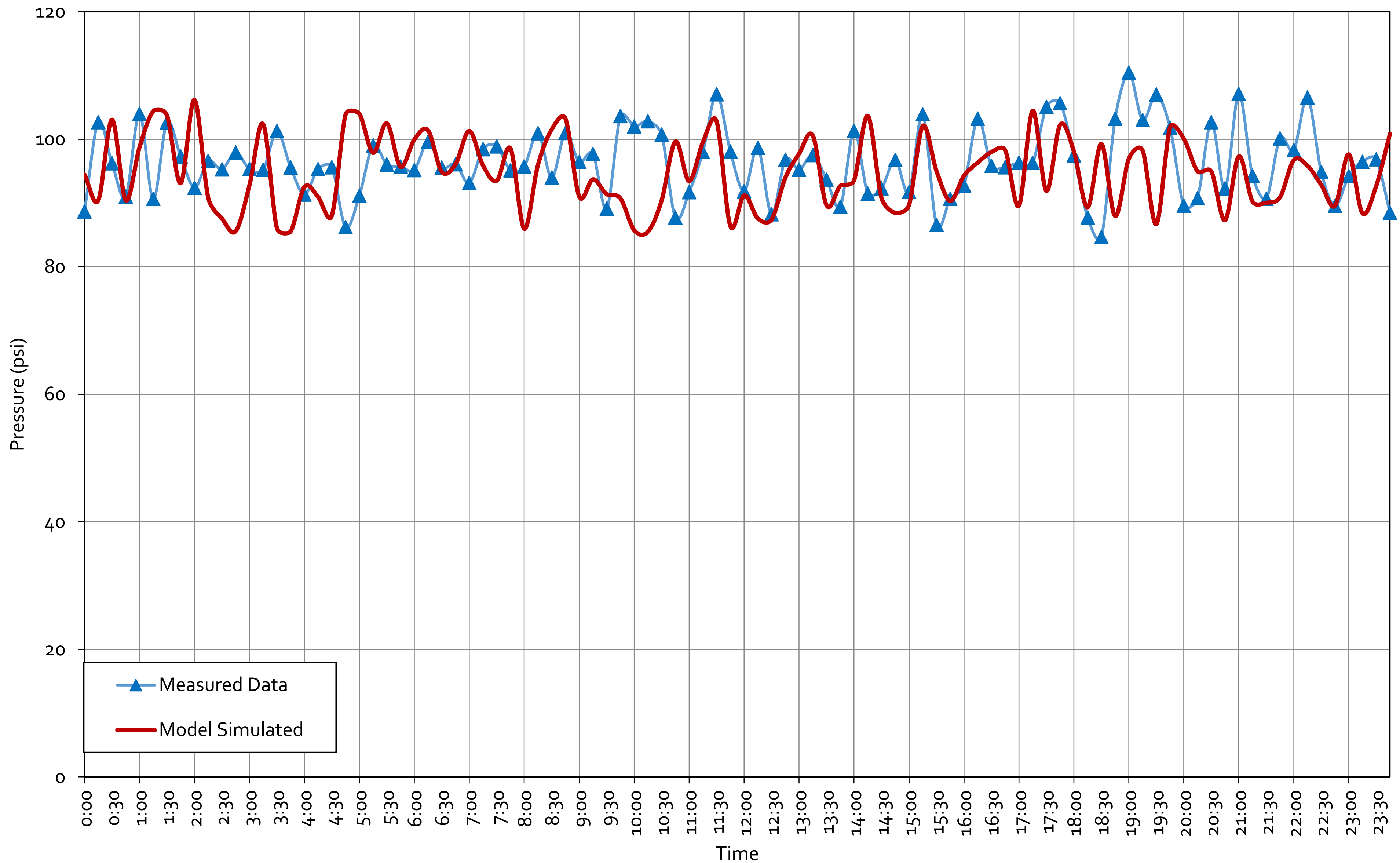
Water Distribution Infrastructure Plan

EPS CALIBRATION - ESCONDIDO PS SUCTION PRESSURE



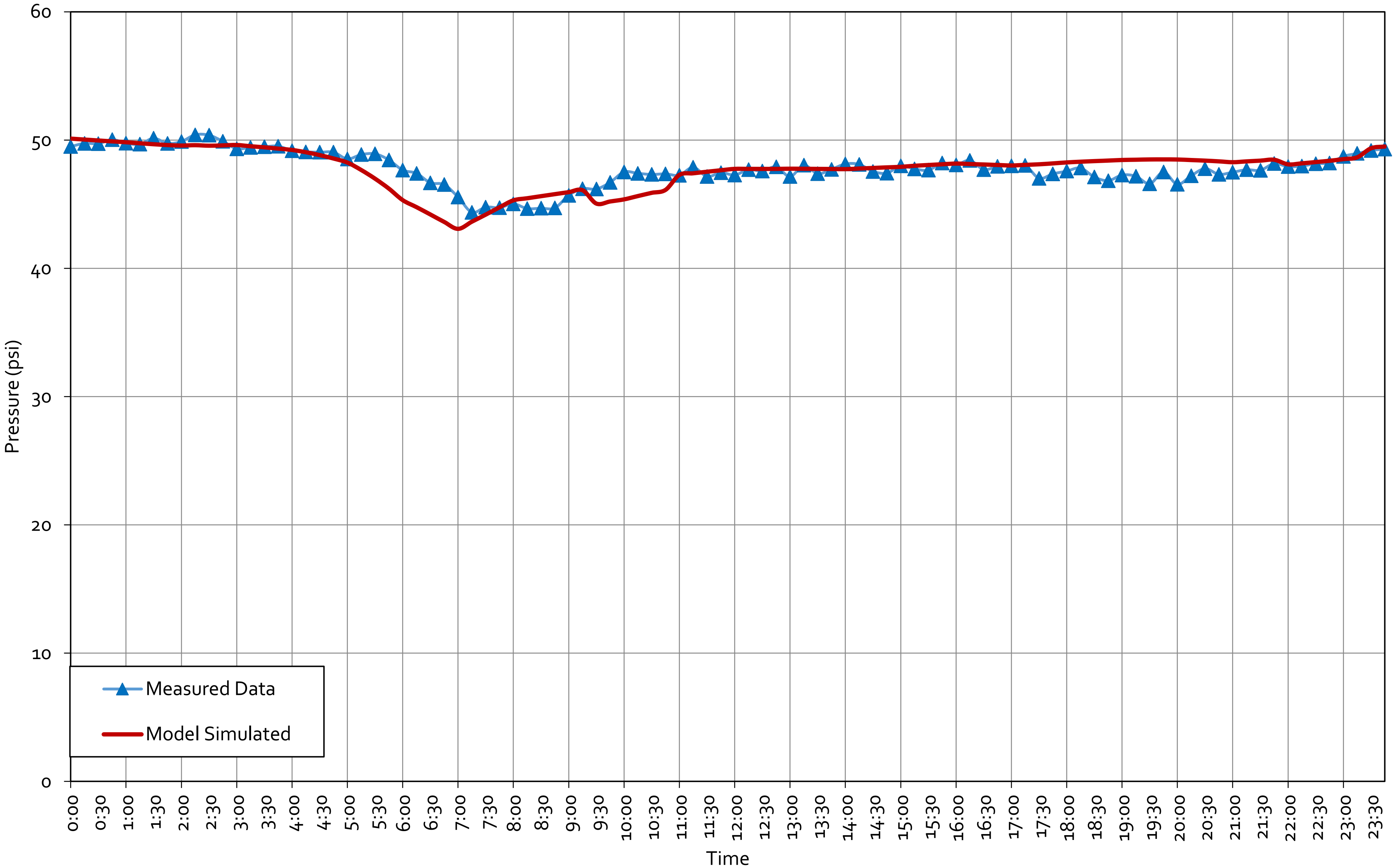
Water Distribution Infrastructure Plan

EPS CALIBRATION - ESCONDIDO PS DISCHARGE PRESSURE



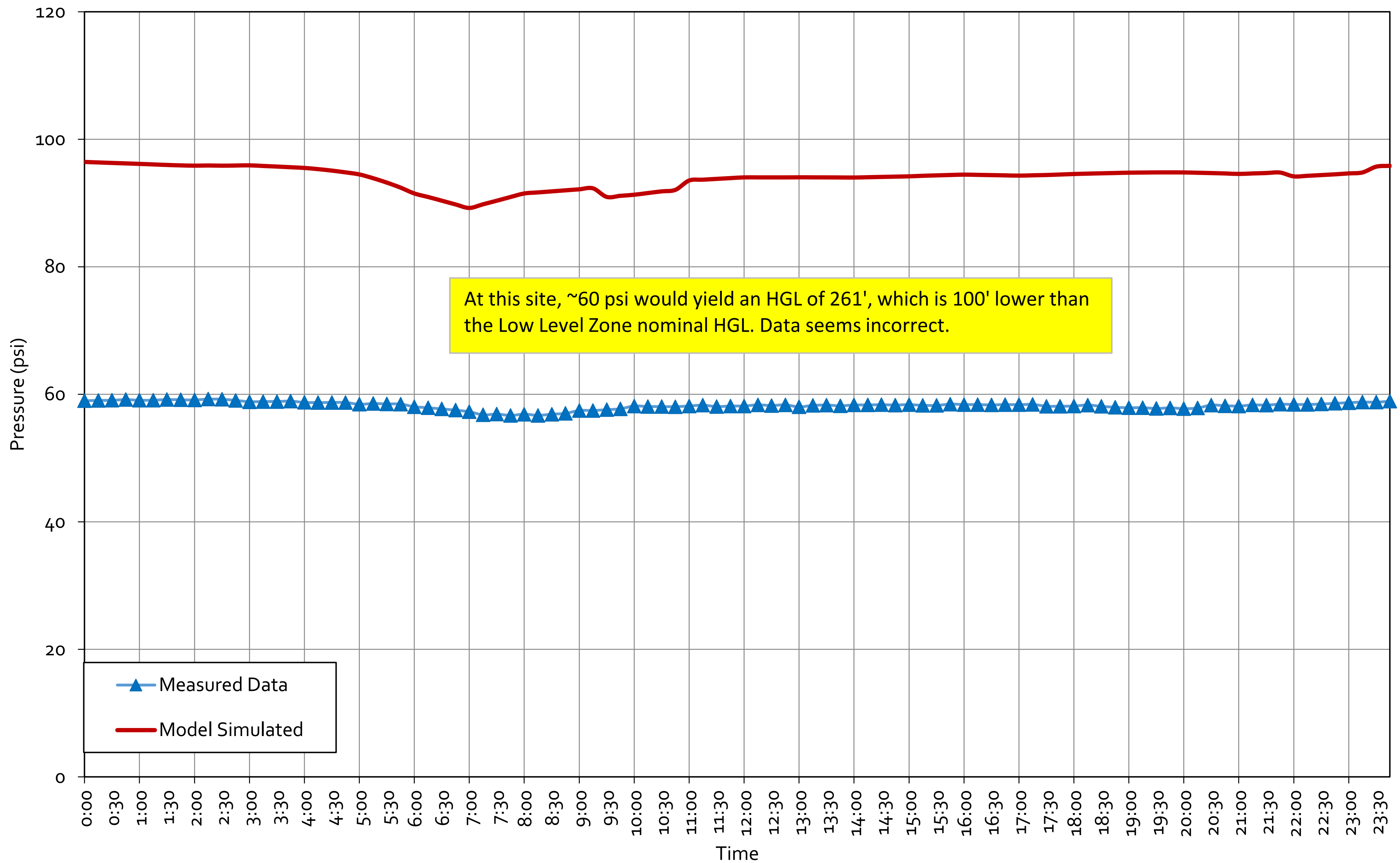
Water Distribution Infrastructure Plan

EPS CALIBRATION - GARDEN STREET DOWNSTREAM PRESSURE



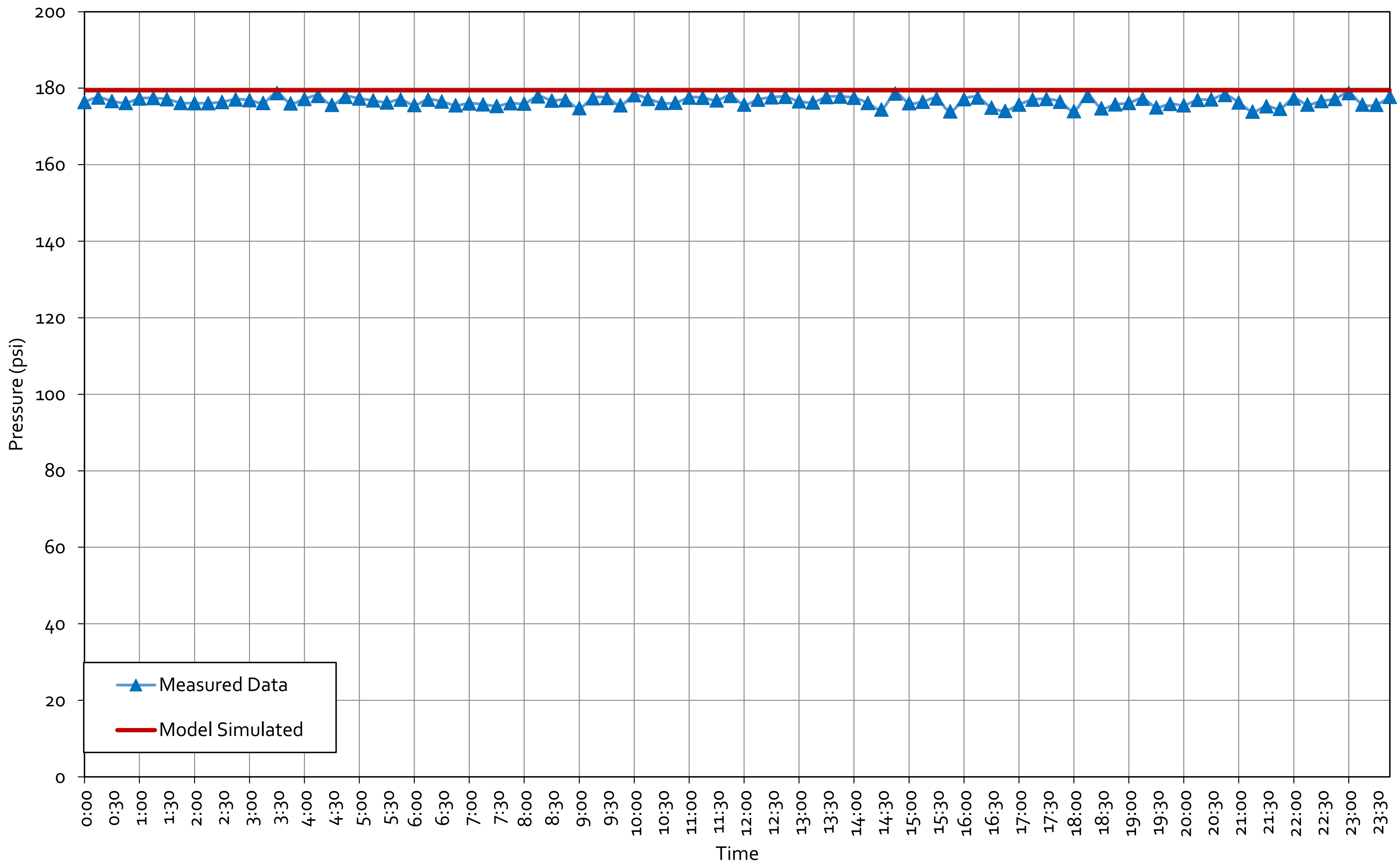
Water Distribution Infrastructure Plan

EPS CALIBRATION - ROBINS DOWNSTREAM PRESSURE



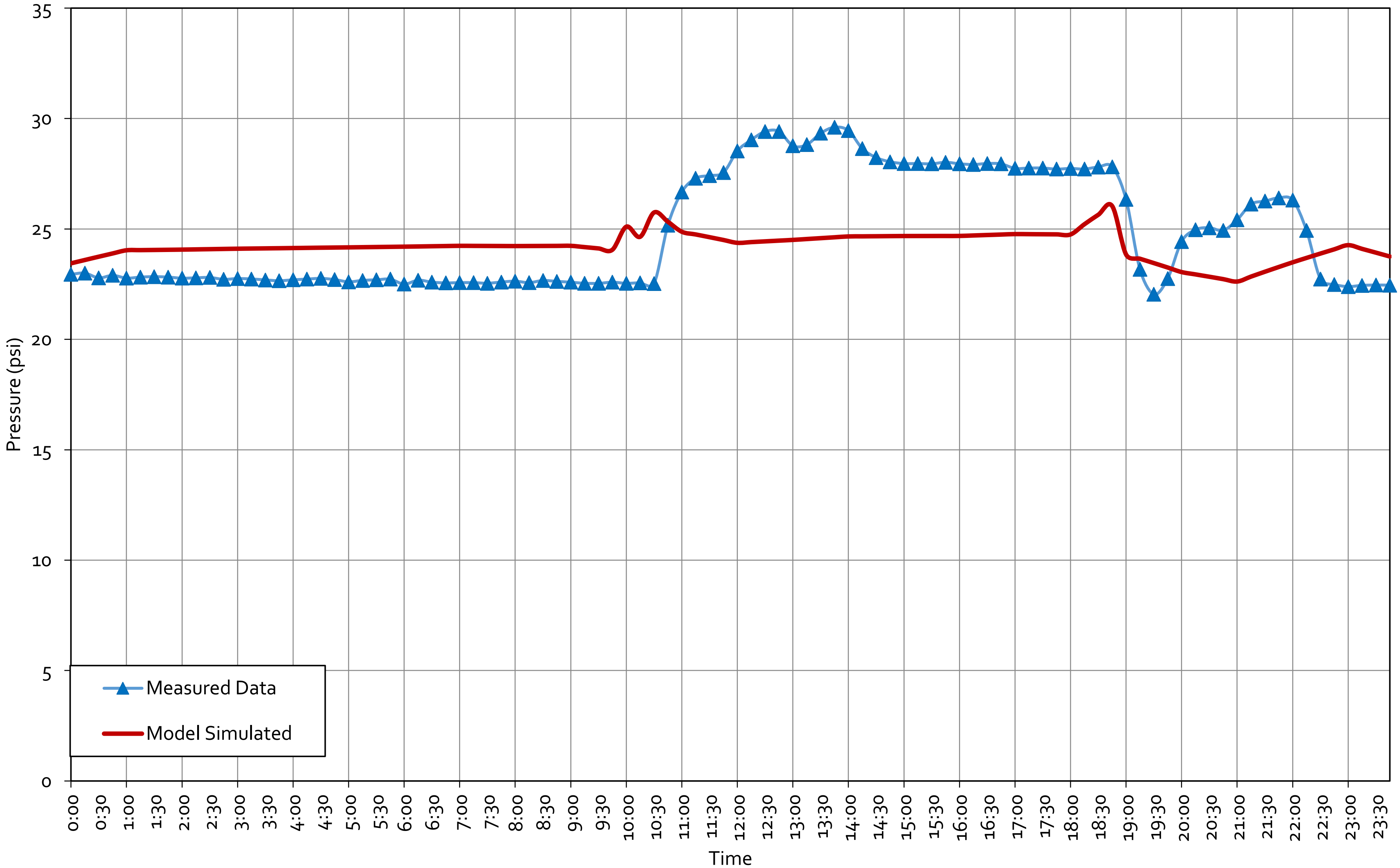
Water Distribution Infrastructure Plan

EPS CALIBRATION - ONTARE NORTHRIDGE DOWNSTREAM PRESSURE



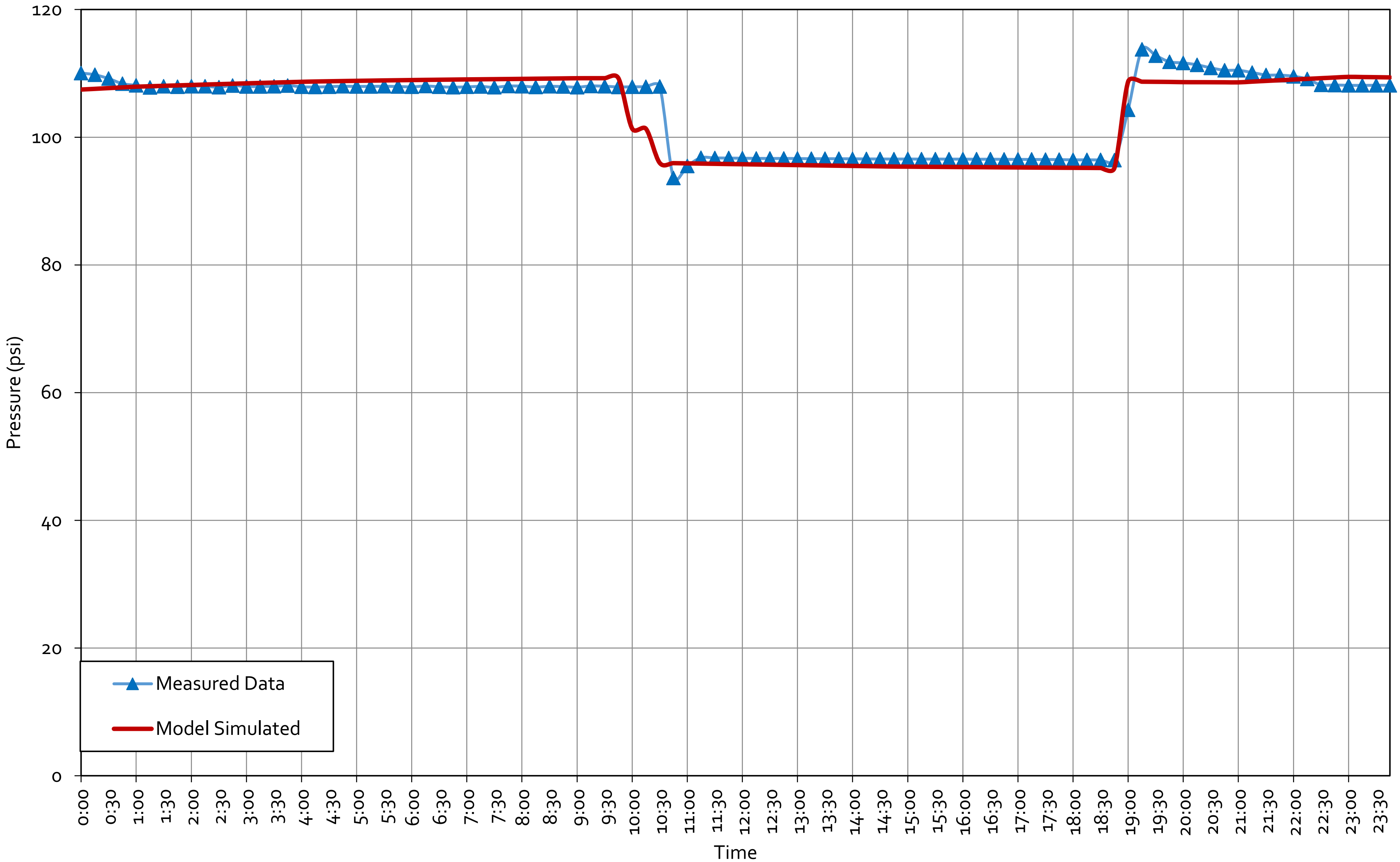
Water Distribution Infrastructure Plan

EPS CALIBRATION - SHEFFIELD PS SUCTION PRESSURE



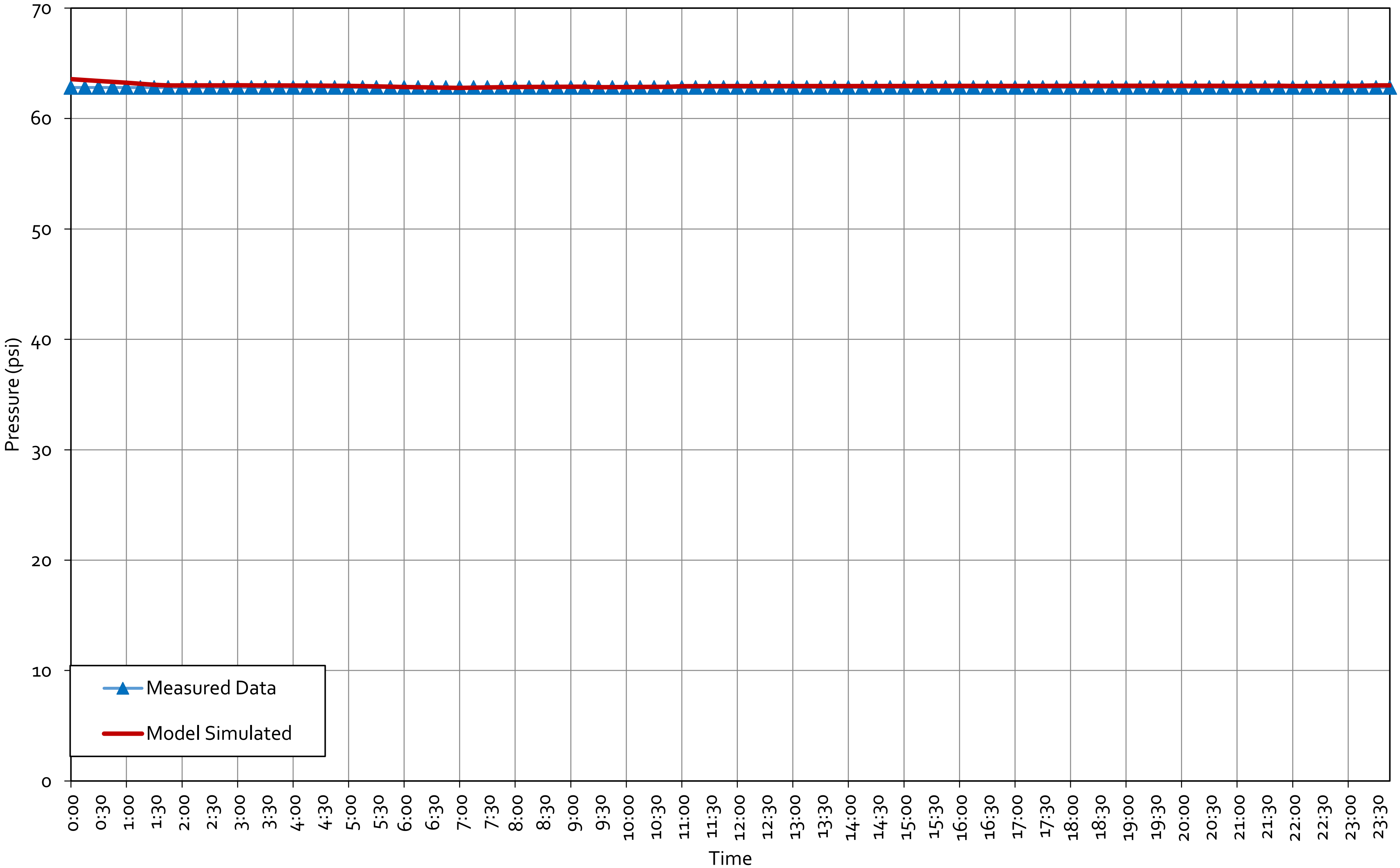
Water Distribution Infrastructure Plan

EPS CALIBRATION - SHEFFIELD PS DISCHARGE PRESSURE



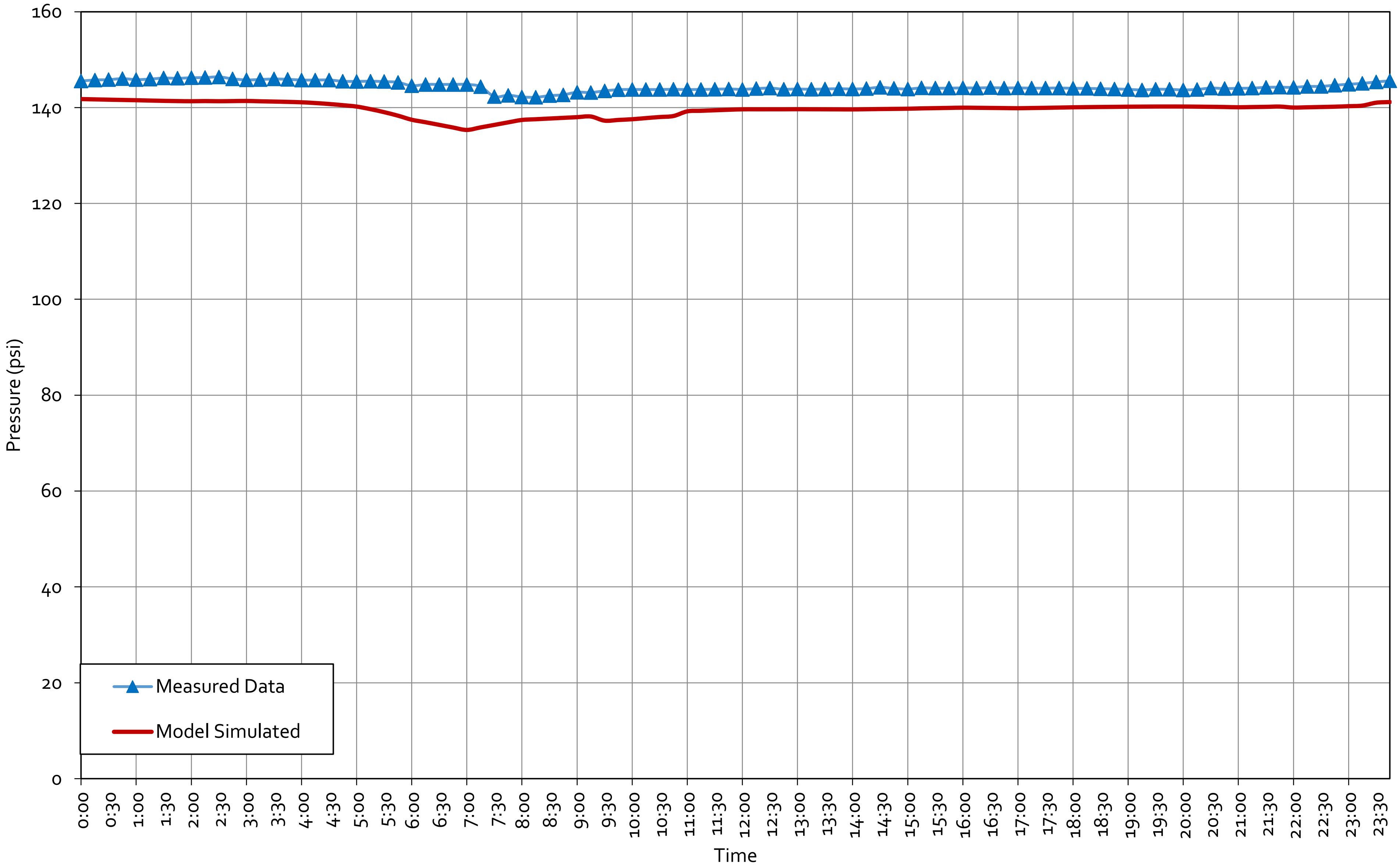
Water Distribution Infrastructure Plan

EPS CALIBRATION - VISTA DEL OCEANO DOWNSTREAM PRESSURE



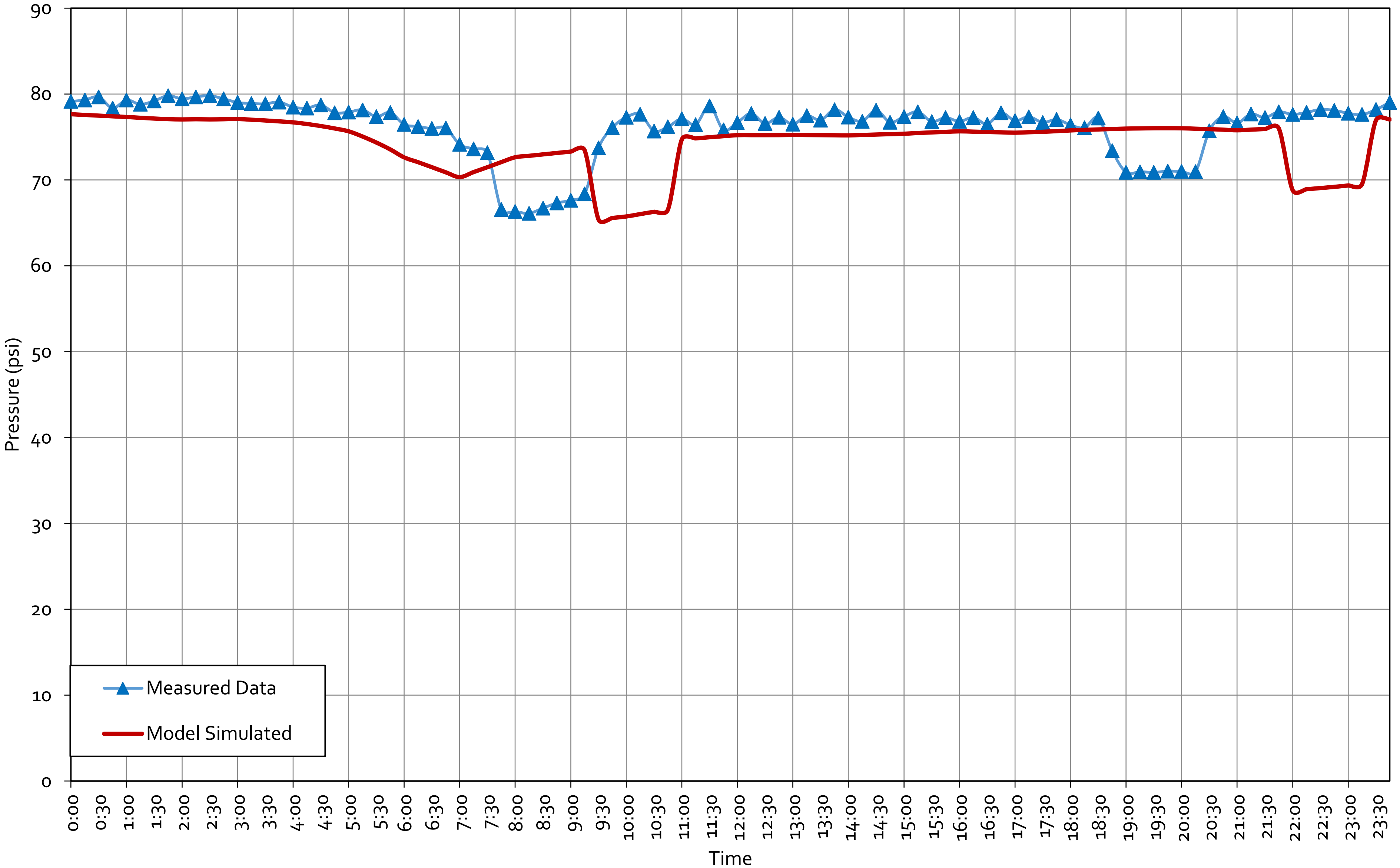
Water Distribution Infrastructure Plan

EPS CALIBRATION - DESAL PLANT PRESSURE



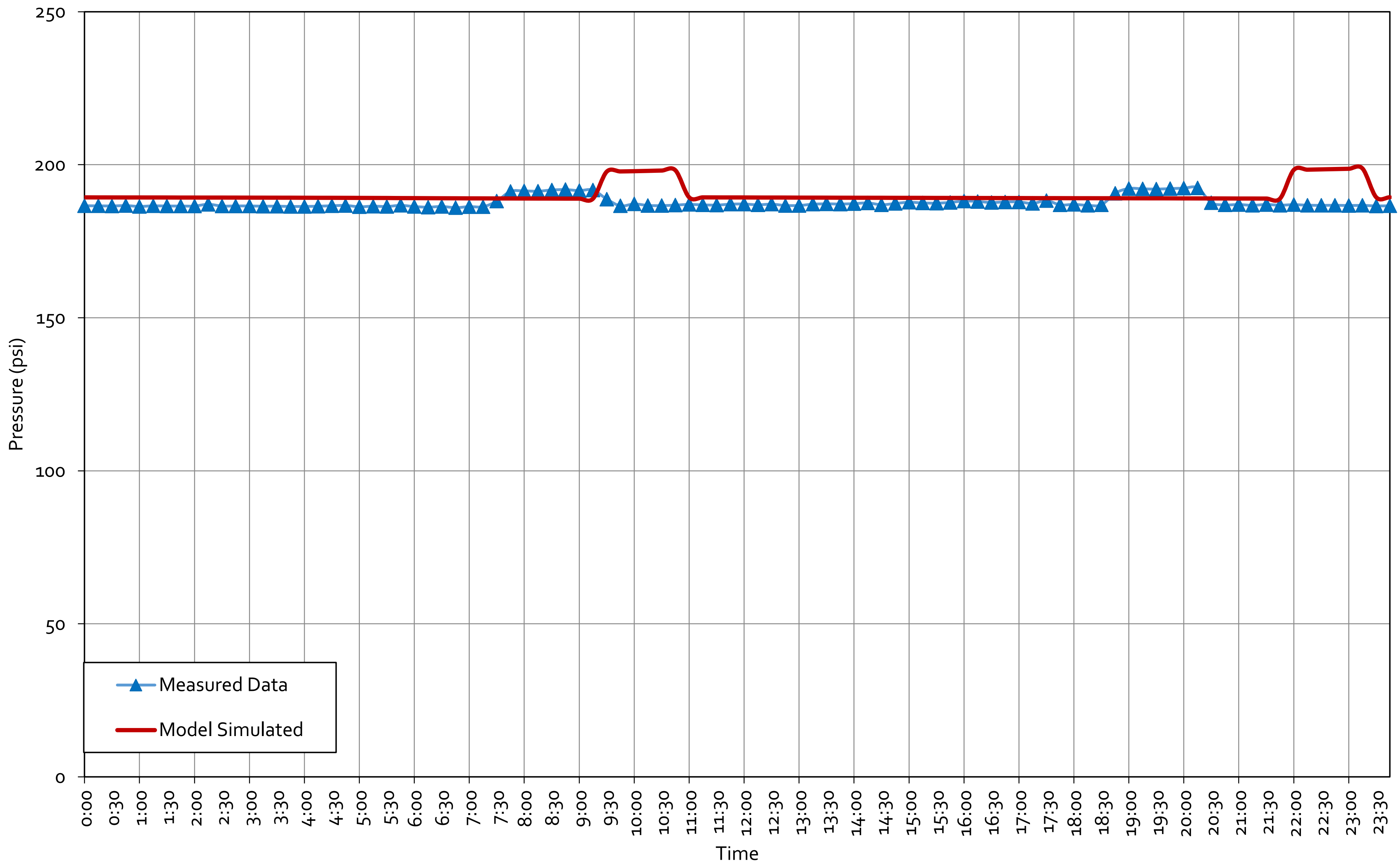
Water Distribution Infrastructure Plan

EPS CALIBRATION - CALLE LAS CALERAS PS SUCTION PRESSURE



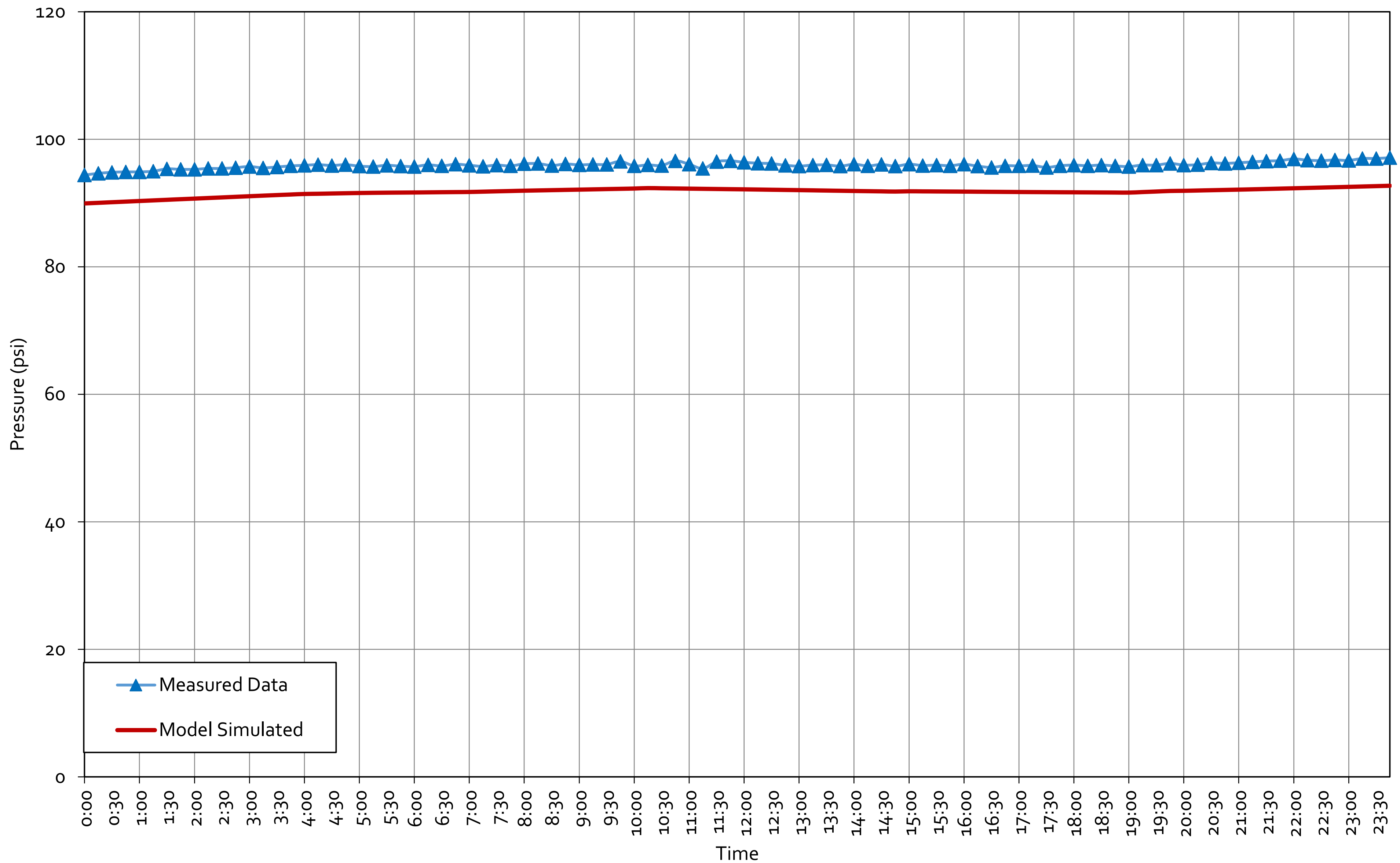
Water Distribution Infrastructure Plan

EPS CALIBRATION - CALLE LAS CALERAS PS DISCHARGE PRESSURE



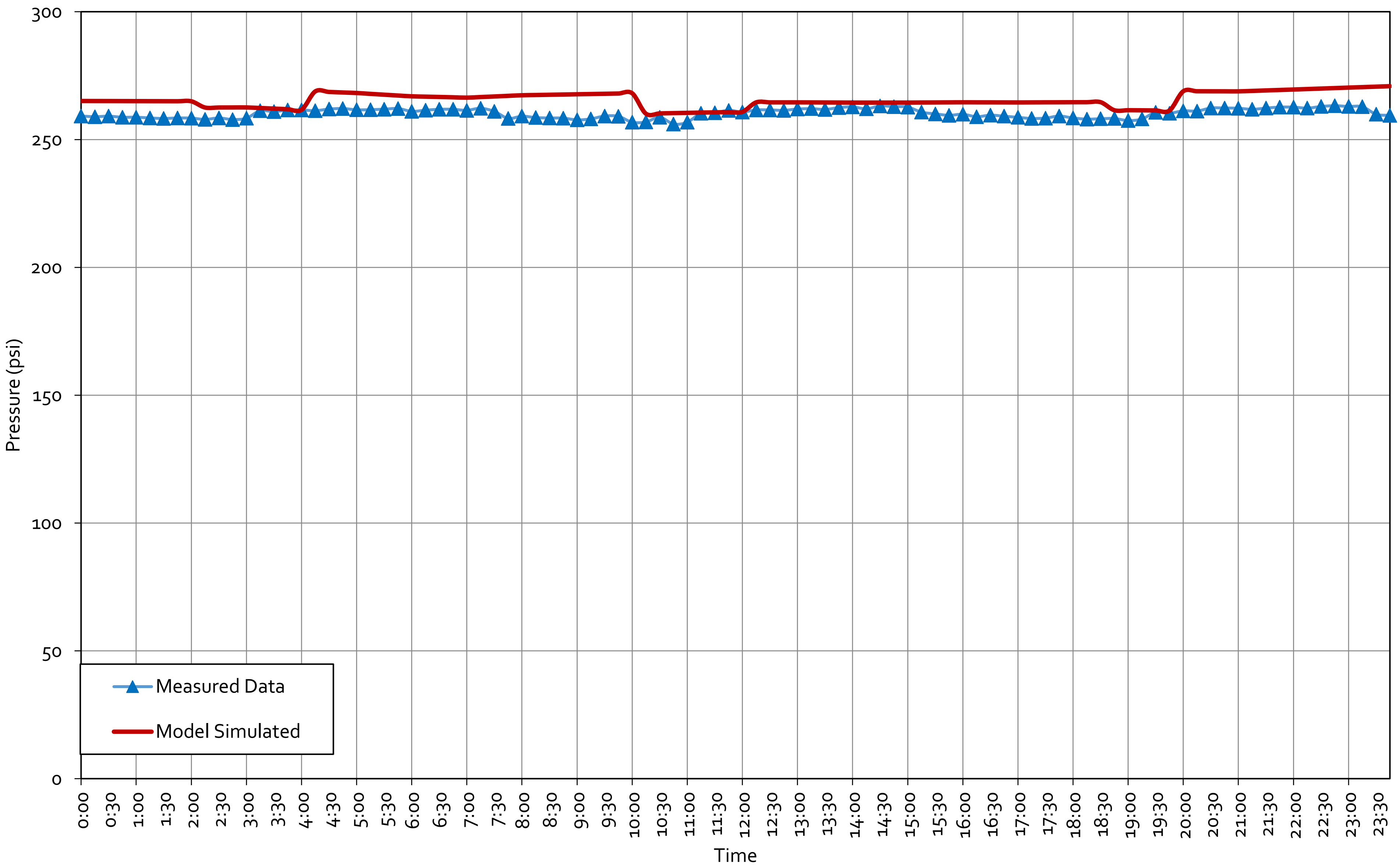
Water Distribution Infrastructure Plan

EPS CALIBRATION - ROCKY NOOK PS SUCTION PRESSURE



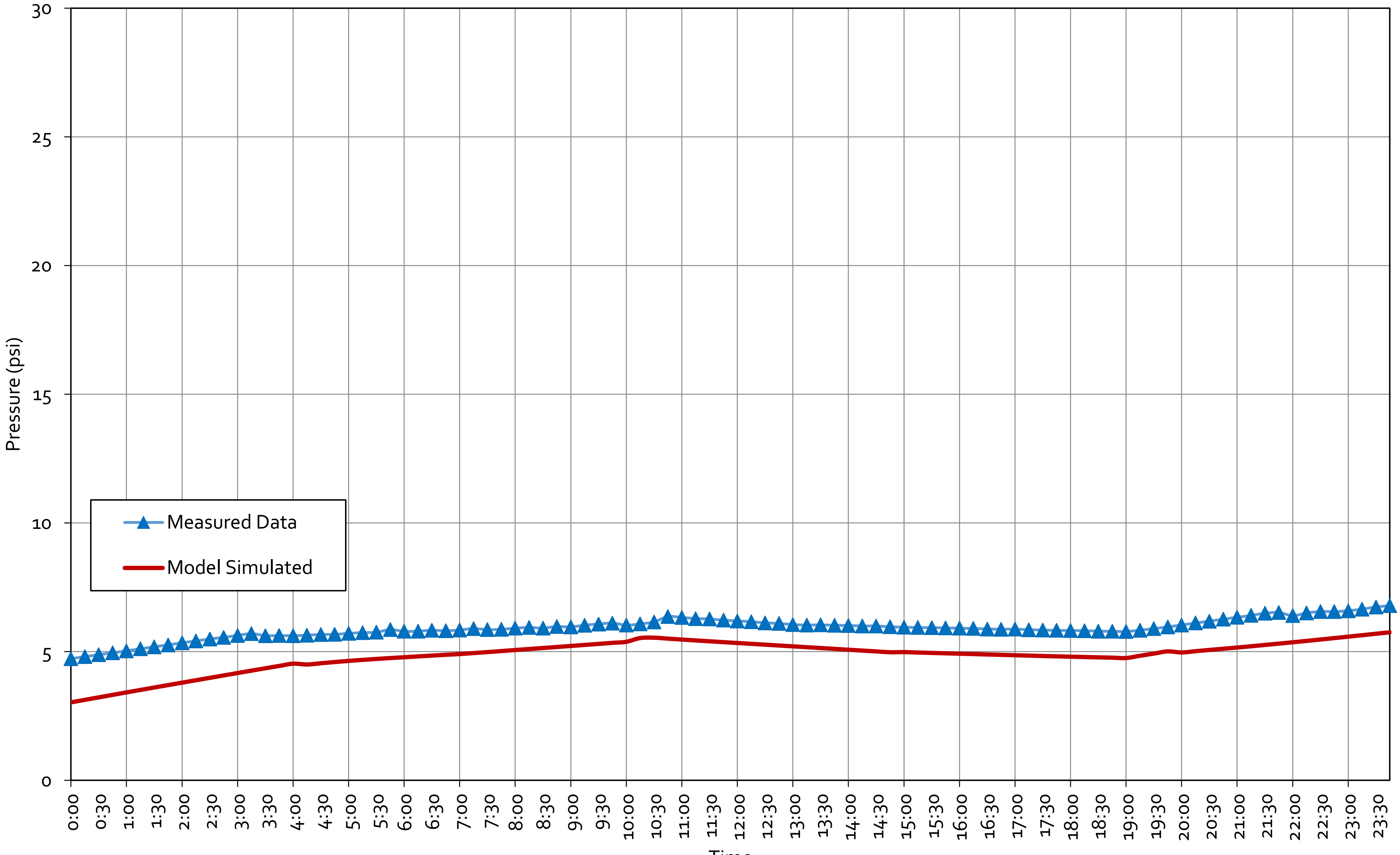
Water Distribution Infrastructure Plan

EPS CALIBRATION - ROCKY NOOK PS DISCHARGE PRESSURE



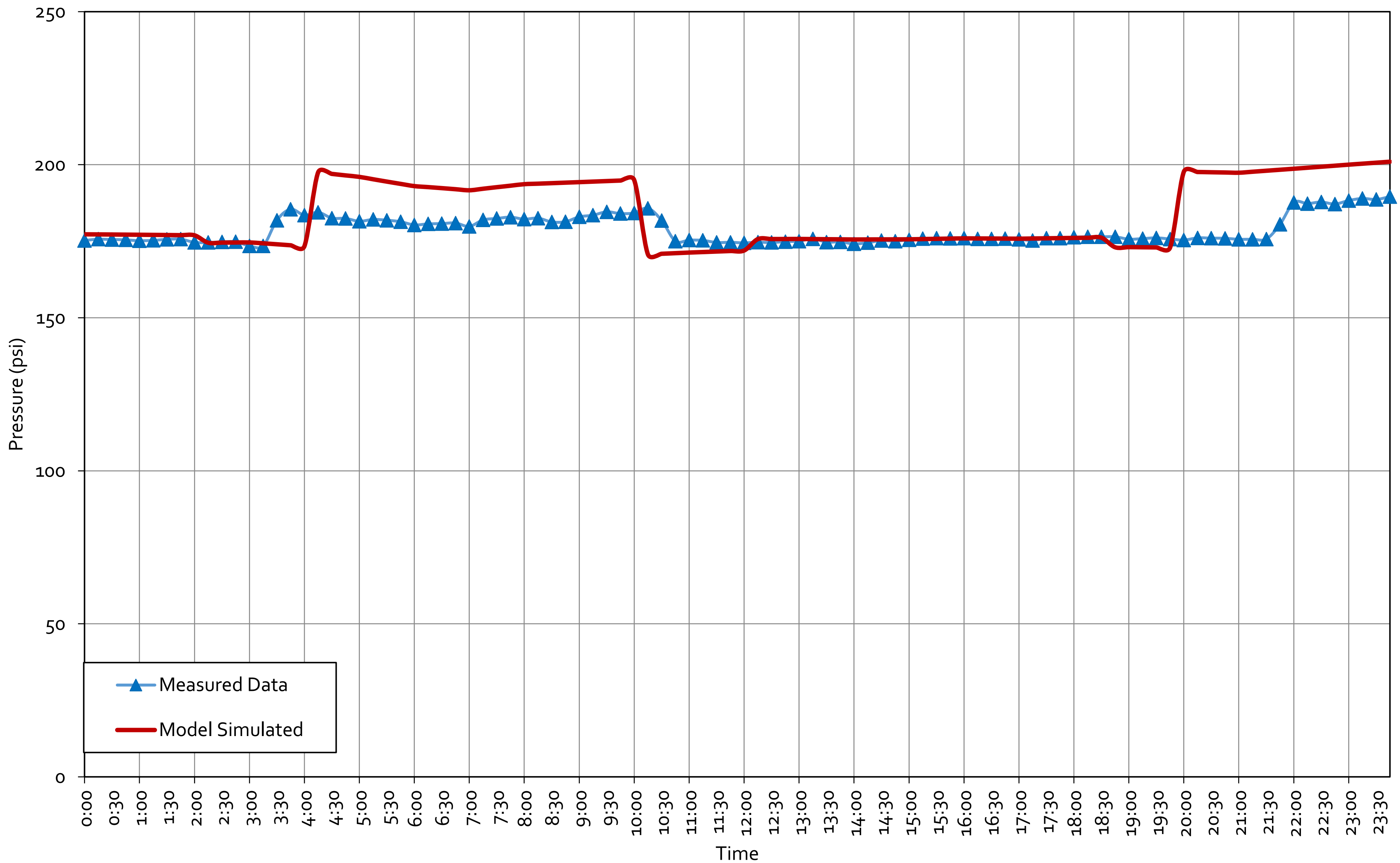
Water Distribution Infrastructure Plan

EPS CALIBRATION - EL CIELITO PS SUCTION PRESSURE



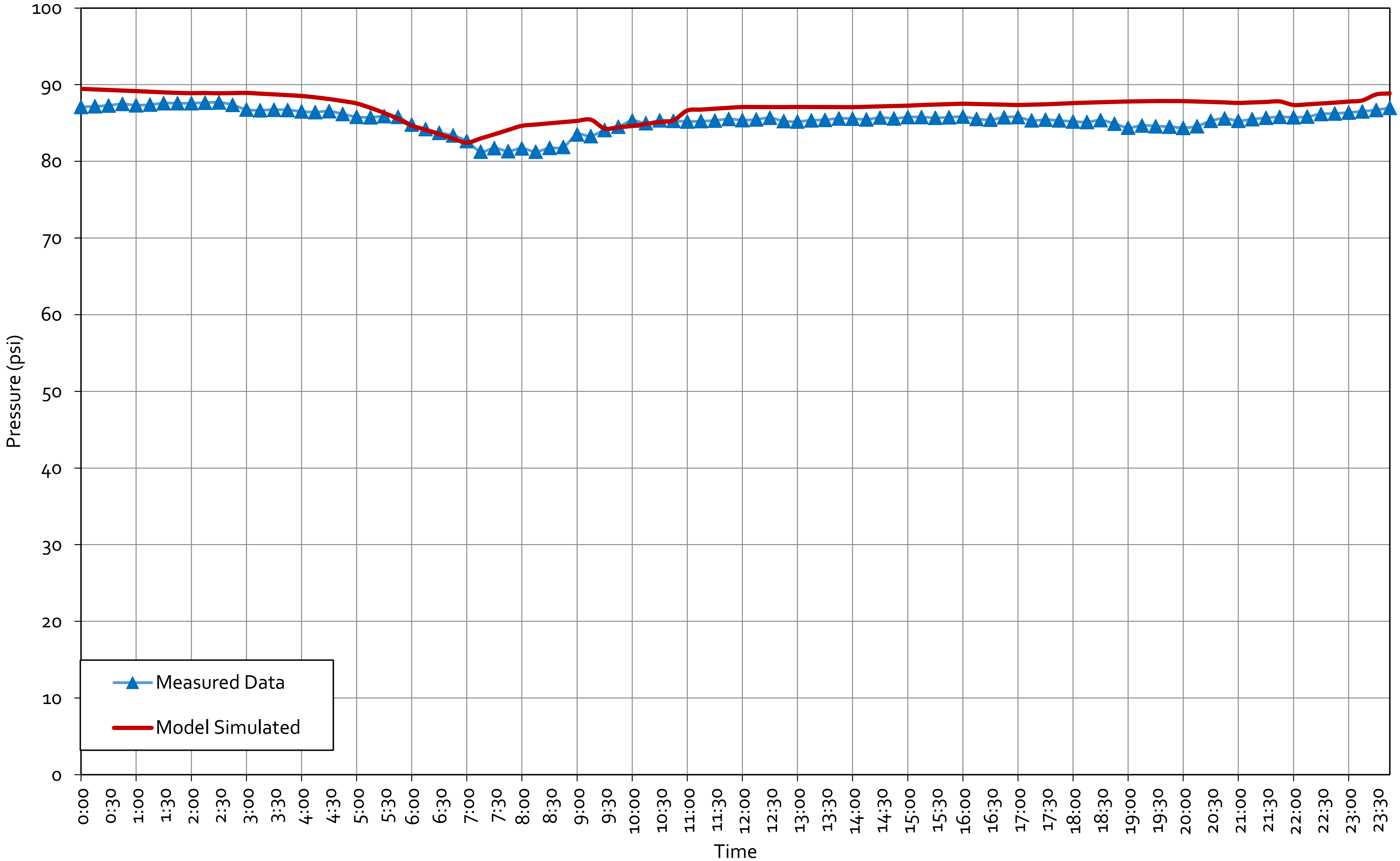
Water Distribution Infrastructure Plan

EPS CALIBRATION - EL CIELITO PS DISCHARGE PRESSURE



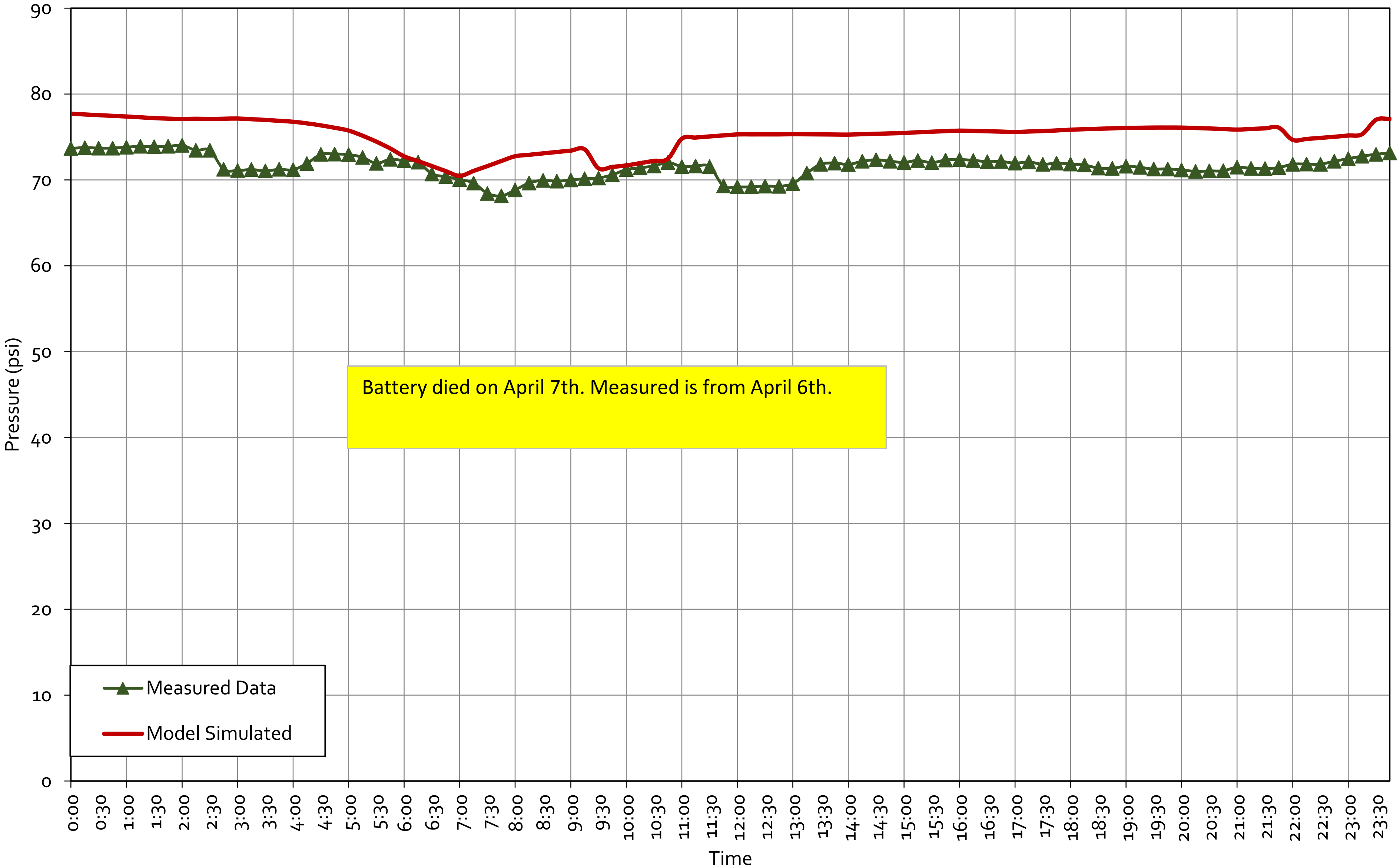
Water Distribution Infrastructure Plan

EPS CALIBRATION - PL 30 PRESSURE



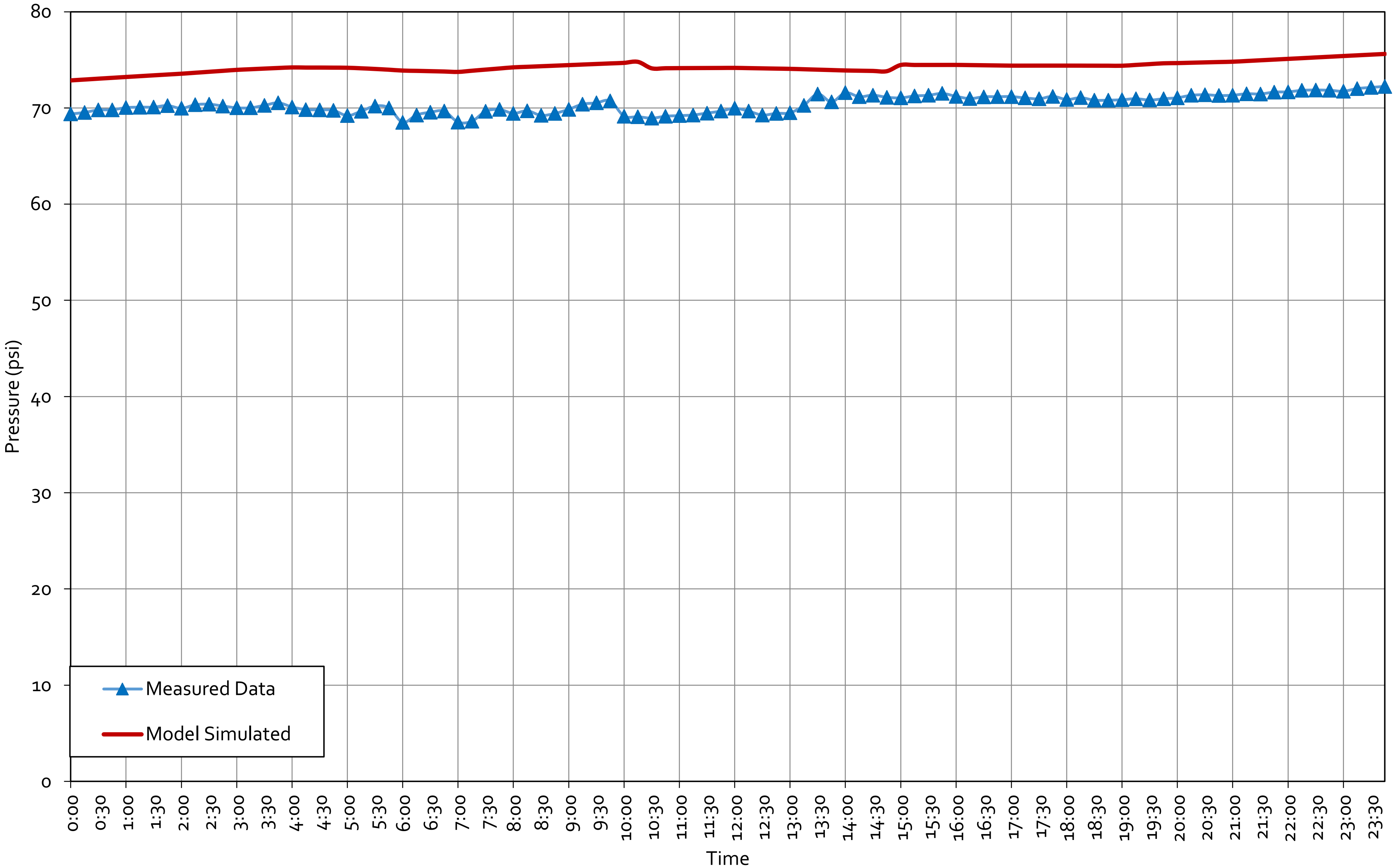
Water Distribution Infrastructure Plan

EPS CALIBRATION - PL 32 PRESSURE



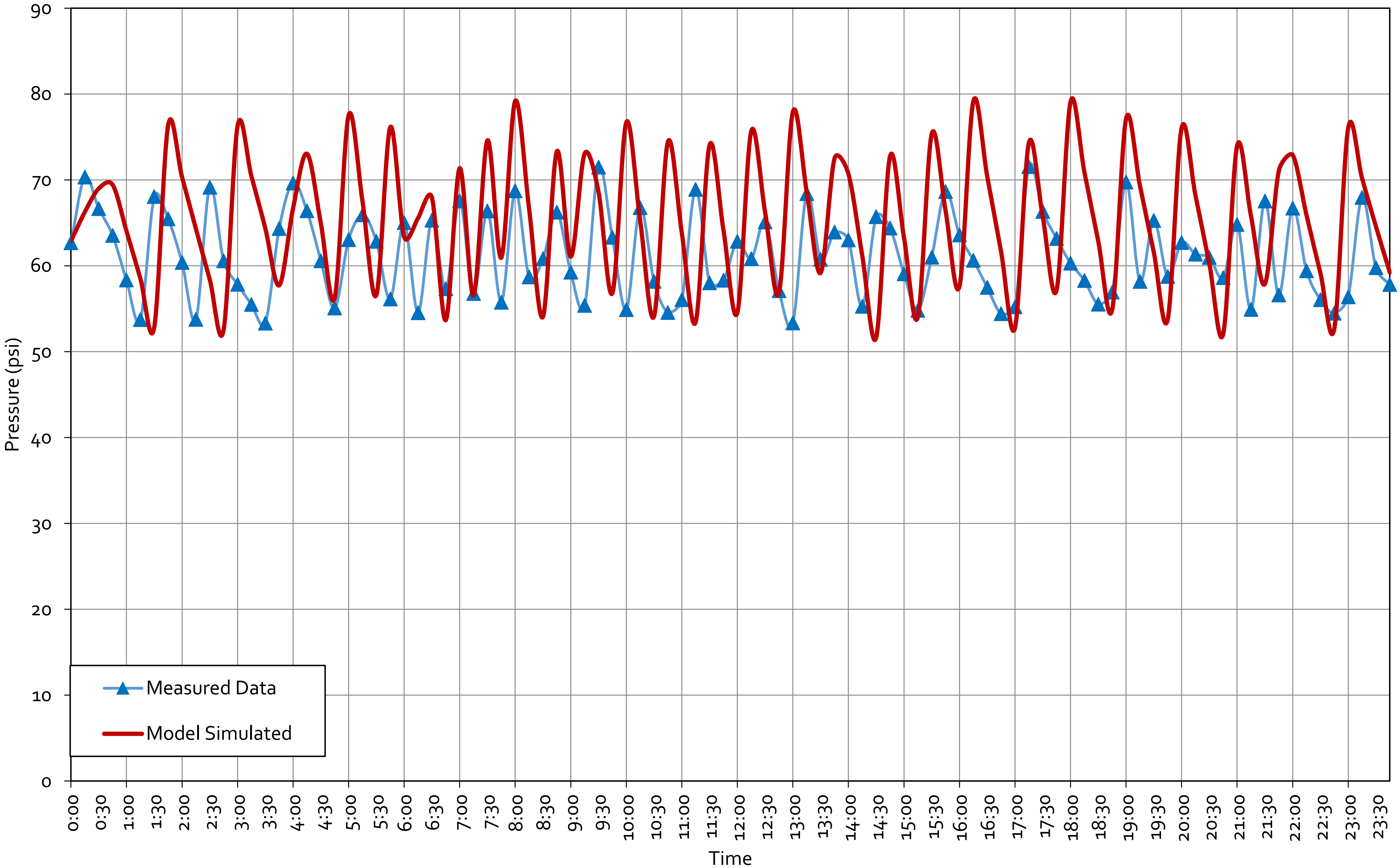
Water Distribution Infrastructure Plan

EPS CALIBRATION - PL 33 PRESSURE



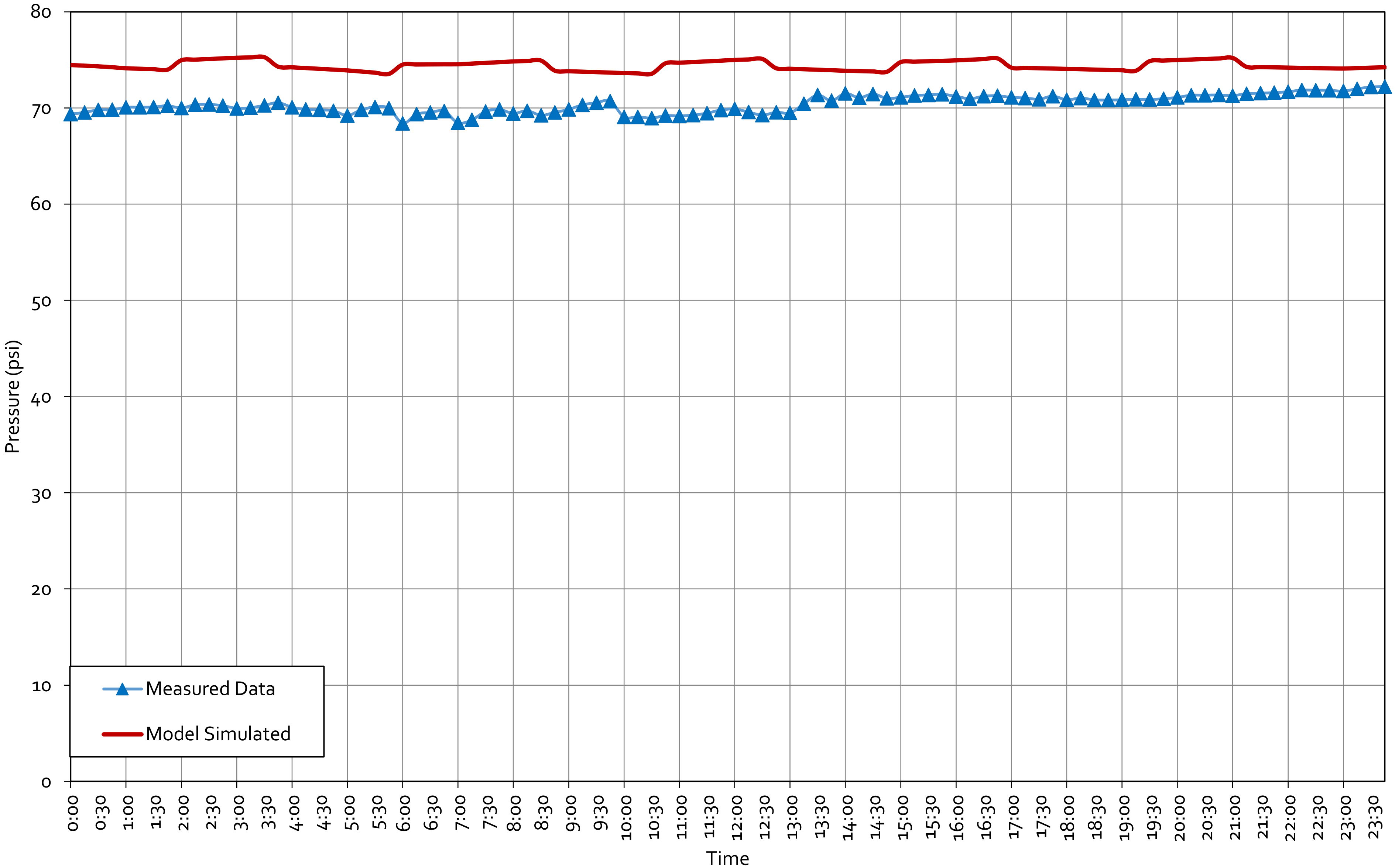
Water Distribution Infrastructure Plan

EPS CALIBRATION - PL 35 PRESSURE



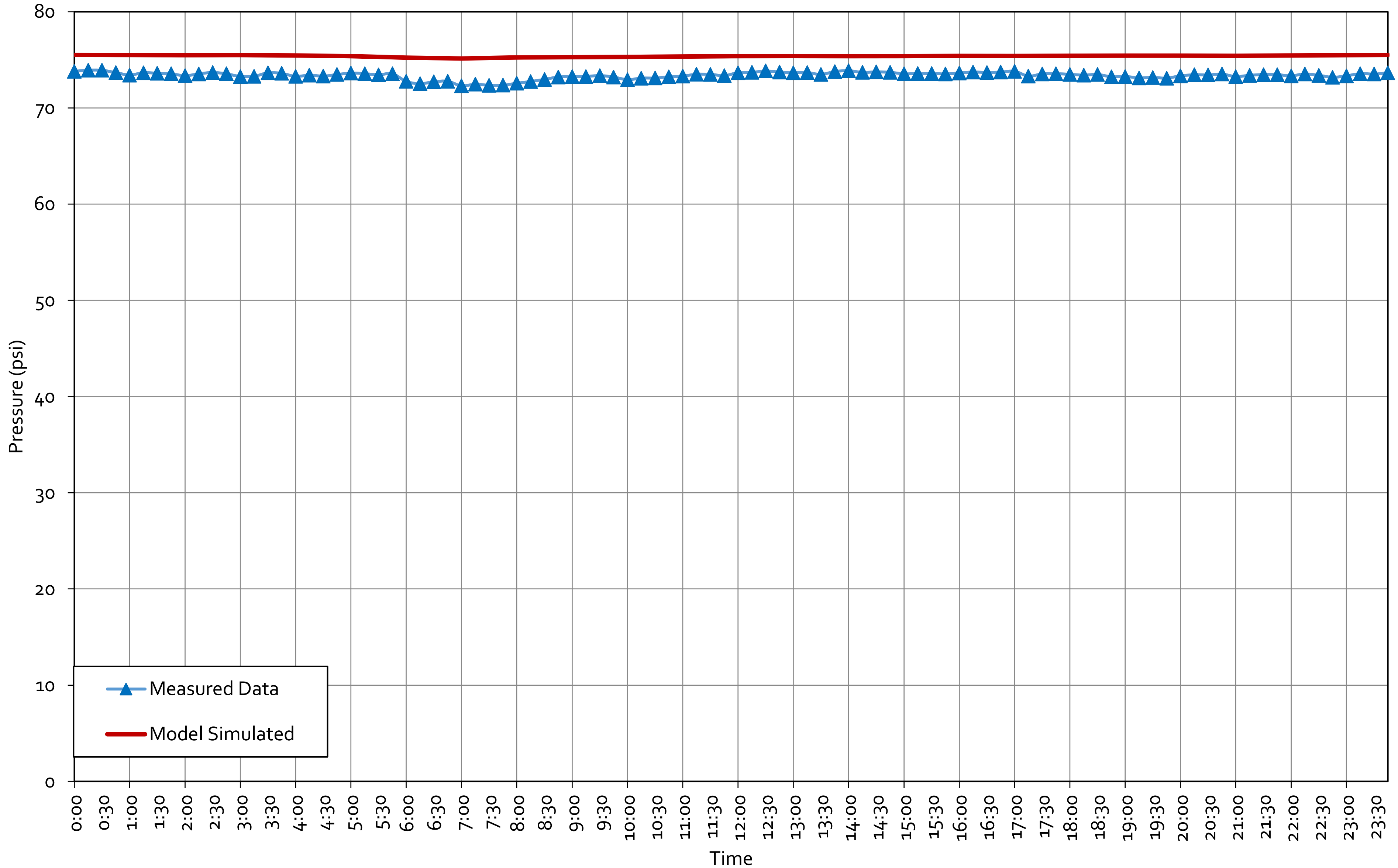
Water Distribution Infrastructure Plan

EPS CALIBRATION - PL 38 PRESSURE



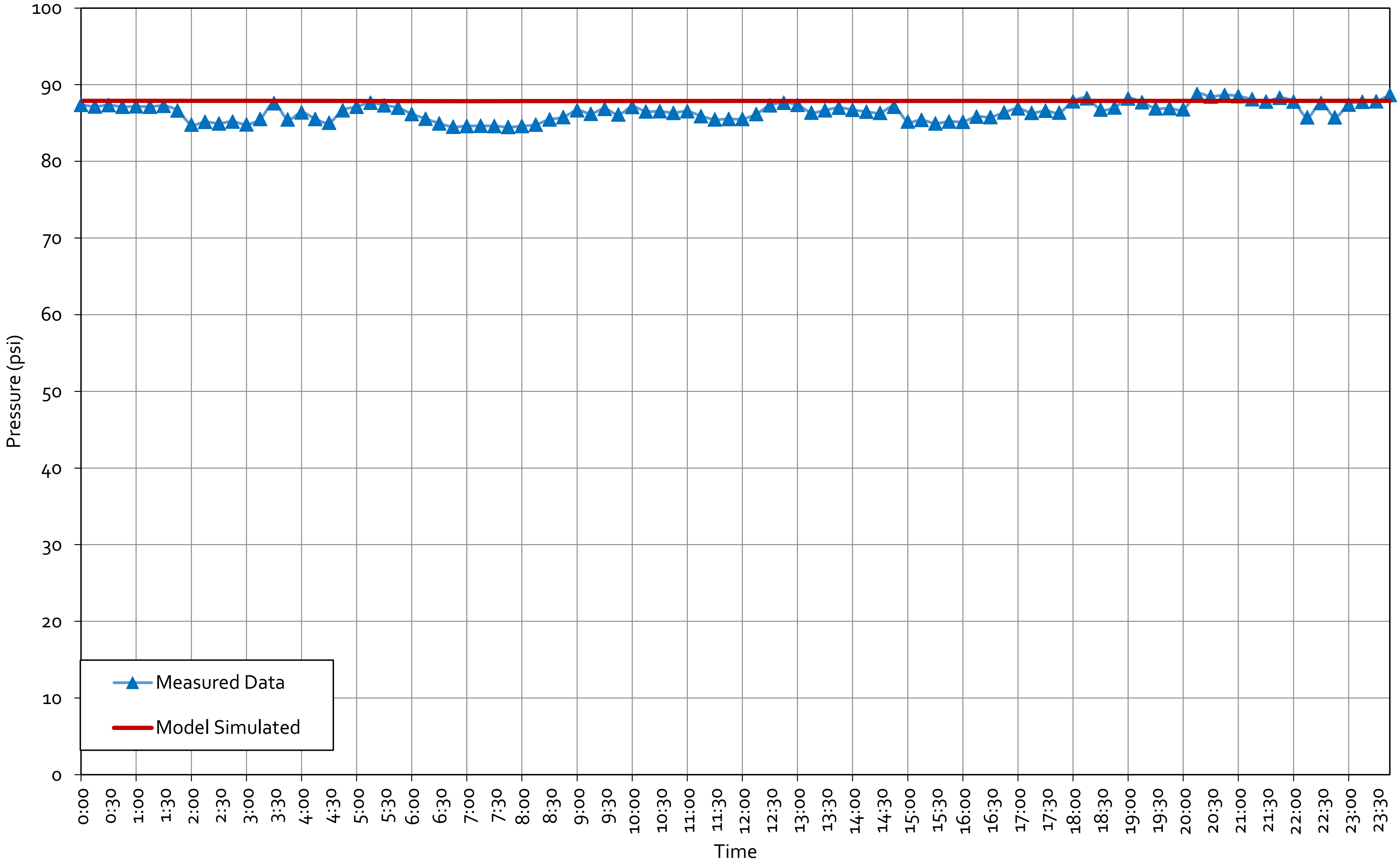
Water Distribution Infrastructure Plan

EPS CALIBRATION - PL 39 PRESSURE



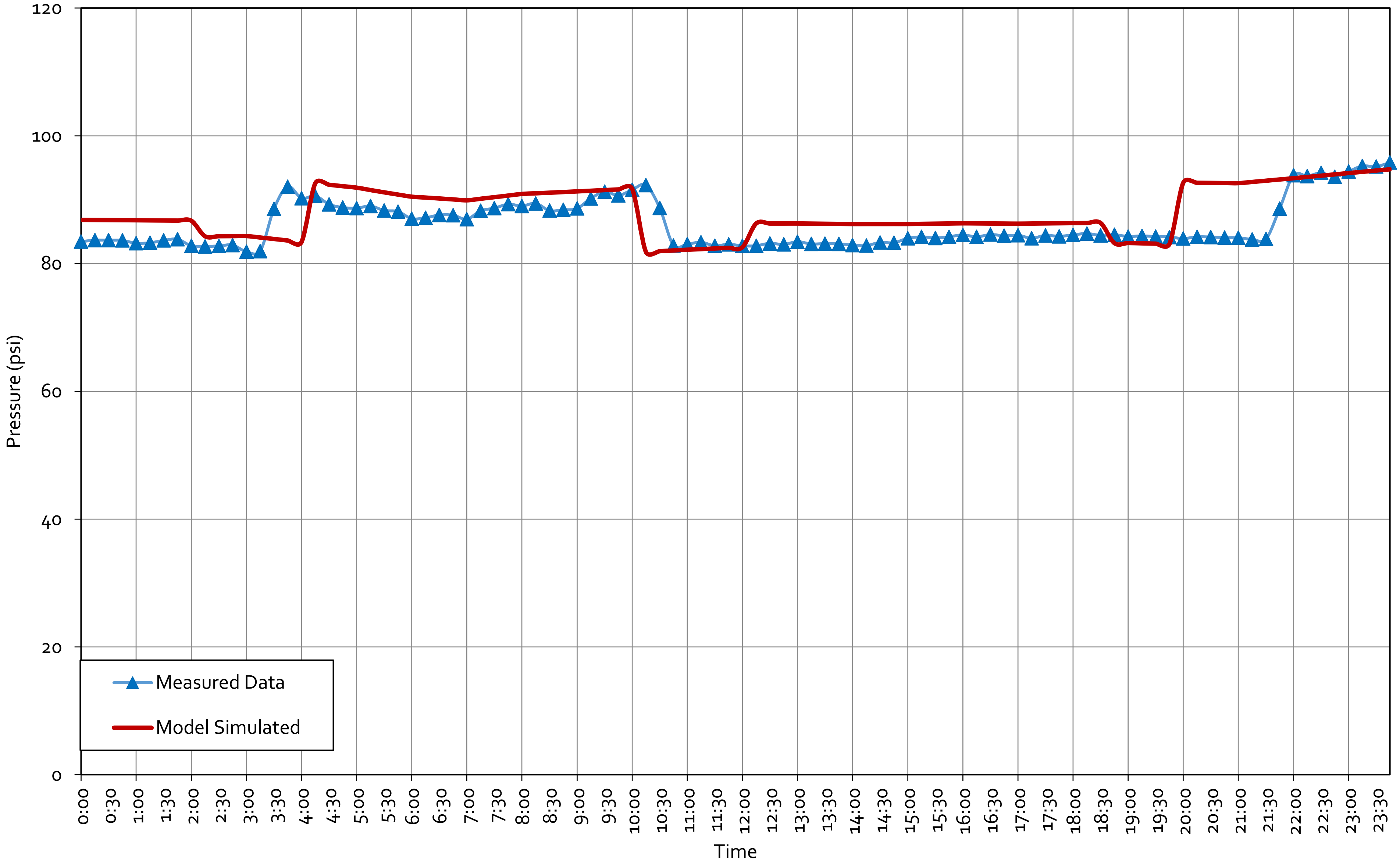
Water Distribution Infrastructure Plan

EPS CALIBRATION - PL 40 PRESSURE



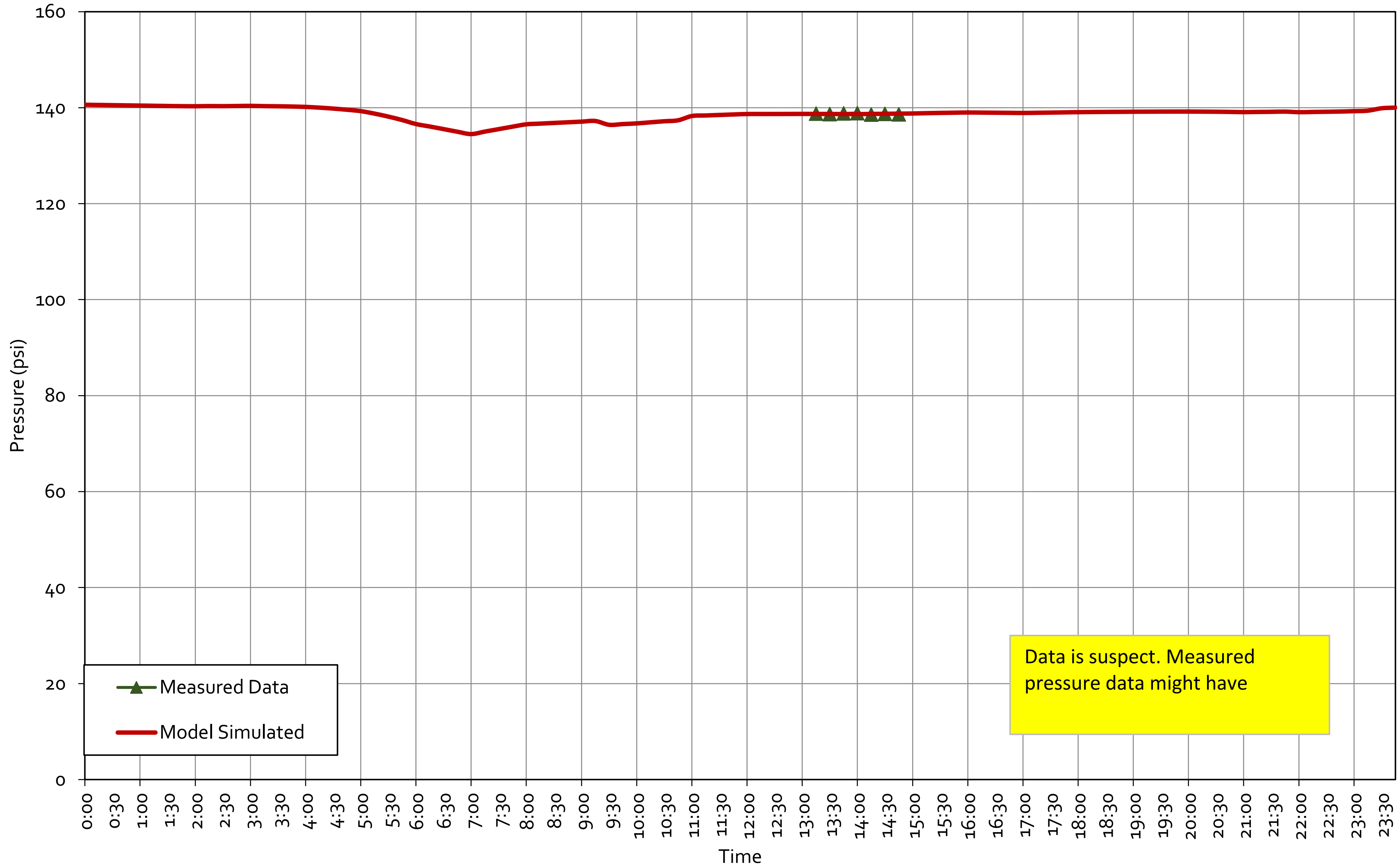
Water Distribution Infrastructure Plan

EPS CALIBRATION - PL 41 PRESSURE



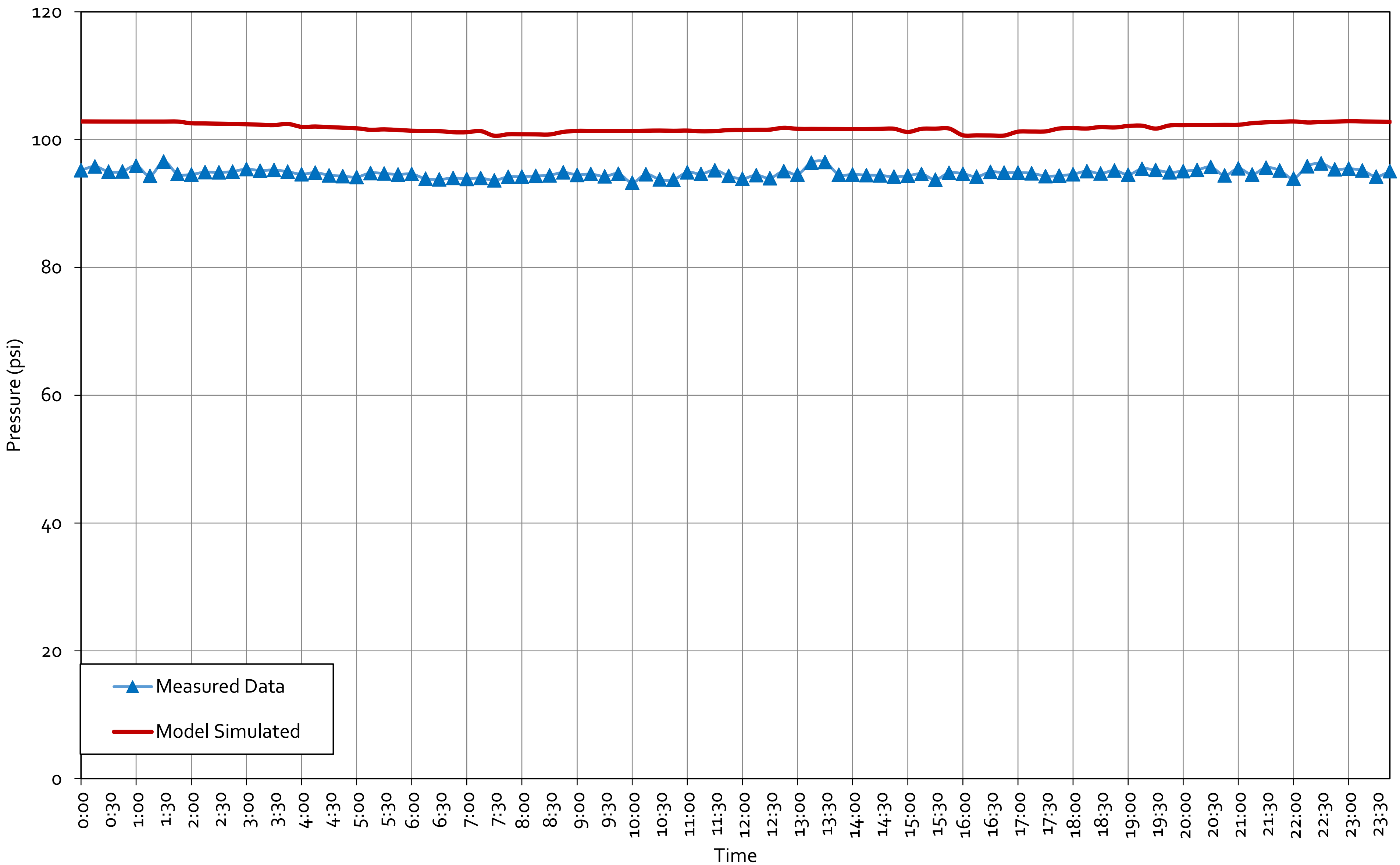
Water Distribution Infrastructure Plan

EPS CALIBRATION - PL 43 PRESSURE



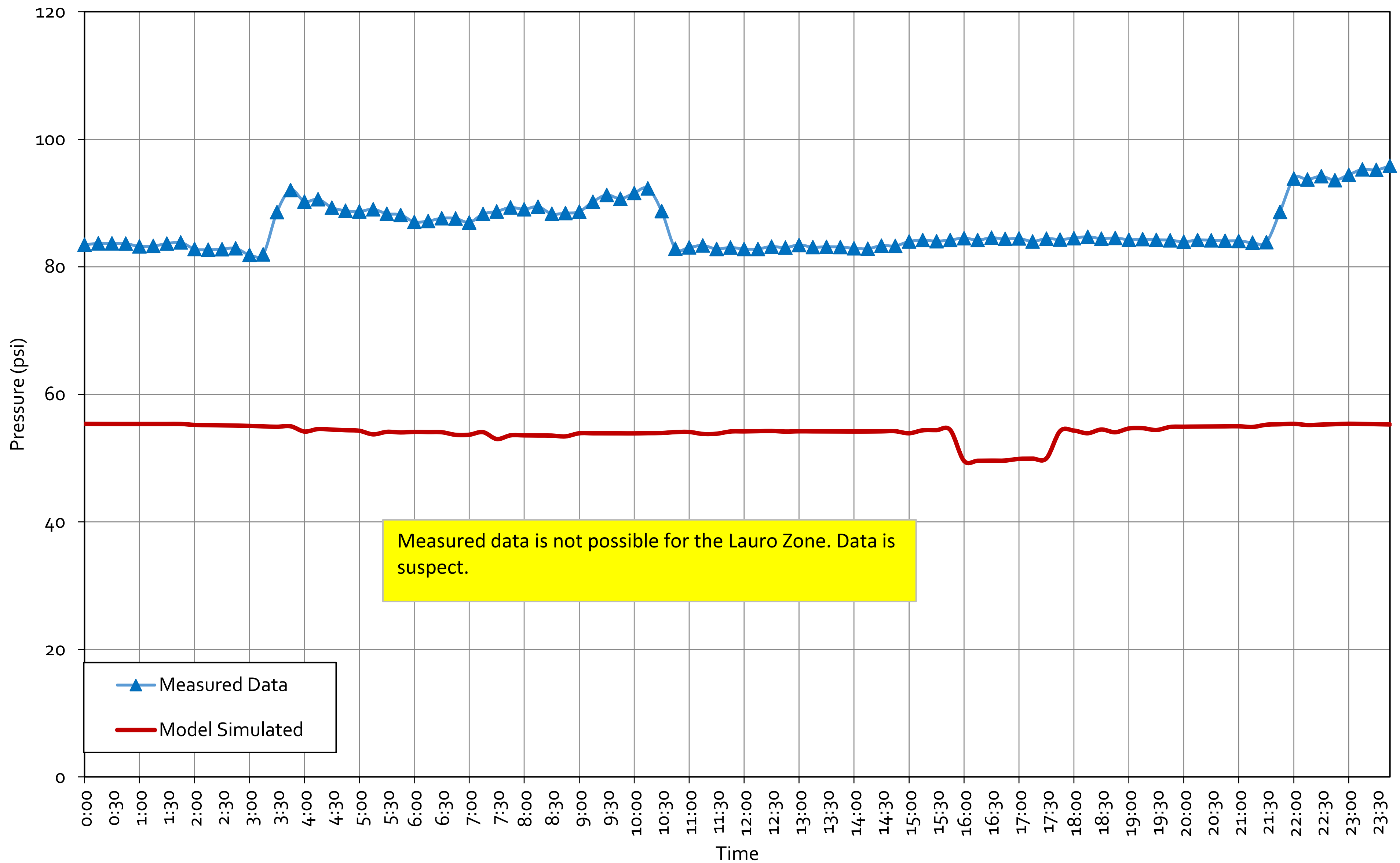
Water Distribution Infrastructure Plan

EPS CALIBRATION - PL 45 PRESSURE



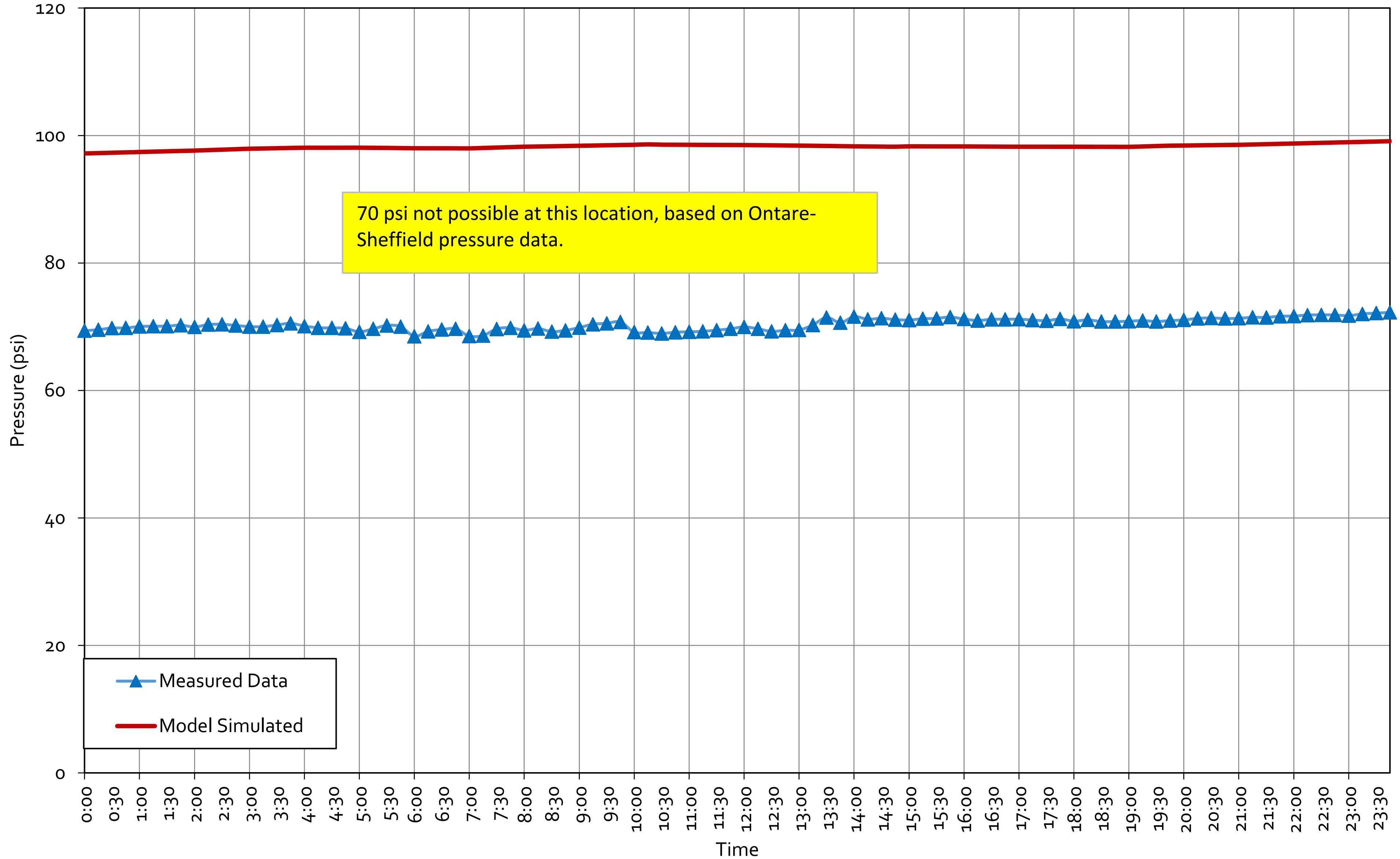
Water Distribution Infrastructure Plan

EPS CALIBRATION - PL 36 PRESSURE



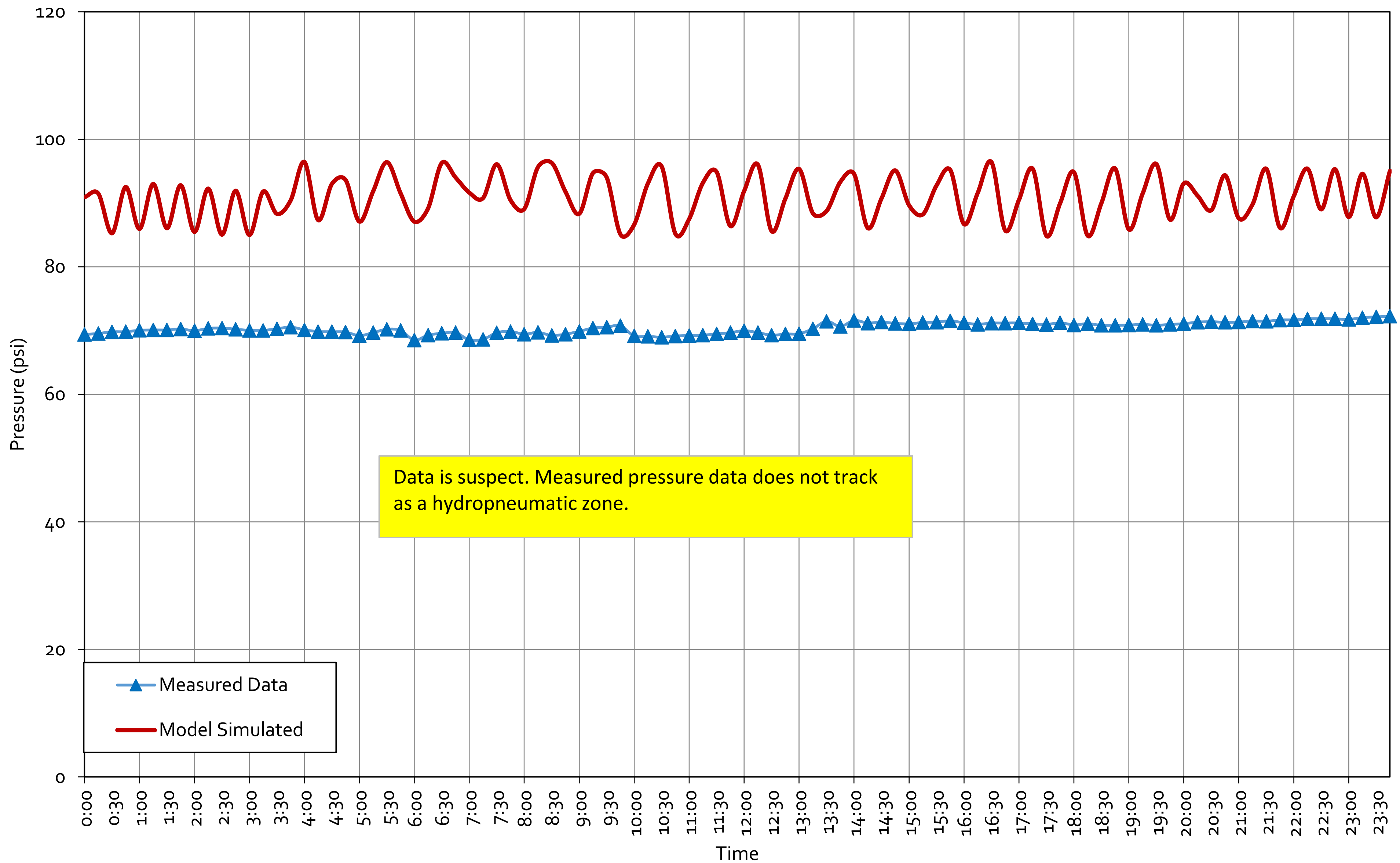
Water Distribution Infrastructure Plan

EPS CALIBRATION - PL 37 PRESSURE



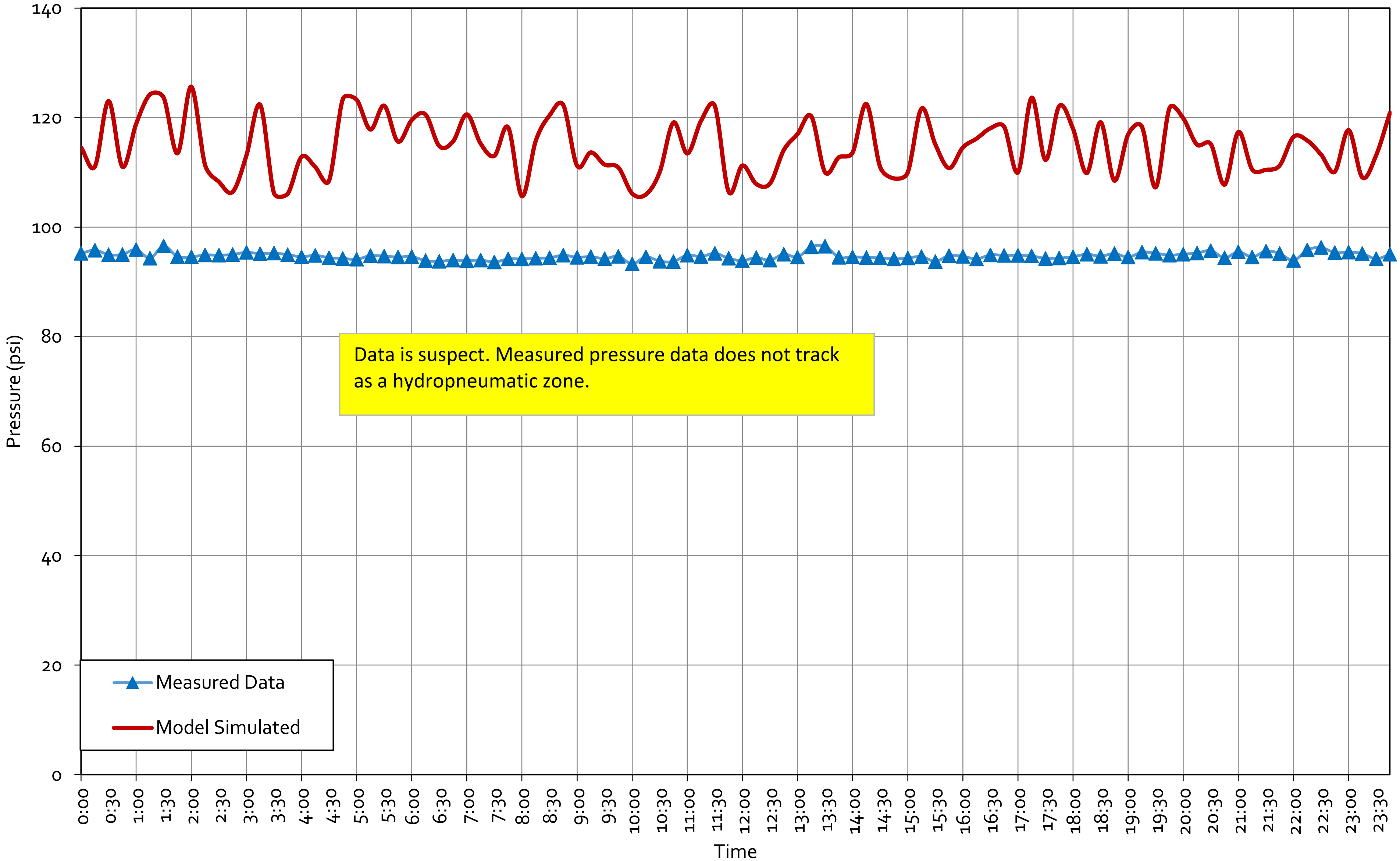
Water Distribution Infrastructure Plan

EPS CALIBRATION - PL 42 PRESSURE



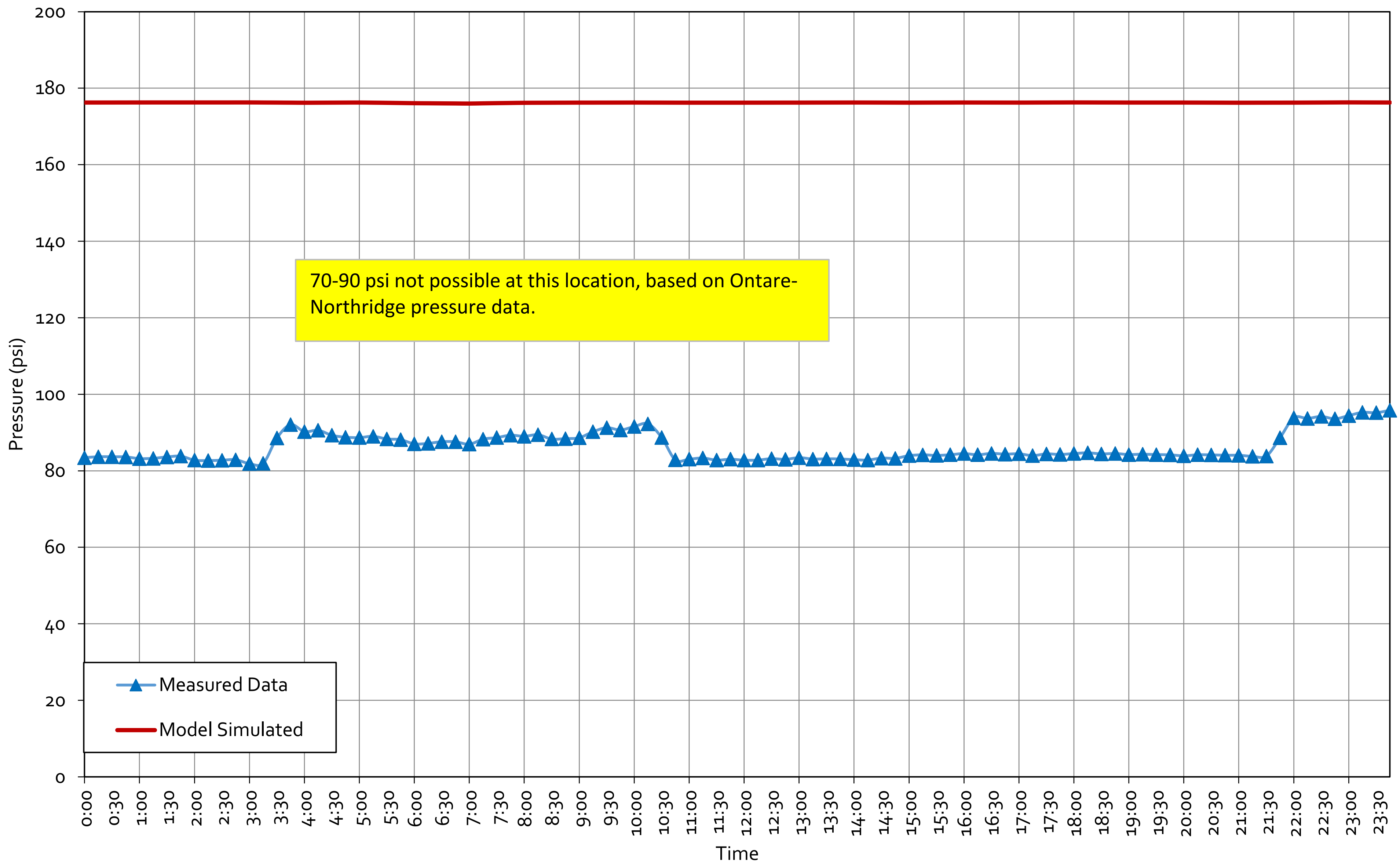
Water Distribution Infrastructure Plan

EPS CALIBRATION - PL 44 PRESSURE



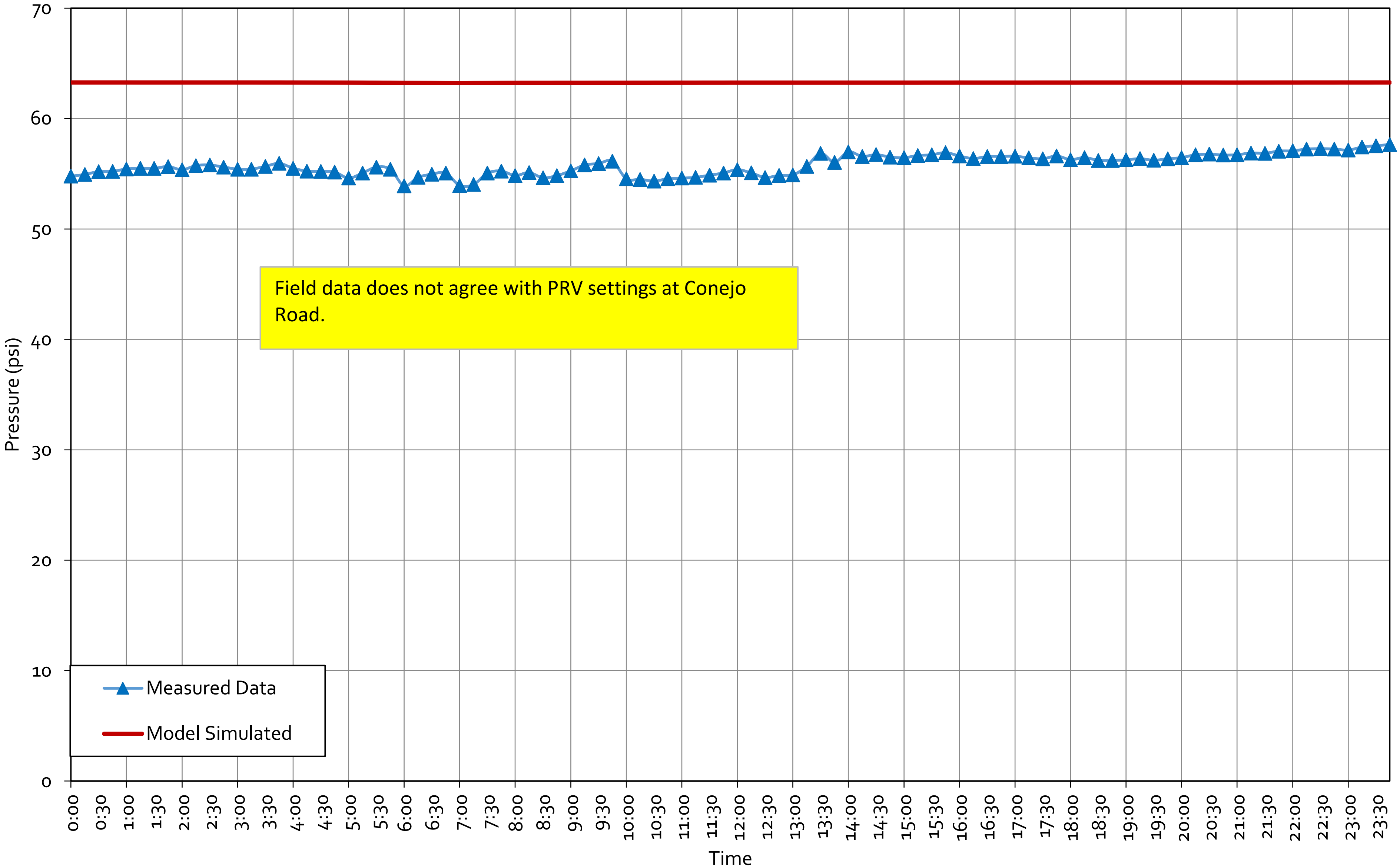
Water Distribution Infrastructure Plan

EPS CALIBRATION - PL 46 PRESSURE



Water Distribution Infrastructure Plan

EPS CALIBRATION - PL 47 PRESSURE



Appendix 1C

FIRE FLOW FIELD TEST CALIBRATION RESULTS

Water Distribution Infrastructure Plan

FIRE FLOW TEST RESULTS

Test Site	Test Location	Time	Hydrant Type	Hydrant ID	Field Measured Data			Model Simulated Data		Percent Difference	
					Hydrant Flow (gpm)	Hydrant Pressure (psi)		Hydrant Pressure (psi)			
						Static	Residual	Static	Residual	Static	Residual
1	De La Guerra and Olive	4/9/2019 14:13	Flowing 1	FH-G08-001	1,372	-	-	-	-	-	-
		4/9/2019 14:15	Flowing 2	FH-H08-021	1,341	-	-	-	-	-	-
			Pressure 1	FH-G08-002	-	140	130	143	131	2%	1%
			Pressure 2	FH-H07-017	-	145	105	142	114	-2%	9%
2	Chapala and Sola	4/9/2019 10:18	Flowing 1	FH-F08-012	1,286	-	-	-	-	-	-
		4/9/2019 10:20	Flowing 2	FH-F08-041	1,286	-	-	-	-	-	-
			Pressure 1	FH-F08-013	-	105	100	106	101	1%	1%
			Pressure 2	FH-F08-040	-	110	107	113	109	3%	2%
3	Chino and Western	4/8/2019 9:06	Flowing 1	FH-E09-023	1,383	-	-	-	-	-	-
		4/8/2019 9:01	Flowing 2	FH-E09-004	1,095	-	-	-	-	-	-
			Pressure 1	FH-E09-016	-	112	104	112	106	0%	2%
			Pressure 2	FH-E09-022	-	115	105	114	107	-1%	2%
4	Las Ondas and Santa Catalina	4/8/2019 9:40	Flowing 1	FH-F12-024	1,330	-	-	-	-	-	-
		4/8/2019 9:44	Flowing 2	FH-F13-009	1,108	-	-	-	-	-	-
			Pressure 1	FH-F12-026	-	105	92	108	92	3%	0%
			Pressure 2	FH-F13-008	-	125	110	121	99	-3%	-10%
5	Palermo and Calabria	4/8/2019 10:08	Flowing 1	FH-B07-023	1,133	-	-	-	-	-	-
			Flowing 2	FH-B07-024	-	-	-	-	-	-	-
			Pressure 1	FH-C07-011	-	74	65	80	64	8%	-2%
			Pressure 2	FH-B07-025	-	80	75	85	75	6%	0%
6	Campanil and Centinela	4/9/2019 7:11	Flowing 1	FH-B09-002	861	-	-	-	-	-	-
			Flowing 2	FH-A09-004	-	-	-	-	-	-	-
			Pressure 1	FH-A09-003	-	50	32	46	36	-8%	13%
			Pressure 2	FH-B09-003	-	51	35	46	36	-10%	3%
7	Sea Ranch and Marina	4/8/2019 10:33	Flowing 1	FH-A10-001	1,492	-	-	-	-	-	-
			Flowing 2	FH-A10-002	-	-	-	-	-	-	-
			Pressure 1	FH-A10-003	-	112	100	118	96	5%	-4%
			Pressure 2	FH-A11-004	-	177	165	180	152	2%	-8%
8	Litchfield and Westwood	4/8/2019 12:10	Flowing 1	FH-D11-016	1,146	-	-	-	-	-	-
			Flowing 2	FH-D11-009	-	-	-	-	-	-	-
			Pressure 1	FH-D11-017	-	98	85	99	88	1%	4%
			Pressure 2	FH-D11-010	-	-	-	-	-	-	-

Water Distribution Infrastructure Plan

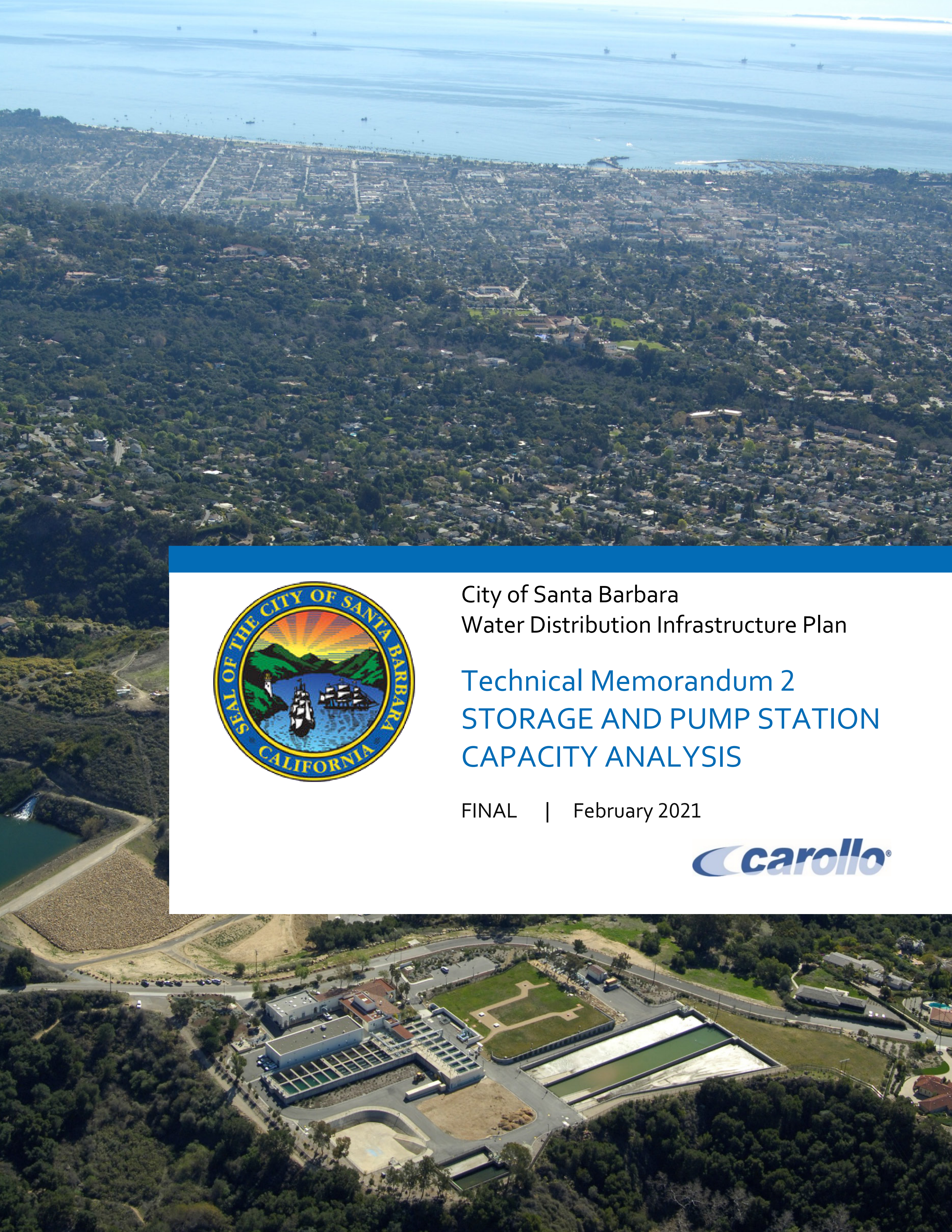
FIRE FLOW TEST RESULTS

Test Site	Test Location	Time	Hydrant Type	Hydrant ID	Field Measured Data			Model Simulated Data		Percent Difference	
					Hydrant Flow (gpm)	Hydrant Pressure (psi)		Hydrant Pressure (psi)			
						Static	Residual	Static	Residual	Static	Residual
9	St James and Live Oak	4/8/2019 12:39	Flowing 1	FH-C09-013	1,330	-	-	-	-	-	-
			Flowing 2	FH-C09-014	-	-	-	-	-	-	-
			Pressure 1	FH-C09-004	-	102	90	97	83	-5%	-8%
			Pressure 2	FH-C09-022	-	105	100	108	101	3%	1%
10	Ontare and Santa Maria	4/8/2019 12:59	Flowing 1	FH-C05-011	1,372	-	-	-	-	-	-
		4/8/2019 13:02	Flowing 2	FH-C06-009	1,108	-	-	-	-	-	-
			Pressure 1	FH-C05-010	-	124	100	125	97	1%	-3%
			Pressure 2	FH-C06-010	-	98	75	98	74	0%	-1%
11	Vista Del La Cumbre	4/8/2019 13:33	Flowing 1	FH-D04-015	1,013	-	-	-	-	-	-
			Flowing 2	FH-D04-016	-	-	-	-	-	-	-
			Pressure 1	FH-D04-014	-	82	55	84	76	2%	38%
			Pressure 2	FH-D04-026	-	95	95	97	96	2%	1%
12	Peach Grove and Osito	4/8/2019 14:01	Flowing 1	FH-B06-022	1,286	-	-	-	-	-	-
			Flowing 2	FH-C06-003	-	-	-	-	-	-	-
			Pressure 1	FH-B06-024	-	124	115	121	110	-2%	-4%
			Pressure 2	FH-C06-008	-	120	100	116	93	-3%	-7%
13	Via Lucero and Bodega	4/9/2019 7:51	Flowing 1	FH-A05-008	1,218	-	-	-	-	-	-
			Flowing 2	FH-A05-004	-	-	-	-	-	-	-
			Pressure 1	FH-A05-002	-	105	95	101	93	-4%	-2%
			Pressure 2	FH-A04-022	-	110	100	108	103	-2%	3%
14	Willowglen and Meru	4/9/2019 8:12	Flowing 1	FH-C03-029	1,068	-	-	-	-	-	-
			Flowing 2	FH-C03-006	-	-	-	-	-	-	-
			Pressure 1	FH-B03-015	-	165	70	167	73	1%	4%
			Pressure 2	FH-C03-007	-	155	65	155	61	0%	-6%
15	Santa Teresita and Francisco	4/9/2019 8:36	Flowing 1	FH-D01-001	1,330	-	-	-	-	-	-
			Flowing 2	FH-D01-002	-	-	-	-	-	-	-
			Pressure 1	FH-D02-001	-	110	95	120	87	9%	-8%
			Pressure 2	FH-C02-005	-	170	150	184	152	8%	1%
16	Cheltenham and Kenmore	4/9/2019 9:03	Flowing 1	FH-E03-025	1,330	-	-	-	-	-	-
			Flowing 2		-	-	-	-	-	-	-
			Pressure 1	FH-E03-004	-	135	100	135	95	0%	-5%
			Pressure 2	FH-F03-019	-	120	85	119	78	-1%	-8%

Water Distribution Infrastructure Plan

FIRE FLOW TEST RESULTS

Test Site	Test Location	Time	Hydrant Type	Hydrant ID	Field Measured Data			Model Simulated Data		Percent Difference	
					Hydrant Flow (gpm)	Hydrant Pressure (psi)		Hydrant Pressure (psi)			
						Static	Residual	Static	Residual	Static	Residual
17	Mission Canyon and Paseo Del Ocaso	4/9/2019 12:08	Flowing 1	FH-F01-011	1,241	-	-	-	-	-	-
			Flowing 2	FH-F01-009	-	-	-	-	-	-	-
			Pressure 1	FH-F01-012	-	140	110	141	116	1%	5%
			Pressure 2	FH-F01-019	-	175	130	172	123	-2%	-5%
18	Garden and Los Olivos	4/9/2019 9:28	Flowing 1	FH-E06-032	1,218	-	-	-	-	-	-
			Flowing 2	FH-F06-008	1,286	-	-	-	-	-	-
			Pressure 1	FH-E06-025		90	85	88	86	-2%	1%
			Pressure 2	FH-F06-010		110	110	111	110	1%	0%
19	Grand and Maple	4/9/2019 9:55	Flowing 1	FH-F05-040	1,308	-	-	-	-	-	-
			Flowing 2	FH-F06-033	-	-	-	-	-	-	-
			Pressure 1	FH-F05-010	-	120	98	123	108	3%	10%
			Pressure 2	FH-F06-024	-	140	120	142	136	1%	13%
20	Las Tunas	4/9/2019 12:49	Flowing 1	FH-G04-004	956	-	-	-	-	-	-
			Flowing 2	FH-G04-016	-	-	-	-	-	-	-
			Pressure 1	FH-F04-019	-	160	100	166	102	4%	2%
			Pressure 2	FH-G04-005	-	130	70	125	69	-4%	-1%
21	Las Canoas Ln	4/9/2019 13:13	Flowing 1	FH-G03-008	1,013	-	-	-	-	-	-
			Flowing 2	FH-G03-007	-	-	-	-	-	-	-
			Pressure 1	FH-G03-009	-	107	85	108	80	1%	-6%
			Pressure 2	FH-F03-003	-	110	85	114	77	4%	-9%
22	Las Canoas	4/9/2019 13:46	Flowing 1	FH-H02-005	717	-	-	-	-	-	-
			Flowing 2	FH-G03-003	-	-	-	-	-	-	-
			Pressure 1	FH-H02-009	-	90	25	98	24	9%	-4%
			Pressure 2	FH-G03-004	-	-	-	-	-	-	-
23	Eucalyptus Hill and Coronada	4/10/2019 7:05	Flowing 1	FH-L06-002	999	-	-	-	-	-	-
			Flowing 2	FH-L06-001	-	-	-	-	-	-	-
			Pressure 1	FH-K06-002	-	120	60	124	86	3%	43%
			Pressure 2	FH-L06-010	-	125	60	123	81	-2%	35%
24	Cima Linda	4/10/2019 7:24	Flowing 1	FH-L07-013	1,158	-	-	-	-	-	-
			Flowing 2	FH-K07-004	-	-	-	-	-	-	-
			Pressure 1	FH-L07-014	-	135	80	145	75	7%	-6%
			Pressure 2	FH-K07-013	-	145	90	152	84	5%	-7%



City of Santa Barbara
Water Distribution Infrastructure Plan

Technical Memorandum 2
STORAGE AND PUMP STATION CAPACITY ANALYSIS

FINAL | February 2021

carollo

City of Santa Barbara
Water Distribution Infrastructure Plan

Technical Memorandum 2
STORAGE AND PUMP STATION CAPACITY ANALYSIS

FINAL | February 2021

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Abbreviations

afy	acre-feet per year
ADD	average day demand
AWWA	American Water Works Association
CIP	Capital Improvement Plan
City	City of Santa Barbara
ES	Executive Summary
Goleta	City of Goleta
gpm	gallons per minute
IBR	irrigation bird refuge
IRF	dedicated residential irrigation
IRG	dedicated commercial irrigation
IRI	dedicated agricultural irrigation
MDD	maximum day demand
MG	million gallons
mgd	million gallons per day
MinDD	minimum day demand
O.O.S.	out of service
PF	peaking factor
PRV	pressure reducing valve
TM	Technical Memorandum
WC0	commercial/industrial water customer category
WDIP	Water Distribution Infrastructure Plan
WIN	industrial water customer category
WM0	single-family water customer category
WM1	1- to 4-unit multi-family water customer category
WM4 / WM5	5+-unit multi-family water customer category
WTP	Water Treatment Plant

Technical Memorandum 2

STORAGE AND PUMP STATION CAPACITY ANALYSIS

2.1 Introduction

The goal of the storage analysis is to evaluate the storage and pump station capacity of the City of Santa Barbara's (City's) existing distribution system under existing and future demand conditions. This technical memorandum (TM) presents:

- The existing system demands, peaking factors (PFs), and projected demands.
- The storage and pump station capacity evaluation criteria and analyses.
- An evaluation of potential temporary outage scenarios under future demand conditions.

Facility outage scenarios reflect temporary conditions caused by repairs or replacements. Recommendations to address identified deficiencies are included in the Capital Improvement Plan (CIP), which is presented in the Executive Summary (ES) of this report.

2.2 Water System Demands

This section describes the City's existing and projected water demands through year 2050.

2.2.1 Historical Water Consumption

Currently, the City's potable water billing meters are read on a monthly basis. The City provided monthly billing data by water code for years 2014 through 2018. The City's uses 22 billing codes based on customer class and usage type. For this analysis, the 22 billing codes were grouped into the following 5 customer categories:

- **Irrigation:** This category includes water usage from irrigation bird refuge (IBR), dedicated residential irrigation (IRF), dedicated commercial irrigation (IRG), and dedicated agricultural irrigation (IRI) accounts.
- **Commercial :** This category includes water usage from commercial accounts.
- **Industrial:** This category includes water usage from industrial (WIN) accounts.
- **Single-Family Residential:** This category includes water usage from single family residential (WM0) accounts.
- **Multi-Family Residential:** This category includes water usage from 1- to 4-units multi-family residential (WM1) and 5+ units multi-family residential (WM4 and WM5) accounts.

In addition to the City's water demands, the City supplies water to the Goleta Water District (GWD) and La Cumbre Mutual Water Company (LCMWC) via GWD throughout the year. The City's consumption data for the last five years including Goleta's water demand are presented in Table 2.1 and graphically presented on Figure 2.1.

Summary observations presented in Table 2.1 and Figure 2.1 include:

- The total City consumption in the last 5 years varied from 8,760 acre-feet per year (afy) (or 7.8 million gallons per day [mgd]) to 10,588 afy (or 9.5 mgd).
- The average City consumption in the last 5 years was approximately 9,252 afy (or 8.3 mgd).
- The total system consumption ranged from 9,281 afy (or 8.3 mgd) to 11,321 afy (or 10.1 mgd), which includes GWD and LCMWC (via GWD) consumption that ranged from 492 afy (or 0.5 mgd) to 733 afy (or 0.6 mgd).
- The total system consumption dropped significantly in 2015 due to drought conditions and conservation.
- The majority of the system consumption consists of single family and multi-family residential customers. The next largest customer class consists of commercial/industrial customers.

Table 2.1 Historical Water Consumption by Customer Class (2014-2018)

Year	Water Consumption by Customer Class(1) (afy)							
	Irrigation	Commercial/ Industrial	Industrial	Single Family Residential	Multi-Family Residential	Interagency Connection	**Total City Consumption**	**Total System Consumption**
2014	671	2,006	235	5,049	2,628	733	**10,588**	**11,321**
2015	568	1,836	194	4,131	2,373	502	**9,102**	**9,604**
2016	577	1,772	198	3,915	2,298	521	**8,760**	**9,281**
2017	527	1,773	279	3,879	2,308	730	**8,766**	**9,496**
2018	579	1,787	186	4,081	2,411	549	**9,044**	**9,593**
Ave.	**584**	**1,835**	**218**	**4,211**	**2,404**	**607**	**9,252**	**9,859**

Notes:
(1) Consumption data summarized from billing data provided by City. Interagency demand consists primarily of Goleta demand.

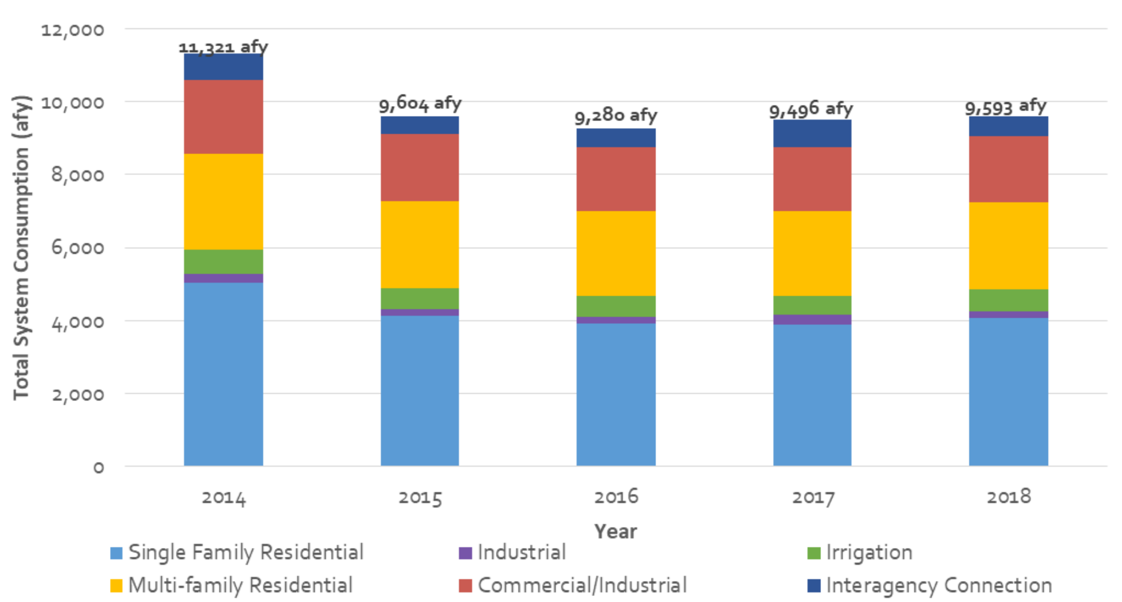

Figure 2.1 Historical System Water Consumption (2014-2018)

2.2.2 Existing Demands (Year 2019)

Water demands represent water that leaves the distribution system through metered or unmetered connections, or at pipe joins (leaks) or breaks. Hence, water demand is defined as the combination of both water consumption (from billing records) and unaccounted-for-water (a.k.a., water loss). Due to inaccuracies in the production meter readings from 2016 to March 2018, water loss was assumed to be 8 percent based on the City's 2015 Urban Water Management Plan assumptions.

The existing average day demand (ADD) for year 2019 is based on the system consumption developed by Maddaus Water Management (9,194 afy) and an 8 percent water loss (807 afy), which equates to 10,001 afy (or 8.93 mgd). A copy of the City of Santa Barbara Water Conservation Strategic Plan, Maddaus Water Management, Inc., is included in in Appendix 2A.

2.2.3 Peaking Factors

Peaking Factors (PFs) are typically used to determine the water demands for conditions other than ADD. PFs account for fluctuations in demands on a seasonally or hourly basis. For example, during hot summer days, water use is typically higher than on a cold winter day due to increased irrigation demands. PFs are determined using the water system demands for a selected period and dividing the quantity by the ADDs.

The maximum day demand (MDD) PF represents the ratio of the largest daily demand observed in one year to the ADD for the same year. This factor can then be applied to the ADD of future planning years to project maximum day water demands. Similarly, the minimum day demand (MinDD) PF represents the ratio of the lowest daily demand observed in one year to the ADD for the same year.

Historical production for year 2014 to 2018 was provided by the City and used to establish the City's MDD and MinDD seasonal PF. The PFs are summarized in Table 2.2. As presented in Table 2.2, the MDD and MinDD PFs ranged from 1.57 to 2.15 and 0.18 to 0.56, respectively.

Since 2018 data was incomplete, it was excluded from the average. The MDD and MinDD PFs used in this study are 1.81 and 0.46, respectively.

Table 2.2 Peaking Factors

Year	ADD (mgd)	MDD (mgd)	MinDD (mgd)	MDD PF	MinDD PF
2014	11.8	21.7	5.7	1.85	0.48
2015	9.4	14.8	4.6	1.57	0.49
2016	8.4	14.0	4.7	1.67	0.56
2017	7.8	16.8	2.4	2.15	0.30
2018	6.8	14.1	1.2	2.08	0.18
Average(1)	**9.4**	**16.8**	**4.4**	**1.81**	**0.46**

Notes:
(1) Since 2018 data was incomplete, 2018 was excluded from the average.

2.2.4 Future Demand Projections

The City performed a water demand projection analysis up to year 2050 and provided the results for this analysis. The projected demands are summarized in Table 2.3.

Table 2.3 Projected Water Demands

Year	Projected Annual Demand(1) (afy)	Projected ADD (mgd)	Projected MDD(2) (mgd)
2020	10,232	9.1	16.5
2025	10,561	9.4	17.1
2030	11,744	10.5	19.0
2035	11,943	10.7	19.3
2040	12,227	10.9	19.8
2045	12,591	11.2	20.3
2050	13,013	11.6	21.0

Notes:
(1) Source: City of Santa Barbara Water Conservation Strategic Plan, Maddaus Water Management, Inc., Draft, December 10, 2019
(2) MDD PF is 1.81.

As listed in Table 2.3, demands are anticipated to increase to 13,013 afy (or 11.6 mgd) by year 2050. This demand is used in the future storage analysis, which is presented in Section 2.4.

2.3 Storage Evaluation Criteria

This section presents the planning criteria that were used to evaluate the City's storage capacity. The total storage required for a water system consists of the following three components:

- Operational Storage
- Firefighting Storage
- Emergency Storage

These three components are determined for each pressure zone to evaluate the ability of the water system to meet the storage criteria on both a zone-by-zone basis, as well as a system-wide basis. The criteria used for these three storage requirements are presented in Table 2.4 and discussed in more detail below.

Table 2.4 Storage Volume Criteria

Description	Criteria
Operational Storage	25% MDD
Firefighting Storage	Highest Fire Flow in Zone times required duration
Emergency Storage	100% ADD

Notes:
(1) Values used for planning purposes only.

2.3.1 Operational Storage

Operational storage is defined as the quantity of water that is supplied to meet daily fluctuations in demand beyond the quantity of water that is produced on a daily basis. It is necessary to coordinate the production rates of water sources (e.g., treatment plants) and the available storage capacity to provide a continuous supply of water to the system. Water systems are often designed so that the sources supply enough water to meet MDD. Water storage is then used to supply water for peak hour flows that may occur throughout the day. This operational storage is continuously replenished throughout the day to maintain water quality.

American Water Works Association (AWWA) recommends portions of a distribution system with storage tanks generally need to be sized only to meet maximum daily demands, with storage tanks providing water during instantaneous peak hourly demands. Thus, it is recommended that an operational supply volume ranging from one-quarter to one-third of the demand experienced during one maximum day is used to accommodate the instantaneous peak hourly demands. Therefore, for the City's purposes it is recommended that the pressure zones have operational storage of 25 percent of MDD supplied by reservoirs.

2.3.2 Firefighting Storage

The governing fire department provided the City with the fire flow rate and duration to determine if fire storage is required for a pressure zone. Typical values for varying different land use types are presented in Table 2.5 as a reference and used in this analysis. Fire flow storage is determined based on the single greatest fire flow requirement (flow and duration) within each pressure zone.

Table 2.5 Fire Flow Requirements

Land Use	Fire Flow Requirement (gpm)	Duration (hours)
Foothill Residential	750	2
Low Density Residential	750	2
Medium Density Residential	750	2
High Density Residential	1,250	4
Commercial	1,250	4
Industrial	2,500	4
Public Facilities	1,250	4
Open Space	750	2

Notes:
Abbreviation: gpm - gallons per minute.
(1) Values used for planning purposes only.

2.3.3 Emergency Storage

Storage is also required to meet system demands during emergencies. Emergencies cover a wide range of rare but probable events, such as water contamination, failure at a water treatment plant (WTP), power outages, transmission pipeline ruptures, several simultaneous fires, and earthquakes. The volume of water that is needed during an emergency is usually based on the estimated amount of time expected to elapse before the disruptions caused by the emergency are corrected. The occurrence and magnitude of emergencies is difficult to predict. Since the City has multiple supply sources, the City's recommended emergency storage is 100 percent ADD.

2.4 Storage Analysis

The purpose of a storage analysis is to understand if the water distribution system has sufficient storage to meet the evaluation criteria discussed in Section 2.3. This storage volume analysis also includes five outage scenarios where certain reservoirs are assumed to be taken out of service temporarily for repair/maintenance purposes.

As mentioned in TM 1, the City's distribution system is hydraulically separated into 17 pressure zones with 13 active storage reservoirs. Though the total storage capacity is about 39.2 million gallons (MG), the total usable storage volume is estimated to be 32.0 MG due to unusable storage volume at the top and/or bottom of the reservoirs. A summary of the total and usable reservoir capacities is presented in Table 2.6. It should be noted that the "usable storage" is typically less than the total storage volume of a tank caused by "dead" storage. The dead storage is the volume within the reservoir that cannot be utilized for a variety of reasons, such as to provide the minimum suction pressure for discharge pumps to avoid cavitation, maintain a minimum hydraulic grade line (HGL), seismic constraints, or due to the difference between the spillway elevation and the top of a tank. It is very common for reservoirs to have a certain amount of dead storage. For realistic planning purposes the usable volume was used in the storage evaluations presented in this study.

Table 2.6 Reservoir Capacity

Facility	Total Volume(1) (MG)	Usable Volume(2)(3) (MG)
Cater Clearwell(4)	5.00	1.70(4)
East Reservoir	1.00	0.58
Escondido(5)	O.O.S.	O.O.S.
El Cielito Reservoir	1.10	0.98
Hoover Reservoir(6)	6.50	5.34
Hope Reservoir	0.86	0.72
La Mesa Reservoir	1.50	1.50
La Vista Reservoir	2.30	2.25
McLaughlin Reservoir(6)	6.50	5.34
Reservoir No. 1	1.08	0.75
Reservoir No. 2	1.68	1.58
Skofield Reservoir	0.58	0.47

Facility	Total Volume(1) (MG)	Usable Volume(2)(3) (MG)
Tunnel Reservoir	1.06	0.76
Vic Trace Reservoir	10.01	10.01
Total	**39.17**	**31.99**

Notes:
Abbreviation: O.O.S. – out of service.
(1) Source: City of Santa Barbara's Reservoir Summary.
(2) Usable volume calculated using the reservoir's dimensions and the operating range. The City provided operating ranges for each reservoir in an email sent on August 14, 2019.
(3) Reduced capacity volume due to unusable (or "dead") volume at the top or bottom of the reservoir.
(4) The difference between the total and usable storage amount is significant for the Cater Clearwell because this tank also provides operational storage for the Cater Treatment Plant, which requires 0.3 MG of storage for filter backwash and up to 3.0 MG of storage for chlorine contact time based on the maximum Cater WTP production capacity of 36 mgd. Hence, the usable storage remaining for the distribution system is 1.7 MG (5.0 MG - 3.3 MG).
(5) Escondido Reservoir has been out of service since 2000. Thus, it was assumed to be out of service for the purpose of the storage analysis.
(6) The City typically uses one of the two reservoirs in the Sheffield Zone (Hoover and McLaughlin). However, they can be operated at the same time as needed.

For the purpose of the storage analysis presented in this study, the pressure zones and storage reservoirs were grouped into eight groups based on hydraulic connections, such as pressure reducing valves (PRVs) and pump stations. Figure 2.2 shows the City's water distribution system hydraulic profile which illustrates the HGL of gravity reservoirs, pressure zones, and the configuration of the City's water system facilities that connect to and from each pressure zone. The groups for the storage analysis are summarized in Table 2.7.

Table 2.7 Storage Analysis Grouping

Grouped Zone	Pressure Zones within Grouped Zone	Storage Reservoirs within Grouped Zone	Usable Storage (MG)
Skofield Grouped Zone	Skofield Skofield El Cielito	Skofield Reservoir	0.47
El Cielito Tunnel Grouped Zone	Conejo El Cielito Tunnel Mission Canyon Heights Mission Ranchos Northridge Upper Tunnel Road	El Cielito Reservoir Tunnel Reservoir	1.74
Hope Grouped Zone	Campanil Hills Hope	Hope Reservoir	0.72
Sheffield Zone	Sheffield	McLaughlin Reservoir Hoover Reservoir	10.68
Bothin Zone	Bothin	East Reservoir	0.58
Lauro Grouped Zone	Escondido La Coronilla Lauro	Cater Clearwell Vic Trace Reservoir	11.71
La Vista Zone	La Vista	La Vista Reservoir	2.25
Low Level Zone	Low Level	Reservoir No. 1 Reservoir No. 2 La Mesa Reservoir	3.84
Total			**31.99**

2.4.1 Existing Demand Conditions (Year 2019)

As presented in Section 2.2.2, the City's existing demand is 10,001 afy (or 8.93 mgd). Using the existing demands and the usable storage capacities of each reservoir in Table 2.6, a storage evaluation was completed for each group to determine the additional (i.e., deficit) or surplus storage for each grouped zone. The City's distribution system included connectivity between the grouped zones due to the presence of PRVs. Therefore, surplus storage in the City's grouped zones can often supplement the storage deficit in lower pressure zones, if gravity flow through a PRV is available. A summary of the required and available storage volumes is presented in Table 2.8, while details of this analysis are included in Appendix 2B.

As presented in Table 2.8, the existing storage analysis demonstrates that the City has an existing storage surplus of about 16.35 MG. However, the Low Level Zone has a deficit of 3.57 MG. This deficit can be mitigated by using existing PRVs to convey excess water from the Lauro Zone and/or Sheffield Zone to the Low Level Zone. Therefore, no storage capacity improvements are required under existing demand conditions.

Table 2.8 Existing Storage Analysis (Year 2019)

Grouped Pressure Zone	Existing Storage[(1)] (MG)	Required Storage[(2)] (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer (MG)	Net Deficit/ Surplus (MG)
Skofield Grouped Zone	0.47	0.11	0.36	0.00	0.36
El Cielito Tunnel Grouped Zone	1.74	1.25	0.49	0.00	0.49
Hope Grouped Zone	0.72	0.22	0.50	0.00	0.50
Sheffield Zone	10.68	1.81	8.87	0.00	8.87
Bothin Zone	0.58	0.28	0.30	0.00	0.30
Lauro Grouped Zone	11.71	2.69	9.01	-3.57	5.44
La Vista Zone	2.25	1.86	0.39	0.00	0.39
Low Level Zone	3.84	7.41	-3.57	3.57	0.00
Total[(3)]	**31.99**	**15.64**	**16.35**	**0.00**	**16.35**

Notes:
(1) Existing storage is based on usable storage at each reservoir (from Table 2.6).
(2) Required storage includes operational storage, firefighting storage, and emergency storage.
(3) Detailed storage analysis is included in Appendix 2B.

2.4.2 Future Demand Conditions (Year 2050)

Since the City has sufficient storage to meet the storage capacity requirements under existing demand conditions and no storage improvement recommendations were made, the City's existing usable storage capacity was assumed to remain at 32.0 MG under future demand conditions. As presented in Table 2.3, the future year 2050 ADD and MDD are projected to be 11.6 mgd and 21.0 mgd, respectively. Using these future demands and the usable storage capacities of each reservoir in Table 2.6, a storage evaluation is completed for future demand conditions to again evaluate the additional (i.e., deficit) or surplus storage for each grouped zone. A summary of the required and available storage volumes is presented in Table 2.8, while details of this analysis are included in Appendix 2B.

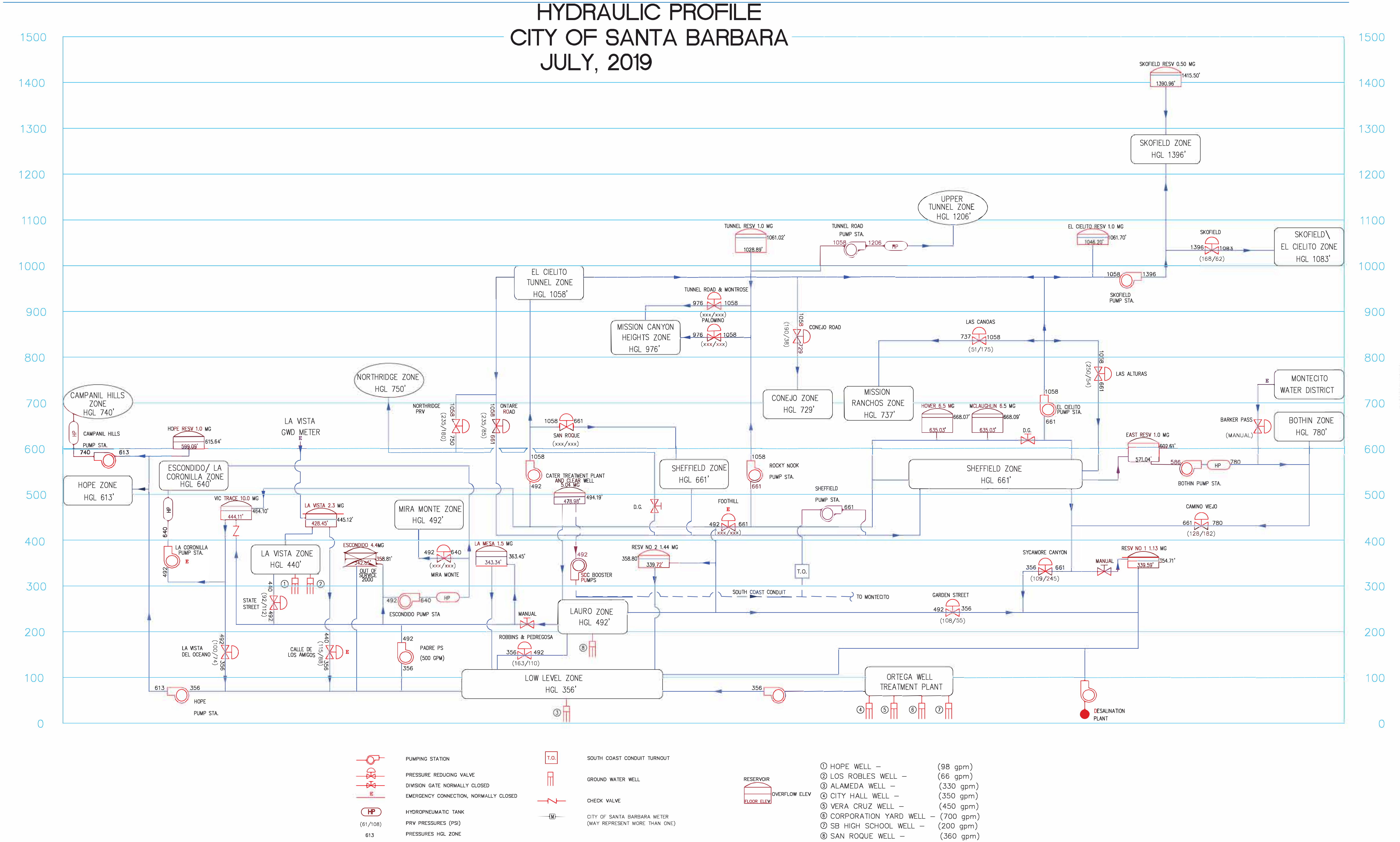

Figure 2.2 Hydraulic Profile

As presented in Table 2.9, the future storage analysis demonstrates that the City's overall future storage surplus is approximately 12.45 MG. However, storage capacity deficiencies exist within the grouped zones that can be mitigated by transferring water from higher zones that have a storage surplus, as indicated below:

- La Vista Grouped Zone has a required storage of 2.33 MG. However, only 2.25 MG of storage is available, resulting in a storage deficit of 0.08 MG. To mitigate this deficit, it is recommended that 0.08 MG of excess storage in the Lauro Grouped Zone be conveyed to the La Vista pressure zone via the State Street PRV. Thus, no storage capacity improvements are recommended.
- Low Level Zone has a required storage of 9.46 MG. However, only 3.84 MG of storage is available, resulting in a storage deficit of 5.62 MG. To mitigate this deficit, it is recommended that 5.62 MG of excess storage in the Lauro Grouped be conveyed to the Low Level Zone via the Garden Street PRV, Robbins & Pedregosa PRV, and/or La Vista Del Oceano PRV. Thus, no storage capacity improvements are recommended.

Table 2.9 Future Storage Analysis (Year 2050)

Grouped Pressure Zone	Usable Storage Volume(1) (MG)	Required Storage(2) (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer (MG)	Net Deficit/ Surplus (MG)
Skofield Grouped Zone	0.47	0.12	0.35	0.00	0.35
El Cielito Tunnel Grouped Zone	1.74	1.54	0.20	0.00	0.20
Hope Grouped Zone(3)	0.72	0.26	0.46	0.00	0.46
Sheffield Zone	10.68	2.18	8.50	0.00	8.50
Bothin Zone	0.58	0.34	0.24	0.00	0.24
Lauro Grouped Zone	11.71	3.32	8.38	-5.70	2.68
La Vista Zone	2.25	2.33	-0.08	0.08	0.00
Low Level Zone	3.84	9.46	-5.62	5.62	0.00
Total	**31.99**	**19.54**	**12.45**	**0.00**	**12.45**

Notes:
(1) Future storage is based on the existing usable storage at each reservoir since no capacity improvements are needed under existing conditions.
(2) Required storage includes operational storage, firefighting storage, and emergency storage.
(3) Detailed storage analysis is included in Appendix 2B.

2.4.3 Storage Scenarios Analysis

As discussed in the storage capacity analysis, the City's distribution system has surplus storage capacity under both existing (year 2019) and future demand conditions (year 2050). However, many of the City's existing reservoirs are aging and will need to be rehabilitated at some point in the future. Additionally, it is important that the City maintain adequate storage capacity in the system when maintenance is being performed on major reservoirs in the system (e.g., Vic Trace). For this reason, five additional storage analyses were conducted as part of this study to evaluate the system's storage capacity with specific reservoirs out of service to mimic these conditions. The out of service scenarios evaluate how the system would operate when a reservoir is temporarily out of service for rehabilitation or routine maintenance. The water supply mix in the analysis is not modified between scenarios, unless explicitly stated.

The following scenarios were evaluated under future demand conditions and discussed in the following sections:

- Reservoir 1 out of service.
- Reservoir 2 out of service.
- Vic Trace out of service.
- Future conditions with Cater Clearwell (temporarily out of service due to repairs).
- Future conditions with multiple reservoirs out of service.

2.4.3.1 Storage Scenarios Analysis – Reservoir No. 1 Out of Service

Reservoir No. 1 is located in the Low Level pressure zone with a total capacity of 1.15 MG and a usable capacity of 0.75 MG. In the past, this reservoir had infrastructure issues that caused leaks when water levels reached above 5 feet. The City has since lined the reservoir and is currently able to use the full capacity. The City has considered taking Reservoir No. 1 out of service due to its age to reduce maintenance and operational costs.

This scenario evaluates the City's storage capacity with Reservoir No. 1 out of service under future demand conditions. A summary of the required and available storage volumes is presented in Table 2.10, while details of this analysis are in Appendix 2B.

Table 2.10 Future Storage Scenarios Analysis (Year 2050) – Reservoir No. 1 Out of Service

Grouped Pressure Zone	Future Storage(1) (MG)	Required Storage(2) (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer (MG)	Net Deficit/ Surplus (MG)
Skofield Grouped Zone	0.47	0.12	0.35	0.00	0.35
El Cielito Tunnel Grouped Zone	1.74	1.54	0.20	0.00	0.20
Hope Grouped Zone	0.72	0.26	0.46	0.00	0.46
Sheffield Zone	10.68	2.18	8.50	0.00	8.50
Bothin Zone	0.58	0.34	0.24	0.00	0.24
Lauro Grouped Zone	11.71	3.32	8.38	-6.45	1.93
La Vista Zone	2.25	2.33	-0.08	0.08	0.00
Low Level Zone	3.08	9.46	-6.37	6.37	0.00
Total	**31.24**	**19.54**	**11.69**	**0.00**	**11.69**

Notes:
(1) Existing storage is based on usable storage at each reservoir.
(2) Required storage includes operational storage, firefighting storage, and emergency storage.
(3) Detailed storage analysis is included in Appendix 2B.

As shown in Table 2.10, with Reservoir No. 1 out of service, the storage analysis demonstrates that the City has a storage surplus of approximately 11.69 MG.

In addition to the storage deficits/transfers identified in Section 2.4.2, the following is noted:

- Low Level Zone has a required storage of 9.46 MG. However, with Reservoir No. 1 out of service, only 3.08 MG of storage is available, resulting in a storage deficit of 6.37 MG. To mitigate this deficit, it is recommended that 6.37 MG of excess storage in the Lauro Grouped Zone be conveyed to the Low Level Zone via the Garden Street PRV, Robbins & Pedregosa PRV, and/or La Vista Del Oceano PRV. Thus, no storage capacity improvements are recommended.
- La Vista Grouped Zone has a required storage of 2.33 MG. However, only 2.25 MG of storage is available, resulting in a storage deficit of 0.08 MG. To mitigate this deficit, it is recommended that 0.08 MG of excess storage in the Lauro Grouped Zone be conveyed to the La Vista pressure zone via the State Street PRV. Thus, no storage capacity improvements are recommended.
- The total transfer from Lauro Grouped Zone to La Vista Zone and the Low Level Zone is 6.45 MG.

2.4.3.2 Storage Scenarios Analysis – Reservoir No. 2 Out of Service

Reservoir No. 2 is located in the Low Level pressure zone with a total capacity of 1.65 MG and a usable capacity of 1.58 MG. This reservoir is located behind the Mission Santa Barbara, which makes it difficult to conduct rehabilitation work on the aging reservoir. The City has considered taking Reservoir No. 2 out of service due to its age and location.

This scenario evaluates the City's storage capacity with Reservoir No. 2 out of service under future demand conditions. A summary of the required and available storage volumes is presented in Table 2.11, while details of this analysis are in Appendix 2B.

Table 2.11 Future Storage Scenarios Analysis (Year 2050) – Reservoir No. 2 Out of Service

Grouped Pressure Zone	Future Storage(1) (MG)	Required Storage(2) (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer (MG)	Net Deficit/ Surplus (MG)
Skofield Grouped Zone	0.47	0.12	0.35	0.00	0.35
El Cielito Tunnel Grouped Zone	1.74	1.54	0.20	0.00	0.20
Hope Grouped Zone	0.72	0.26	0.46	0.00	0.46
Sheffield Zone	10.68	2.18	8.50	0.00	8.50
Bothin Zone	0.58	0.34	0.24	0.00	0.24
Lauro Grouped Zone	11.71	3.32	8.38	-7.28	1.10
La Vista Zone	2.25	2.33	-0.08	0.08	0.00
Low Level Zone	2.25	9.46	-7.20	7.20	0.00
Total	**30.41**	**19.54**	**10.86**	**0.00**	**10.86**

Notes:
(1) Existing storage is based on usable storage at each reservoir.
(2) Required storage includes operational storage, firefighting storage, and emergency storage.
(3) Detailed storage analysis is included in Appendix 2B.

As shown in Table 2.11, with Reservoir No. 2 out of service, the storage analysis demonstrates that the City has a storage surplus of approximately 10.86 MG. In addition to the storage deficits/transfers identified in Section 2.4.2, the following is noted:

- Low Level Zone has a required storage of 9.46 MG. However, with Reservoir No. 2 out of service, only 2.25 MG of storage is available, resulting in a storage deficit of 7.20 MG. To mitigate this deficit, it is recommended that 7.20 MG of excess storage in the Lauro Grouped Zone be conveyed to the Low Level Zone via the Garden Street PRV, Robbins & Pedregosa PRV, and/or La Vista Del Oceano PRV. Thus, no storage capacity improvements are recommended.
- La Vista Grouped Zone has a required storage of 2.33 MG. However, only 2.25 MG of storage is available, resulting in a storage deficit of 0.08 MG. To mitigate this deficit, it is recommended that 0.08 MG of excess storage in the Lauro Grouped Zone be conveyed to the La Vista pressure zone via the State Street PRV. Thus, no storage capacity improvements are recommended.
- The total transfer from Lauro Grouped Zone to La Vista Zone and the Low Level Zone is 7.28 MG.

2.4.3.3 Storage Scenarios Analysis – Vic Trace Reservoir ~~Temporary~~ Out of Service

Vic Trace Reservoir is located in the Lauro Zone with a usable capacity of 10.01 MG. Due to the size and location of this reservoir, it is considered one of the critical reservoirs in the City's distribution system.

This scenario evaluates the City's storage capacity with Vic Trace Reservoir temporary out of service for replacement under future demand conditions. A summary of the required and available storage volumes is presented in Table 2.12, while details of this analysis are in Appendix 2B.

Table 2.12 Future Storage Scenarios Analysis (Year 2050) – Vic Trace Reservoir ~~Temporary~~ Out of Service

Grouped Pressure Zone	Future Storage(1) (MG)	Required Storage(2) (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer (MG)	Net Deficit/ Surplus (MG)
Skofield Grouped Zone	0.47	0.12	0.35	0.00	0.35
El Cielito Tunnel Grouped Zone	1.74	1.54	0.20	0.00	0.20
Hope Grouped Zone	0.72	0.26	0.46	0.00	0.46
Sheffield Zone	10.68	2.18	8.50	-7.32	1.18
Bothin Zone	0.58	0.34	0.24	0.00	0.24
Lauro Grouped Zone	1.70	3.32	-1.62	1.62	0.00
La Vista Zone	2.25	2.33	-0.08	0.08	0.00
Low Level Zone	3.84	9.46	-5.62	5.62	0.00
Total	**21.99**	**19.54**	**2.44**	**0.00**	**2.44**

Notes:
(1) Existing storage is based on usable storage at each reservoir.
(2) Required storage includes operational storage, firefighting storage, and emergency storage.
(3) Detailed storage analysis is included in Appendix 2B.

As shown in Table 2.12, with Vic Trace Reservoir out of service, the storage analysis demonstrates that the City has a storage surplus of approximately 2.44 MG. In addition to the storage deficits/transfers identified in Section 2.4.2, the following is noted:

- The Lauro Grouped Zone has a required storage of 3.32 MG. However, only 1.70 MG of storage is available when Vic Trace Reservoir is out of service, resulting in a storage deficit of 1.62 MG. To mitigate this deficit, it is recommended that 1.62 MG of excess storage in Sheffield Zone be conveyed to Lauro Zone via Foothill PRV:
  - Foothill PRV is currently out of service. It is recommended that Foothill PRV undergo the necessary renewal projects to make it operable (Project RRV-1).
- Under normal future operating conditions as discussed in Section 2.4.2, it was recommended that 0.08 MG of excess storage in the Lauro Grouped Zone be conveyed to the La Vista Zone via the State Street PRV to mitigate its storage deficit. However, with the Vic Trace Reservoir out of service, the Lauro Grouped Zone does not have enough storage capacity to supply the La Vista Zone. Therefore, it is recommended that 0.08 MG of the excess storage in the Sheffield Zone be conveyed to the La Vista Zone via the Lauro Grouped Zone to mitigate the deficiency.

2.4.3.4 Storage Scenarios Analysis – Cater Clearwell Out of Service

The Cater Clearwell is located at the Cater Treatment Plant in the Lauro Zone with a total storage capacity of 5.00 MG and usable capacity of 1.70 MG. The difference between the total and usable storage amount of the Cater Clearwell is significant because this clearwell also provides operational storage for the Cater Treatment Plant to backwash the filters and provide sufficient chlorine contact time based on the maximum WTP production capacity of 36 mgd.

The Cater Clearwell is considered a very critical storage facility in the City's distribution system because it acts as a central point to distribute water supply from the Cater WTP.,

This scenario evaluates the City's storage capacity with the Cater Clearwell temporary out of service under future demand conditions. Due to its critical role, it is assumed that any outages related to maintenance would be well planned situation that only occurs for a short amount of time under low demand conditions. A summary of the required and available storage volumes is presented in Table 2.13, while details of this analysis are included in Appendix 2B.

Table 2.13 Future Storage Scenarios Analysis (Year 2050) – Cater Clearwell Out of Service

Grouped Pressure Zone	Future Storage(1) (MG)	Required Storage(2) (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer (MG)	Net Deficit/ Surplus (MG)
Skofield Grouped Zone	0.47	0.12	0.35	0.00	0.35
El Cielito Tunnel Grouped Zone	1.74	1.54	0.20	0.00	0.20
Hope Grouped Zone(3)	0.72	0.26	0.46	0.00	0.46
Sheffield Zone	10.68	2.18	8.50	0.00	8.50
Bothin Zone	0.58	0.34	0.24	0.00	0.24
Lauro Grouped Zone	10.01	3.32	6.68	-5.70	0.98
La Vista Zone	2.25	2.33	-0.08	0.08	0.00
Low Level Zone	3.84	9.46	-5.62	5.62	0.00
Total	**30.29**	**19.54**	**10.75**	**0.00**	**10.75**

Notes:
(1) Existing storage is based on usable storage at each reservoir.
(2) Required storage includes operational storage, firefighting storage, and emergency storage.
(3) Detailed storage analysis is included in Appendix 2B.

As shown in Table 2.13, with the Cater Clearwell out of service, the storage analysis demonstrates that the City has a storage surplus of approximately 10.75 MG. In addition to the storage deficits/transfers identified in Section 2.4.2, the following is noted:

- Low Level Zone has a required storage of 9.46 MG. However, only 3.84 MG of storage is available, resulting in a storage deficit of 5.62 MG. To mitigate this deficit, it is recommended that 5.62 MG of the excess storage in the Lauro Grouped Zone be conveyed to the Low Level Zone via the Garden Street PRV, Robbins & Pedregosa PRV, and/or La Vista Del Oceano PRV. Since Vic Trace Reservoir represents the majority of the storage in the Lauro Zone, there is sufficient storage capacity in the Lauro Zone if Cater Clearwell is taken out of service. Thus, no storage capacity improvements are recommended. However, the HGL of Vic Trace reservoir is 30 feet lower than the Cater Clearwell. As a result, system pressures in the Lauro Zone are predicted to be approximately 13 psi lower when Cater Clearwell is out of service.

2.4.3.5 Storage Scenarios Analysis – Multiple Reservoirs Out of Service

As mentioned previously, the City's distribution system has a storage surplus under both existing and future demand conditions. To reduce rehabilitation and operational costs, the following five reservoirs have the potential to be taken out of service:

- East Reservoir (Bothin Zone).
- La Vista Reservoir (La Vista Zone).
- Reservoir No. 1 (Low Level Zone).
- Reservoir No. 2 (Low Level Zone).
- La Mesa Reservoir (Low Level Zone).

East Reservoir (1.0 MG, with a usable volume of 0.58 MG) is not a critical reservoir and only serves the Bothin Zone. With East Reservoir taken out of the service, the Bothin Zone is served by the Sheffield Zone via the Bothin Pump Station. Thus, the Sheffield Zone and Bothin Zone become the Sheffield Grouped Zone in this scenario.

La Vista Reservoir (2.3 MG, with a usable volume of 2.24 MG) only serves the La Vista Zone. With the La Vista Reservoir out of service, the La Vista Zone will be merged with the Lauro Zone by opening the three valves and by closing and bypassing the State Street PRV. The City has operated the La Vista Zone in the manner in the past. In addition, the City plans to automate an existing 24-inch diameter plug valve near Robbins Street and Pedregosa Street to fill Vic Trace Reservoir from the Lauro Zone (Project V-2). This valve will isolate a portion of the Lauro Zone and create the Vic Trace Grouped Zone, which will include the small portion of the Lauro Zone and the Escondido La Coronilla Zone. The City plans to replace the existing Vic Trace Reservoir with an equally sized below ground reservoir of 10.0 MG to maximize useful life of the new storage facility. The replacement reservoir could be constructed with either two equally sized chambers or two separate tanks to provide operational flexibility for maintenance. The exact configuration of the new Vic Trace reservoir needs to be evaluated in a separate study that considers site constraints, costs, and the importance of redundancy for this site as it serves a critical role for city-wide distribution system operations (Project SR-2).

It is recommended that Vic Trace Reservoir will be isolated from the Lauro Zone via automated valve at the intersection of Robbins Street and Pedregosa Street (Project: V-2) to improve system operations because the Cater Clearwell and Vic Trace operate at different HGLs. The proposed valve should be controlled based on Vic Trace Reservoir level.

The three Low Level Zone reservoirs that potentially could be taken out of service are:

- Reservoir No. 1 (1.08 MG, with a usable volume of 0.75 MG) is an aging reservoir with historical infrastructure issues.
- Reservoir No. 2 (1.68 MG, with a usable volume of 1.58 MG) is an aging reservoir in a difficult location to rehabilitate.
- La Mesa Reservoir (1.50 MG, with a usable volume of 1.50 MG) is normally out of service and only brought online if needed.

For easy of operations, it is recommended that at least one gravity reservoir remain in service to feed the Low Level Zone. However, if all three reservoirs would be taken out of service, the Low Level Zone would need to be supplied by PRVs from the Sheffield and the new Vic Trace Zones. The Low Level Zone risks becoming over pressurized when all three gravity fed reservoirs are taken out of service and the Ortega WTP and/or the Desal Plant would discharge directly into the Low Level Zone. To avoid over pressurization of the Low Level Zone, it is recommended that multiple pressure relief valves are installed at locations where excess water can be directed into either an open channel, stormdrain, or other conveyance feature to avoid localized flooding. In addition, it is recommended that Padre PS be equipped with readily available backup power to allow it to pump excess water out of the Low Zone at all times. It is recommended that at least one gravity fed reservoir (e.g. Reservoir 1 due to its location and recent lining project) remain in service until the dedicated Desalination Conveyance Transmission Main is constructed and operational.

In addition, El Cielito Reservoir's (1.10 MG, with a usable volume of 0.98 MG) has a HGL of 1,064 feet above mean sea level (ft-msl) and does not match the HGL of Tunnel Reservoir, which is 1,061 ft-msl. This 3 foot difference makes it challenging to completely fill and fully utilize the storage of El Cielito Reservoir, especially during high demand conditions when dynamic headlosses are greater. It is recommended that the El Cielito Reservoir be replaced with a reservoir that matches hydraulically with the Tunnel Reservoir (Project SR-3).

In addition, the existing Cater Clearwell (5.00 MG, with a usable volume of 1.70 MG), is assumed to undergo seismic upgrades to have a minimum 2.30 MG of contact basin, and 2.20 MG of distribution system storage. The minimum storage capacity of the contact basin and storage reservoir volumes are discussed in detail in Section 2.4.4. The City is evaluating alternative for the contact basin storage volume. The cost estimates presented in this WDIP are based on the minimum distribution and contact basin storage volumes, which were estimated to be 4.5 MG (Project SR-1A and SR-1B). *(It should be noted that since the completion of the WDIP analysis, the City has further investigated the Cater Clearwell site configuration options. The current plan (February 2021) is to build a 2.0 MG CT tank, in addition to the 5.0 MG Clear Well that will operate in series, allowing the clear well to be dedicated to usable storage. Hence, a total of 7.0 MG of storage would be sited at the Cater WTP.)*

Taking the five reservoirs discussed above out of service would decrease the City's usable storage capacity from 35.0 MG to 25.84 MG.

This scenario evaluates the City's storage capacity with East Reservoir, La Vista Reservoir, Reservoir No. 1, Reservoir No. 2, and La Mesa Reservoir out of service under future demand conditions. A summary of the required and available storage volumes is presented in Table 2.14, while details of this analysis are in Appendix 2B.

Table 2.14 2050 Storage Scenarios Analysis – Multiple Reservoirs Out of Service

Grouped Pressure Zone	Existing Storage(1) (MG)	Required Storage(2) (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer (MG)	Net Deficit/ Surplus (MG)
Skofield Grouped Zone	0.47	0.12	0.35	0.00	0.35
El Cielito Tunnel Grouped Zone	1.76	1.54	0.22	0.00	0.22
Hope Grouped Zone	0.72	0.26	0.46	0.00	0.46
Sheffield Grouped Zone(3)	10.68	2.43	8.26	-2.91	5.35
Lauro Zone(4)	2.20(5)	4.69	-2.49	2.49	0.00
NEW Vic Trace Grouped Zone(6)	10.00	0.96	9.04	-9.04	0.00
Low Level Zone	0.00	9.46	-9.46	9.46	0.00
Total	**25.84**	**19.45**	**6.38**	**0.00**	**6.38**

Notes:
(1) Existing storage is based on usable storage at each reservoir.
(2) Required storage includes operational storage, firefighting storage, and emergency storage.
(3) La Vista Zone is incorporated into the Lauro Zone after La Vista Reservoir is abandoned.
(4) Sheffield Group Zone consists of Sheffield Zone and Bothin Zone.
(5) Cater Clearwell's Distribution System storage volume was calculated in Section 2.4.4.
(6) The New Vic Trace Grouped Zone consists of a proportion of Lauro Zone and the Escondido La Coronilla Zone.
(7) Detailed storage analysis is included in Appendix 2B.

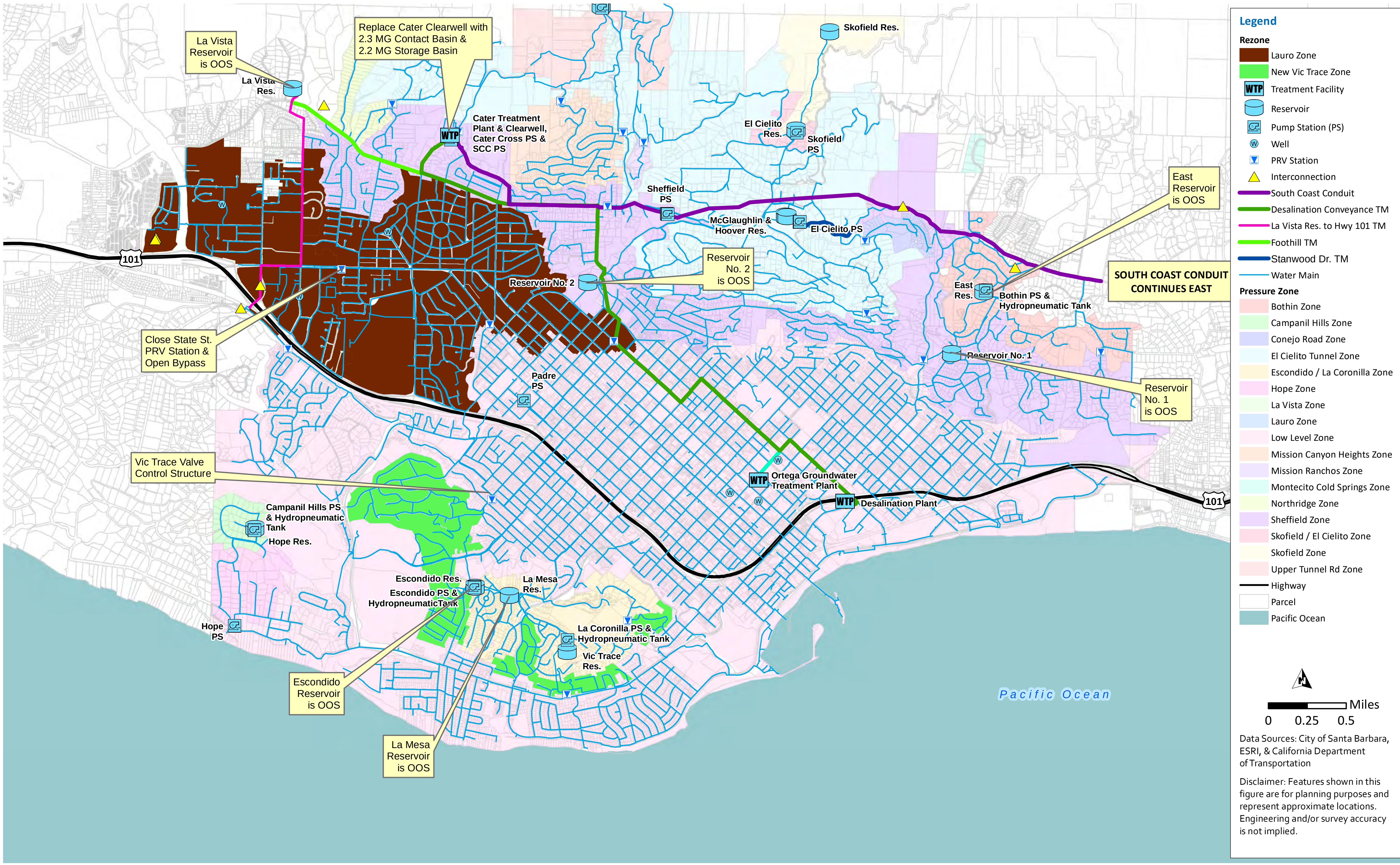

Figure 2.3 New Pressure Zone - Scenario 10

As shown in Table 2.14, with the five reservoirs out of service, the storage analysis demonstrates that the City has a storage surplus of approximately 6.38 MG. However, the following is noted:

- The available storage in the Low Level Zone would be reduced due to the removal of all three Low Level Reservoirs. In this scenario, 9.04 MG of the excess storage in the Vic Trace Grouped Zone would need to be conveyed to the Low Level Zone via the Garden Street PRV, Robbins & Pedregosa PRV, and/or La Vista Del Oceano PRV.
- In addition, 0.42 MG will need to be conveyed from the Sheffield Grouped Zone via the Sycamore Canyon PRV. Thus, no storage capacity improvements are recommended. It should be noted that if Reservoir 1 and 2, and La Mesa Reservoir are all taken out of service, then the City's largest pressure zone (Low Level Zone) would operate as a "closed zone" without any dedicated gravity storage. There are operational challenges/risks associated with this change, such as the risk of over pressurizing the Low Zone, the potential for an increased in water hammer within the zone, a potential reduction in system pressures, and increased reliance on PRVs to move water to Low Level Zone. To prevent over pressurization in the Low Level Zone, it is recommended either maintain one of the gravity reservoirs, or if all gravity reservoirs are taken out of service to install pressure relief valves, consider backup power at Padre PS, and keep Reservoir No. 1 in service until the dedicated Desalination Conveyance Transmission Main is constructed.
- Lauro Zone has a required storage of 4.69 MG. However, only 2.20 MG of proposed storage (see Section 2.4.4) is available, resulting in a storage deficit of 2.49 MG. To mitigate this deficit, it is recommended that 2.49 MG of excess storage in Sheffield Zone be conveyed to Lauro Zone via Foothill PRV.

2.4.4 Cater Clearwell Sizing

The Cater Clearwell plays a critical role in water treatment (i.e., primary disinfection), plant operations (i.e., backwash and South Coast Conduit Pump Station supply) and operational storage for the City's distribution system. Due to the essential nature of water supply facilities, current structural design standards classify this facility a Risk Category IV, which results in concerns regarding the stability of the underlying soil and the overall seismic integrity of the structure. Although these concerns can be mitigated through extensive rehabilitation efforts, this would result in difficult construction and shutdown procedures. Therefore, the City is considering constructing a new Cater Clearwell to alleviate much of the risk associated with upgrading the existing Cater Clearwell. This study therefore considers the required volume for treatment and plant operations and the volume required for distribution storage.

It is important that the City maintain adequate distribution storage in the future system when maintenance is being performed on major reservoirs in the system (e.g., Vic Trace). Three additional storage analyses were conducted under future demand conditions to help determine the minimum volume needed for the distribution system storage needs to replace the existing Cater Clearwell. These analyses assumed that the same five storage facilities are taken out of service as discussed in Section 2.4.3.5 (namely Reservoir No. 1, Reservoir No. 2, La Mesa Reservoir, East Reservoir and La Vista Reservoir). In addition, the Cater Clearwell was removed for all scenarios to determine the minimum required distribution required. The following two scenarios were evaluated:

- Hoover Reservoir is out of service and McLaughlin Reservoir is in service.

- Vic Trace Reservoir is operating at half capacity.

A summary of the storage analyses is presented in the following sections, while details of this analysis are included in Appendix 2B.

2.4.4.1 Cater Clearwell Analysis - Hoover Reservoir is Out of Service

Hoover Reservoir is located in the Sheffield Zone with a usable capacity of 5.34 MG and is able to transfer stored water to Lauro Zone via Foothill PRV station. Due to the size and location of this reservoir, it is considered one of the critical reservoirs in the City's distribution system.

This scenario evaluates the required storage capacity in the Lauro Zone with Hoover Reservoir temporarily out of service for replacement under future demand conditions. A summary of the required and available storage volumes is presented in Table 2.15, while details of this analysis are included in Appendix 2B.

Table 2.15 Cater Clearwell Analysis - Hoover Reservoir Out of Service

Grouped Pressure Zone	Future Storage(1) (MG)	Required Storage(2) (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer (MG)	Net Deficit/ Surplus (MG)
Skofield Grouped Zone	0.47	0.12	0.35	0.00	0.35
El Cielito Tunnel Grouped Zone	1.76	1.54	0.22	0.00	0.22
Hope Grouped Zone	0.72	0.26	0.46	0.00	0.46
Sheffield Grouped Zone(3)	5.34	2.43	2.92	-2.92	0.00
Lauro Zone(4)	0.00	4.69	-4.69	2.50	-2.19
NEW Vic Trace Grouped Zone(5)	10.00	0.96	9.04	-9.04	0.00
Low Level Zone	0.00	9.46	-9.46	9.46	0.00
Total	18.30	19.45	-1.16	0.00	-1.16

Notes:
(1) Existing storage is based on usable storage at each reservoir.
(2) Required storage includes operational storage, firefighting storage, and emergency storage.
(3) Sheffield Group Zone consists of Sheffield Zone and Bothin Zone.
(4) La Vista Zone is incorporated into the Lauro Zone after La Vista Reservoir is abandoned.
(5) The New Vic Trace Grouped Zone consists of a proportion of Lauro Zone and the Escondido La Coronilla Zone.
(6) Detailed storage analysis is included in Appendix 2B.

As shown in Table 2.15, the Lauro Zone has a required storage of 4.69 MG. To reduce the storage deficit, 2.50 MG of excess storage in Sheffield Zone can be conveyed to Lauro Zone via the Foothill PRV. Approximately 2.2 MG of storage would be required at the Cater Clearwell to mitigate the remaining storage deficit.

2.4.4.2 Cater Clearwell Analysis – Vic Trace Reservoir Operating at Half Capacity

The Vic Trace Reservoir would be located in the new Vic Trace Grouped Zone with a usable capacity of 10.00 MG. As discussed above, the exact configuration of this new reservoir be evaluated in a separate study to consider below ground construction, separate storage chambers or tanks, site constraints, redundancy, and costs.

This scenario evaluates the required storage capacity in the Lauro Zone with Vic Trace Reservoir operating at half capacity (5.00 MG). A summary of the required and available storage volumes is presented in Table 2.16, while details of this analysis are included in Appendix 2B.

Table 2.16 Cater Clearwell Analysis - Vic Trace Reservoir Operating at Half Capacity

Grouped Pressure Zone	Future Storage(1) (MG)	Required Storage(2) (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer (MG)	Net Deficit/ Surplus (MG)
Skofield Grouped Zone	0.47	0.12	0.35	0.00	0.35
El Cielito Tunnel Grouped Zone	1.76	1.54	0.22	0.00	0.22
Hope Grouped Zone	0.72	0.26	0.46	0.00	0.46
Sheffield Grouped Zone(3)	10.68	2.43	8.26	-8.26	0.00
Lauro Zone(4)	0.00	4.69	-4.69	2.84	-1.85
NEW Vic Trace Grouped Zone(5)	5.00	0.96	4.04	-4.04	0.00
Low Level Zone	0.00	9.46	-9.46	9.46	0.00
Total	**18.64**	**19.45**	**-0.82**	**0.00**	**-0.82**

Notes:
(1) Existing storage is based on usable storage at each reservoir.
(2) Required storage includes operational storage, firefighting storage, and emergency storage.
(3) Sheffield Group Zone consists of Sheffield Zone and Bothin Zone.
(4) La Vista Zone is incorporated into the Lauro Zone after La Vista Reservoir is abandoned.
(5) The New Vic Trace Grouped Zone consists of a proportion of Lauro Zone and the Escondido La Coronilla Zone.
(6) Detailed storage analysis is included in Appendix 2B.

As shown in Table 2.16, the Low Level Zone has a required storage of 9.46 MG. However, no storage is available, resulting in a storage deficit of 9.46 MG. To reduce the storage deficit, 4.04 MG of the excess storage in Vic Trace Reservoir can be conveyed to the Low Level Zone via the Garden Street PRV, Robbins & Pedregosa PRV, and/or La Vista Del Oceano PRV. To mitigate the remaining storage deficit, 5.42 MG of storage in the Sheffield Zone can be conveyed to Low Level Zone via Sycamore Canyon PRV Station.

As shown in Table 2.16, the new Lauro Grouped Zone has a required storage of 4.69 MG. To reduce the storage deficit, the remaining 2.84 MG of excess storage in the Sheffield Zone can be conveyed to the Lauro Zone via Foothill PRV. The new Cater Clearwell would need to be 1.85 MG in this scenario to mitigate the remaining storage deficit.

2.4.4.3 Cater Clearwell Analysis Conclusion

Based on the distribution storage analyses, a minimum distribution system storage volume of 2.2 MG is required to accommodate both scenarios discussed in Sections 2.4.4.1 and 2.4.4.2. This would provide sufficient distribution storage in cases where Hoover Reservoir is out of service or Vic Trace Reservoir operates at half capacity. For the purpose of this WDIP, a minimum distribution storage volume of 2.2 MG is included in the CIP (Project SR-1B).

2.4.4.4 Chlorine Contact Basin

In addition, previous studies recommended that the new contact basin be constructed with a minimum storage volume of 2.3 MG. This would provide 2.0 MG dedicated for disinfection (i.e., chlorine contact time) and 0.3 MG for filter backwash. The recommended disinfection storage is less than the existing storage of 3.0 MG because the new basin can be improved by design with a baffling factor of at least 0.5. Although the City is still evaluating alternatives, a minimum required contact basin volume of 2.3 MG was included in the CIP (Project SR-1A).

The City is still studying options for the 5.0 MG Cater Clearwell replacement. However, for the purposes of this WDIP, it is assumed that the City will construct a separate chlorine contact basin of 2.3 MG and distribution system reservoir of 2.2 MG to meet the treatment and distribution system storage objectives stated in this study. It should be noted that the actual configuration this total combined storage volume of 4.5 MG may differ upon more detailed analysis and consideration of site constraints.

2.5 Pump Station Evaluation Criteria

Typically, a pump station consists of multiple pump units, including one spare pump to provide reliability in case of a breakdown or repair. For the purpose of this analysis, the capacity and design criteria were based on system conditions typically evaluated as part of a master plan. These criteria are the sizing of pump stations under MDD and MDD plus maximum fire flow demand conditions for zones with and without gravity storage, respectively. Each pump station shall have sufficient capacity to meet the required MDD and the maximum zone fire flow demand with the firm pump station capacity. The firm capacity is defined as the pumping capacity with the largest pump unit out of service.

2.6 Pump Station Analysis

As mentioned in TM 1, the City's distribution system is hydraulically separated into 17 pressure zones with 14 pump stations. A summary of the total and firm capacities of pump stations and supply facilities are listed in Table 2.17 and Table 2.18, respectively.

Table 2.17 Pumping Station Capacity

Pump Station	Total Capacity (gpm)	Firm Capacity(1) (gpm)
Bothin	2,520	1,680
Calle Las Calleras (Hope)	1,000	500
Campanil	1,725	900
Cater Cross-Tie	3,975	2,650
El Cielito	3,300	2,200
Escondido	2,925	1,950
La Coronilla	645	0
Padre	1,000	500
Rocky Nook	1,200	800
Sheffield	1,700	1,70
Skofield Inside	510	210
Skofield Outside	700	350
Tunnel Road(2)	1,125	750

Notes:
(1) Firm capacity is defined as the facilities capacity if largest pump is out of service.
(2) Tunnel Road PS was replaced (during the completion of this WDIP) with three pumps each with a capacity of 375 gpm.

Table 2.18 Supply Facilities Capacity

Supply Facility	Total Capacity (gpm)	Firm Capacity[(1)] (gpm)
Cater WTP[(2)]	25,694	15,417[(2)]
Desal Plant	2,100	2,100
Ortega WTP[(3)]	1,160	1,160
Hope Well	250	250
Los Robles Well	70	70
San Roque Well	390	390

Notes:
(1) Firm capacity is defined as the facilities capacity if largest pump is out of service.
(2) Wholesale users and the City share the costs of Cater WTP at 40% and 60%, respectively. The City is obligated to supply the wholesale users which is scheduled with and delivered in bulk by the City. For conservative planning purposes it was assumed that the City's Cater WTP firm capacity is 60% of the total capacity.
(3) The Ortega WTP capacity ranges between 1,000 gpm to 1,500 gpm. Fr the purpose of this the Pumping/Supply Capacity Analysis 1,160 gpm was used.

For the purpose of the pump station analysis, the pressure zones and pump stations were grouped into ten groups based on hydraulic connections. For instance, the El Cielito Tunnel Zone can be supplied by three pump stations, namely Cater Cross Tie PS, El Cielito PS, and Rocky Nook PS. These three pump stations need to have sufficient firm pumping capacity to not only feed the El Cielito Tunnel Zone, but also the demand of the four pressure zones that are connected to the El Cielito Tunnel Zone via PRVs because this is the only way to feed those zones (Conejo Zone, Mission Canyon Heights Zone, Mission Ranchos Zone, and Northridge Zone). As a result, these five pressure zones are grouped. The City's distribution system is divided into nice pressure zone groups for the pump station analysis as summarized in Table 2.19.

Table 2.19 Pump Station Analysis Grouping

Grouped Zone	Pressure Zones within Grouped Zone	Pump Stations within Grouped Zone	Grouped Zone with Gravity Storage?
Skofield Grouped Zone	Skofield Skofield El Cielito	Skofield Pump Station	Yes
Upper Tunnel Road	Upper Tunnel Road	Tunnel Road Pump Station	No
El Cielito Tunnel Grouped Zone	Conejo El Cielito Tunnel Mission Canyon Heights Mission Ranchos Northridge	Cater Cross-Tie Pump Station El Cielito Pump Station Rocky Nook Pump Station	Yes
Sheffield Zone	Sheffield	Sheffield Pump Station	Yes
Bothin Zone	Bothin	Bothin Pump Station	No
Campanil Hills Zone	Campanil Hills	Campanil Pump Station	No
Escondido La Coronilla Zone	Escondido La Coronilla	Escondido Pump Station La Coronilla Pump Station	No
Hope Zone	Hope	Hope Pump Station	Yes

Grouped Zone	Pressure Zones within Grouped Zone	Pump Stations within Grouped Zone	Grouped Zone with Gravity Storage?
Lauro Grouped Zone	Lauro La Vista	Cater WTP Padre Pump Station Hope Well Los Robles Well	Yes
Low Level Zone	Low Level	Ortega WTP Desal Plant San Roque Well	Yes

2.6.1 Existing Conditions (Year 2019)

As presented in Section 2.2.2, the City's existing ADD is 10,001 afy (or 8.93 mgd). Using the existing demands and the firm pump station capacities of each pump station listed in Table 2.18, a pump station evaluation is completed for each group. The City's distribution system included connectivity between the grouped zones due to the presence of PRVs and water supply. Therefore, surplus supply in the City's grouped zones can often supplement the existing capacity deficit in lower pressure zones if excess supply and a flow path through a PRV is available.
A summary of the required and available pump station capacity is presented in Table 2.20, while details of this analysis are included in Appendix 2C.

Table 2.20 2019 Pump Station Analysis

Grouped Zone	Existing Capacity(1) (gpm)	Required Capacity(2) (gpm)	Zone Deficit/ Surplus (gpm)	Zone Transfer (gpm)	Net Deficit/ Surplus (gpm)
Skofield Grouped Zone	560	19	541	0	541
Upper Tunnel Road Zone	750	784	-34	0	-34
El Cielito Tunnel Grouped Zone	5,650	789	4,861	0	4,861
Sheffield Zone	1,700	1,050	650	0	650
Bothin Zone	1,680	914	766	0	766
Campanil Hills Zone	900	792	108	0	108
Escondido La Coronilla Zone	1,950	1,484	466	0	466
Hope Zone	500	72	428	0	428
Lauro Grouped Zone	16,237	2,927	13,310	-2,241	11,069
Low Level Zone	3,650	5,891	-2,241	2,241	0

Notes:
(1) Existing Capacity is based on firm pump capacity at each pump station.
(2) Required capacity includes that grouped zones capacity.
(3) Detailed pump station analysis is included in Appendix 2C.

As shown in Table 2.20, the existing pump station analysis demonstrates that a majority of the City's grouped zones have sufficient pump station capacity to meet the existing required firm pump station capacity, with the following exceptions:

- Upper Tunnel Road Zone has a required pump station capacity of 784 gpm, which is primarily driven by the required fire flow in this zone of 750 gpm. The Tunnel Road Pump Station has station capacity of 1,125 gpm and an available firm pumping capacity (one pump out of service) of 750 gpm, which is slightly below the required pumping capacity by 34 gpm.

The Tunnel Road Pump Station has hookups to connect the City's portable pump truck in case of an emergency which will increase the pumping capacity. No recommendation is made as the additional pumping requirement falls within the normal operating range of the pumps at Tunnel Pump Station. If there is a high demand on the system reducing the discharge pressure, the pump will respond with increased flow. The Low Level Zone has a required capacity of 5,891 gpm but, only 3,550 gpm of supply capacity within the zone itself, resulting in a pumping deficiency of 2,241 gpm. However, excess supply from Cater WTP in the Lauro Grouped Zone can be conveyed to the Low Level Zone via the Garden Street PRV, Robbins & Pedregosa PRV, and/or La Vista Del Oceano PRV. Therefore, no pump station capacity improvements are recommended.

2.6.2 Future Conditions (Year 2050)

As presented in Table 2.3, future ADD and MDD are projected to be 11.6 mgd and 21.0 mgd, respectively. Using these future demands and the existing firm pump station capacities of each pump station in Table 2.18, a pump station evaluation was completed for each pressure zone group under future demand conditions. A summary of the pump station evaluation is presented in Table 2.21, while details of this analysis are included in Appendix 2C.

Table 2.21 2050 Pump Station Analysis

Grouped Zone	Future Capacity[(1)] (gpm)	Required Capacity[(2)] (gpm)	Zone Deficit/ Surplus (gpm)	Zone Transfer (gpm)	Net Deficit/ Surplus (gpm)
Skofield Grouped Zone	560	25	535	0	535
Upper Tunnel Road Zone	750	794	-44	0	-44
El Cielito Tunnel Grouped Zone	5,650	1,027	4,623	0	4,623
Sheffield Zone	1,700	1,367	333	0	333
Bothin Zone	1,680	964	716	0	716
Campanil Hills Zone	900	805	95	0	95
Escondido La Coronilla Zone	1,950	1,554	396	0	396
Hope Zone	500	94	406	0	406
Lauro Grouped Zone	16,237	3,808	12,429	-4,015	8,413
Low Level Zone	3,650	7,665	-4,015	4,015	0

Notes:
(1) Existing Capacity is based on firm pump capacity at each pump station.
(2) Required capacity includes that grouped zones capacity.
(3) Detailed pump station analysis is included in Appendix 2C.

As shown in Table 2.21, the future pump station analysis demonstrates that a majority of the City's grouped zones have sufficient pump station capacity to meet future required firm pump station capacity. No additional deficiencies were identified as part of the future pumping analysis. The proposed zone transfer recommendations under existing conditions can be used to meet future demand conditions for year 2050.

2.7 Recommendations

The storage and pump station recommendations identified in this TM are summarized below. Cost estimates for each of these recommendations are included in the executive summary and CIP. Based on the storage and pump station analysis, the following improvements are proposed:

- **Existing Conditions:**
  - If Vic Trace Reservoir or Cater Clearwell are taken out of service, the Lauro Zone relies on the Foothill PRV Station to mitigate the storage deficiency. The following projects are recommended before Cater Clearwell or Vic Trace Reservoir are taken offline:
    - Foothill PRV Station Rehabilitation (RRV-1). This PRV Station is currently out of service and needs to be rehabilitated to become operational.
  - The Cater Clearwell is a critical treatment and storage facility that does not meet the current seismic code. Due to the nature of the seismic vulnerabilities (i.e., structural and geotechnical), it is recommended that the existing Cater Clearwell be upgraded to meet seismic standards, Although the City is currently evaluating alternatives, it is assumed for the purpose of this WDP that the Cater Clearwell be replaced with a minimum of 4.5 MG of storage, consisting of two elements:
    - Cater Contact Basin (SR-1A). The clearwell must have a minimum volume of 2.3 MG for contact time and backwash. The required contact basin volume is dependent on the baffling factor and treatment capacity.
    - Cater Distribution Storage (SR-1B). It is recommended that the Cater Clearwell project have a minimum volume of 2.2 MG dedicated to distribution system storage.
  - Vic Trace Reservoir Replacement (SR-2). It is recommended that Vic Trace Reservoir be replaced with an equally sized reservoir of 10.0 MG that is belowground to maximize its useful life.
  - El Cielito Reservoir Replacement (SR-3). To improve the system operations in the El Cielito Zone, it is recommended that El Cielito Reservoir be rehabilitated the when the condition of the reservoir triggers a major upgrade such that the HGL matches with Tunnel Reservoir's HGL. Moreover, the usable capacity should have a minimum storage volume of 1.5 MG.
  - General Pump Station Design Considerations. The City should consider that future pump stations are designed with equally sized pumps and have a firm capacity able to meet MDD conditions for zones with gravity storage and MDD plus fire flow conditions for zones without gravity storage. These improvements are assumed to be completed as part of the annual pump station replacement and rehabilitation program (Project RRPS-5).
- **Future Conditions:**
  - No storage capacity improvements are recommended for normal operations under existing or future demand conditions.

- Reservoirs taken Out of Service (RRSR-4 through RRSR-9): The reservoirs listed below can be taken out of service, but remain in-place at the current locations, based on the reservoir analysis. The sequencing these reservoir should consider the condition of each reservoir by minimizing rehabilitation cost for these facilities that are planned to be taken offline in the future. If possible, all these projects should be deferred until Cater Clearwell is replaced (Projects SR-1A and SR-1B), Vic Trace Reservoir is replaced (Project SR-2), El Cielito Reservoir is replaced (Project SR-3) and Foothill PRV station is rehabilitated (Project RRV-1).
  - Escondido Reservoir (RRSR-4). This reservoir is currently out of service and no improvement project is required. The City would need to close valves WV-D10-080 and WV-D10-018 to take Escondido Reservoir out of service.
  - East Reservoir (RRSR-5). This project requires completion of Projects SR-1A, SR-1B, SR-2, and SR-3 before it is taken out of service. This project includes field piping such that Bothin PS can bypass East Reservoir. The City would need to close valves WV-K05-076 and WV-K05-036 to take East Reservoir out of service.
  - Reservoir No. 2 (RRSR-6). This Project requires the completion of projects SR-2 and V-1 before taking out of service. Prior to taking out of service, the City must install pressure relief valves to avoid over-pressurization in the Low Level Zone before the last gravity reservoir is taken out of service. The City would need to close valves WV-E05-008 and WV-E05-003 to take Reservoir No. 2 out of service.
  - La Mesa Reservoir (RRSR-7). This Project requires the completion of projects SR-2 and V-1 before being taken out of service. Prior to taking out of service, the City must install pressure relief valves to avoid over-pressurization in the Low Level Zone before the last gravity reservoir is out of service. The City would need to close valves WV-E10-035 and (missing ID) to take La Mesa Reservoir out of service.
  - La Vista Reservoir (RRSR-8). This project requires completion of Projects SR-1A, SR-1B, RRV-1 SR-2, and TM-3, while projects TM-2A and TM-2Bshould be considered, before taking out of service. The City would need to close valve WV-B02-019 to take La Vista Reservoir out of service.
  - Reservoir No. 1 Taken out of Service (RRSR-9). In the future, Reservoir No. 1 can be taken out of service, but should remain available to be put back in service as needed. This Project requires the completion of project SR-2, before this reservoir is taken out of service. Prior to taken the last gravity reservoir of the Low Level Zone out of service, the City must install pressure relief valves to avoid over-pressurization in the Low Level Zone. The City would need to close valves WV-K06-057 and WV-K06-050 to take Reservoir No. 1 out of service.
- Plug Valve Automation at Robbins St. & Pedregosa St. (V-2). To improve system operations at Vic Trace, it is recommended that the 24-inch diameter valve at Robbins Street and Pedregosa Street become automated based on Vic Trace Reservoir level.

Appendix 2A

MADDAUS WATER MANAGEMENT TECHNICAL MEMORANDUM

Technical Memorandum - Final

Prepared for:	The City of Santa Barbara
Project Title:	City of Santa Barbara Water Conservation Technical Analysis
Subject:	Conservation Technical Analysis
Date:	October 20, 2010
To:	Bill Ferguson, City of Santa Barbara
	Alison Jordan, City of Santa Barbara
From:	Bill Maddaus, Maddaus Water Management
	Michelle Maddaus, Maddaus Water Management

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EXECUTIVE SUMMARY

Introduction

This conservation technical analysis was conducted by Maddaus Water Management (MWM) for the City of Santa Barbara (City). The purpose of the analysis is to:

1. Evaluate current conservation measures and identify new conservation measures that will reduce future water demand.
2. Estimate the costs and water savings of these measures.
3. Combine the measures into increasingly more aggressive programs and evaluate the costs and water savings of these programs.

Long-Term Conservation Program Analysis

A list of 92 potential conservation measures was developed from known water saving technologies and services. Twenty-three conservation measures, selected by the City and local stakeholders during an evaluation workshop, were further analyzed by the Least Cost Planning Decision Support System Model (DSS Model). The DSS Model is a planning tool that assists water planners with evaluating alternative water conservation programs. The model itself is an end use model that calculates water savings, costs and benefits from individual measures, and programs of a number of measures. Projections of future water demand with and without water conservation programs are made for the City water service area. Calculations are made for every year in the 30-year analysis period. In addition, twenty one measures, both current and potential future measures, were put into a "Tool Kit" for further qualitative evaluation.

Based on analysis by the model, conservation measures were grouped into alternative programs of increasingly higher water savings and implementation costs (Table ES-1). Conservation Program A consists of 10 measures that are part of the existing City water conservation program. Conservation Program B includes all of Program A, plus those additional measures that have an individual benefit-cost ratio of 0.9 or greater, for a total of 17 measures. Conservation Program C includes all measures evaluated, except for Measure 5 which is replaced with the enhanced Measure 6. The measures included in Conservation Programs A, B, and C are identified in Table ES-1 in the columns at the right. Figure ES-1 shows the projected demand without the effects of the plumbing code, with the plumbing code effects, and with the plumbing code and three conservation program alternates. Water savings were evaluated and benefit-cost ratios computed for 20–year period of 2011 to 2030, coinciding with the City's water supply planning period. Savings were then calculated to the year 2030 for each of these programs (see Table ES-2).

Table ES-3 shows the relative demand reductions in the year 2030, conservation program costs for the utility, present value economic information, and the utility cost of water saved for each of the alternate programs. Demand reduction by 2030 is measured from the 14,825 AFY projected 2030 demand without the effects of the plumbing code. Additional resources and customer contacts as embodied in the conservation programs identified in this memorandum, are required to reach higher levels of potential water savings. Utility costs include the cost to the City to run the program, including staff time, rebates, any contracted services, expense, etc. While utility cost is the primary consideration, this memorandum also considers customer costs and community costs to some extent, as described in the body of the memorandum. The plumbing code is included as passive baseline savings in addition to the long-term conservation program in Programs A-C. Most of the future program water savings consist of outdoor landscape improvements.

A Benefit-Cost ratio, which is the ratio of the present value of benefits to the present value of costs, is the most accurate indicator of cost-effectiveness. When the ratio of the Present Value of the benefits to the Present Value of the costs is greater than 1.0 for a particular program of measures, that program can be said to be cost-effective. Benefits for the utility can also be expressed as the value to the utility of the saved water. For the City, the value of the saved water is the cost savings from not producing the water that is saved. This could range from not treating pumped groundwater to not buying water from the State Water Project. An assessment was made by the City and the value of the saved water was determined to be $600 per acre-foot. This value is hereafter referred to as the City's "Avoided Costs".

Program A reflects estimated water savings derived from the plumbing code and continuing the current program. The additional measures that create programs B and C produce increasing incremental water savings and costs. Figure ES-2 illustrates there are apparent diminishing returns when measures are added beyond Program B. Demand reductions for year 2030 range from 920 to 1,919 AF/Yr. As the plumbing code water savings do not cost the City any money, the graph starts at the plumbing code water savings in 2030.

Table ES-1
Conservation Measures Selected for Programs

No.	Measure Name (ND = Requirements for New Development)	Program A	Program B	Program C
1	Promote Water Efficiency in Green Buildings		✓	✓
2	ND Require High Efficiency Toilets		✓	✓
3	ND Require High Efficiency Faucets and Showerheads		✓	✓
4	Fixture Replacement SB 407		✓	✓
5	Financial Incentives for Irrigation and Landscape Upgrades (Current)	✓	✓	
6	Financial Incentives for Irrigation and Landscape Upgrades			✓
7	Washer Rebates	✓	✓	✓
8	Washer Rebates for High Efficiency Machines			✓
9	High Efficiency Toilet (HET) Rebates	✓	✓	✓
10	Single Family Water Check Up	✓	✓	✓
11	Multifamily Water Check Up	✓	✓	✓
12	Existing Commercial Washer Rebate	✓	✓	✓
13	Cisterns/Rain Catchments			✓
14	Gray water Retrofit SF			✓
15	Current High Efficiency Urinal Rebate (<0.25 gallon)	✓	✓	✓
16	ND Require 0.5 gal/flush or less urinals in new buildings		✓	✓
17	School Building Retrofit		✓	✓
18	Irrigation (Landscape) Water Budgets	✓	✓	✓
19	Irrigation Water Surveys	✓	✓	✓
20	Mulch Program			✓
21	CII Water Check Up Level 1	✓	✓	✓
22	CII Water Check Up Level 2		✓	✓
23	Customized CII Incentive Program			✓
	Total Measures in each Program	10	17	22

Figure ES-1

Long Term Demands with Conservation Programs
(Demand is measured by total water system production, including potable and recycled water)

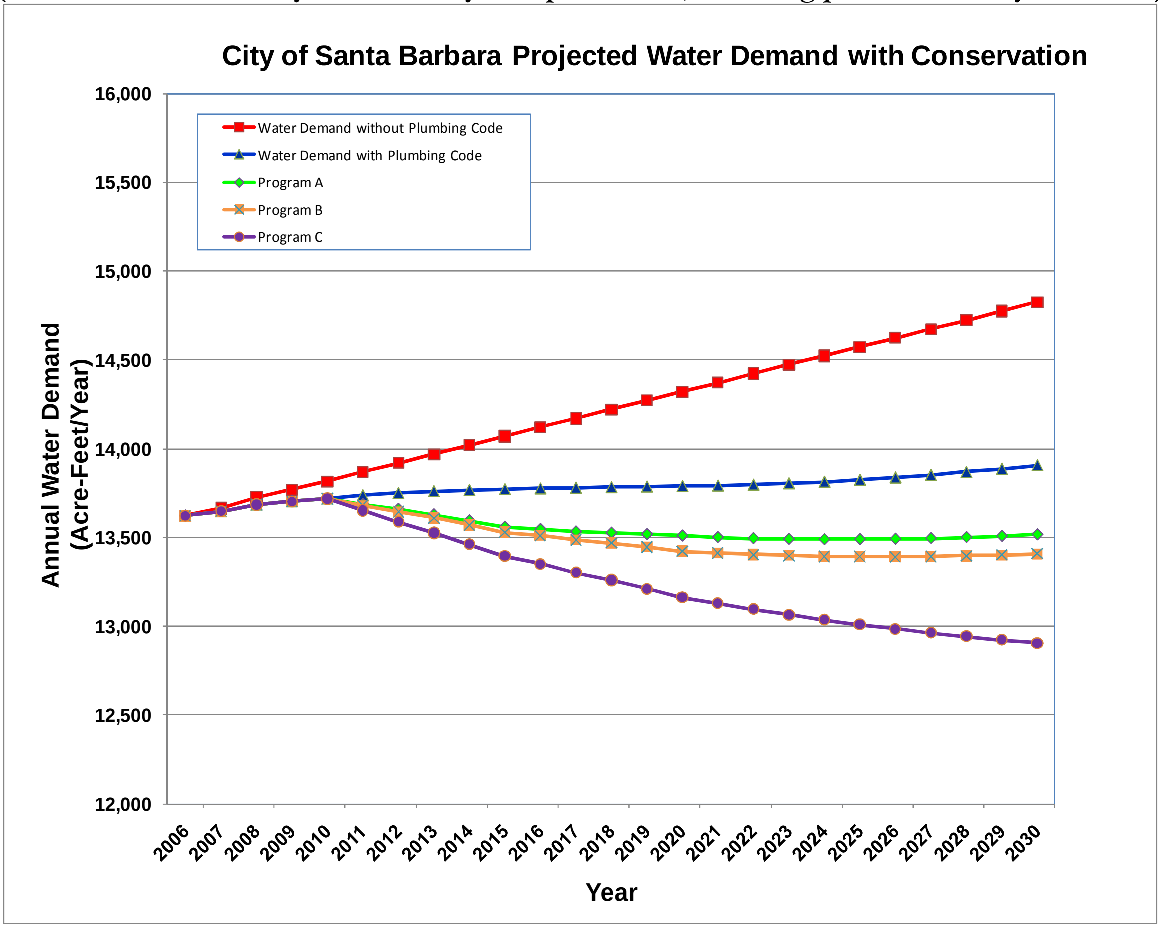


Table ES-2

Conservation Program Description and Future Water Savings

Conservation Program	Description	2030 Demand Reduction (AF/Yr)
-	No Conservation Programs, Plumbing Code Only	919
A	Continue Current Conservation Program (10 measures) and Plumbing Code	1,308
B	Add 7 Cost-Effective Measures to Current Program A and Plumbing Code	1,417
C	Add 5 More Measures to Program B and Plumbing Code	1,919

Table ES-3
Economic Summary of Long-Term Conservation Programs
(Excluding Tool Kit Measures)

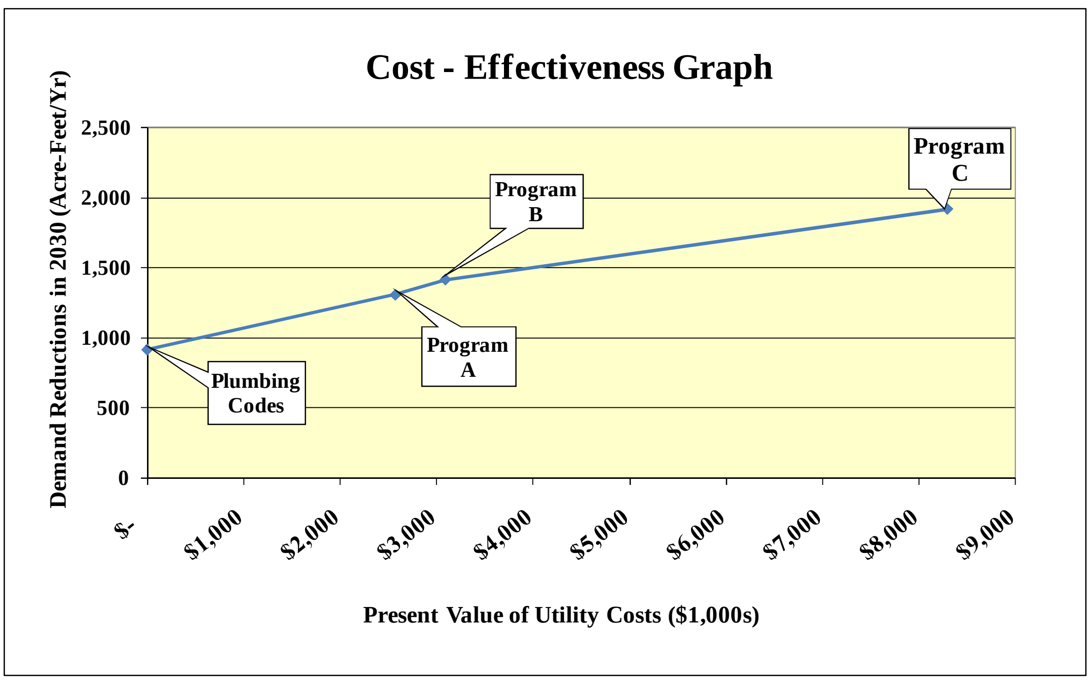
Conservation Program	Demand Reduction by 2030 (AFY)	Total 20-Year Conservation Program Water Savings (AF)	Average Annual Program Cost to Utility ($)	Present Value of Utility Benefits ($)	Present Value of Utility Costs ($)	Utility Benefit - Cost Ratio	Utility Cost of Water Saved ($/AF)
Plumbing Code Only	919	11,085	NA	NA	NA	NA	NA
Program A + Plumbing Code	1,308	16,419	$194,000	$2,455,000	$2,570,000	0.96	$482
Program B + Plumbing Code	1,417	17,801	$233,200	$3,131,000	$3,089,000	1.01	$460
Program C + Plumbing Code	1,919	23,193	$629,400	$5,867,000	$8,287,000	0.71	$684

Notes:

1. The DSS model is a 30-year model. It was run for 2006 to 2036 to include the base year of 2006 and the 20-year conservation program period of 2011 to 2030.
2. Demand Reduction by 2030 is measured from the 14,825 AFY projected 2030 demand without the effects of the Plumbing Code.
3. Average Annual Program Cost excludes any potential costs for the 21 measures in the Tool Kit
4. Utility Cost of Water Saved somewhat undervalues the cost of savings because program costs are discounted to present value and the water benefit is not. Utility Benefit-Cost ratio is the most accurate measure of cost effectiveness, because it accounts for the time value of money.

Figure ES- 2

Present Value of Utility Costs versus Cumulative (Total) Water Saved



1. INTRODUCTION AND PURPOSE

The purpose of this Technical Memorandum is to present an overview of the conservation evaluation process which has been completed for the City of Santa Barbara (City). The goal is to develop a plan that will optimize program cost and water savings. The City has a current water conservation program, which includes the measures that comprise Conservation Program A, described below, in addition to additional qualitative measures. This Technical Memorandum evaluates whether expanding existing efforts is a feasible and cost-effective way to meet future water needs in comparison to using and/or developing other sources of water supply. Based on the analysis of current water use patterns, and taking into account characteristics of the service area, a list of 92 potential conservation measures was compiled and reviewed with the City and key local stakeholders in a measure screening workshop. Participants included:

Goleta Water District

Santa Barbara County Water Agency

Arcadia Studio, Landscape Architecture

All Around Landscape Supply

Oasis Design

Forester Publications Inc., publisher of "Water Efficiency" journal

City Water Commission

During the workshop 23 measures were selected for further detailed economic analysis.

A water savings and benefit-cost evaluation was performed on all of the selected measures using the Least Cost Planning Water Demand Management Decision Support System (DSS Model) developed by MWM. The DSS Model is a planning tool that assists water planners with evaluating alternative water conservation programs. The model itself is an end use model that calculates water savings, costs and benefits from individual measures and programs of a number of measures. Projections of future water demand with and without water conservation programs are made for the City water service area. Calculations are made for every year in the 30-year analysis period.

In this report, demand management and water conservation are used interchangeably. The evaluation includes measures directed at existing accounts as well as new development measures to make new residential and business customers more water efficient. Assumptions and results for each of the 23 individual measures and three programs will be described in detail in this memorandum. Based on a preliminary analysis of the individual measures, three programs (Program A, B and C) were developed by MWM. Each of the three programs are evaluated to determine the net effect of running multiple measures together over the 20-year period of analysis from 2011 to 2030.

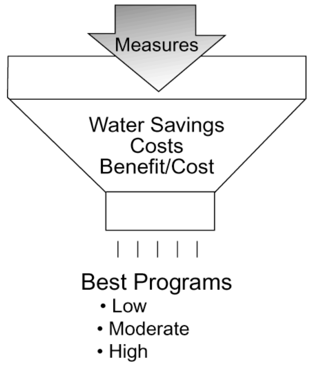
Separate from the measures evaluated by the DSS, 21 additional measures were placed in a "tool kit" for qualitative consideration by the City.

Long Term Conservation Evaluation Process

During the evaluation process, water savings were estimated and cost assumptions for the measures were developed by MWM and City staff. Benefits and costs were compared in a formal present value analysis and conclusions were drawn about which measures produce cost-effective water savings. This process can be thought of as a screening process shown in Figure 1. Packaging the best measures into alternative programs allows City to consider what level of conservation is appropriate.

Figure 1

Evaluation Process



Benefit-cost analysis has been used by many water agencies to evaluate and help select a water conservation measure best suited to local conditions. This analysis requires a locale-specific set of data, such as historical water consumption patterns by customer class, population projections, age of housing stock, and prior conservation efforts.

The following eight steps were used to implement the methodology by expanding upon the same DSS Model used to prepare the demand projections.

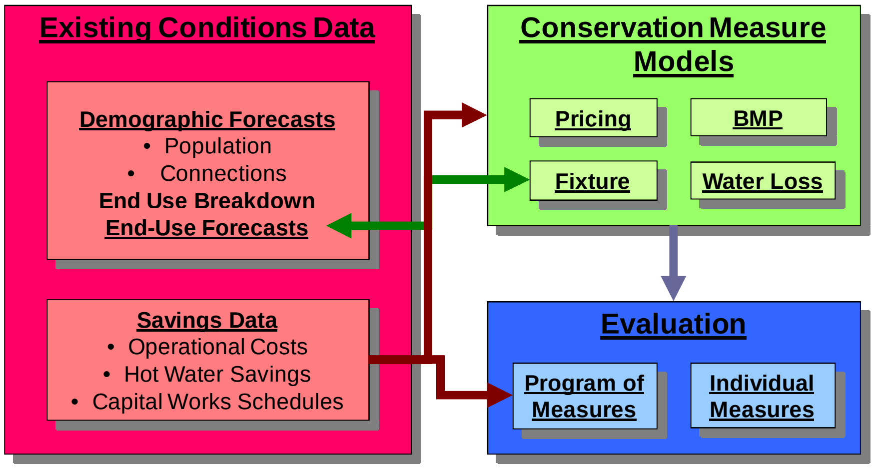
1. **Generate water use projections with and without the state and national plumbing code**. Projections cover each key customer category and are broken down into indoor and outdoor end uses. They include the impact of the plumbing code changes arising from the Federal Energy Policy Acts of 1992 and 2005 and State Legislation relating to plumbing fixtures (requirement for high efficiency toilets and urinals in 2014) and building codes (such as Cal Green that takes effect in 2011).
2. **Identify possible water conservation measures and screen the measures qualitatively** to identify those that are applicable to the service area. Develop appropriate unit water savings and costs for each measure.
3. **Estimate the market penetration rate (or installation rate) for each measure** by dividing the number of customers (or accounts) that would implement the measure each year by the total number of customers (or accounts) in the service area for which the measure applies. This is typically expressed as the percent of customers participating for a specific class of customers.
4. **Estimate total annual average day water savings.** The water savings are computed by multiplying unit water savings, per measure, by the market saturation or installation rate [not clear-suggest delete this], and then multiplying by the number of units in the service area (such as dwelling units) targeted by a particular measure. For example, if the measure saved 20 gallons per account per day, there is a saturation rate of 4% per year, and there are 12,300 accounts targeted by this measure, then the total annual water savings would be 9,840 gallons per day after one year. The indoor and outdoor water savings were also calculated.
5. **Determine initial and annual costs to implement the measures** based upon current conservation program data, local experience, and the costs of goods, services, and labor in the community. Unit costs, $/measure, (separately for the utility and customer) are multiplied by the number of units participating each year to derive the total annual costs (utility and customer). For the annual utility costs, an amount is added to cover overall administration and promotion costs.
6. **Compare costs of measures** by computing the present value of program costs and water saved over the planning period.
7. **Compile three programmatic packages** or programs containing various new and existing measures.

8. **Evaluate the three programs for water savings and cost-effectiveness** and identify the point of diminishing returns from further investments in conservation.

For the conservation measure evaluation, the DSS Model performs economic analysis by using net present value and benefit-to-cost ratio as economic indicators. The benefit-to-cost analysis is performed from various perspectives including the utility, customer, and community perspectives, as discussed in Section 3. Figure 2 shows the structure of the model. Results are presented in subsequent sections.

Figure 2

Structure of the DSS Model



2. BASELINE WATER DEMANDS WITH AND WITHOUT PLUMBING CODE

Water demand projections were developed for the 20-year planning period of 2011-2030 using the DSS Model. This model incorporates information from the:

- City of Santa Barbara, Water Supply Planning Study, August 2009.
- City of Santa Barbara Water Resources Division population forecasts February 2010.
- Data provided by City of Santa Barbara staff including estimates for value of water saved, historical water use, past conservation efforts, and water system facilities.

National Plumbing Code

The Federal Energy Policy Act of 1992, as amended in 2005, requires that only fixtures meeting the following standards be installed in new buildings:

- Toilet – 1.6 gal/flush maximum
- Urinals – 1.0 gal/flush maximum
- Showerhead - 2.5 gal/min at 80 psi
- Residential Faucets – 2.2 gal/min at 60 psi
- Public Restroom Faucets - 0.5 gal/min at 60 psi
- Dishwashing pre-rinse spray valves – 1.6 gal/min at 60 psi

Replacement of fixtures in existing buildings is also governed by the Federal Energy Policy Act that requires only devices with the specified level of efficiency (shown above) can be sold today (2010). The net result of the plumbing code is that new buildings will be more efficient and old inefficient fixtures will slowly be replaced with new more efficient models. The national plumbing code is an important piece of legislation and must be carefully taken into consideration when analyzing the overall water efficiency of a service area.

In addition to the plumbing code the U.S. Department of Energy regulates appliances such as residential clothes washers. Regulations to make these appliances more energy efficient have driven manufactures to dramatically reduce the amount of water these efficient machines use. Generally horizontal axis washing machines use 30-50 percent less water than conventional models (which are still available). In the analysis for City, the DSS Model forecasts a gradual transition to high efficiency clothes washers (using 19 gallons or less) so that by the year 2020 this will be the only type of machines purchased. Given that machines last about 15 years eventually all machines in the City area will be of this type.

State Plumbing Code

The Plumbing Code includes the recent California State law requiring High Efficiency Toilets and High Efficiency Urinals by 2014. The 2010 Cal Green Building Standards (Cal Green), scheduled to take effect in 2011 is treated as a conservation measure as it was not finalized until recently. It is accounted for in Measures 1-3. Cal Green requirements effects all new development in the State of California after January 1, 2011. As this is a new development law, it was assumed actual water savings seen by the City would begin to occur in the year 2012.

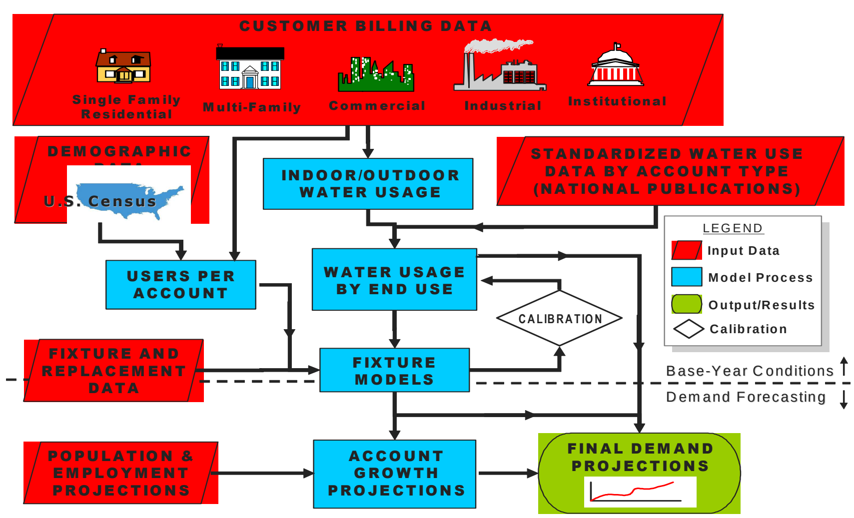
Potential new ordinances and laws are modeled as conservation measures. For example the City's Landscape Design Standards for Water Conservation was not selected as a specific measure to be modeled and is in the Tool Kit as well as embodied in Measure 1 - Promote Green Buildings.

Figure 3 below describes conceptually how the above listed items are incorporated into the flow of information in the DSS Model.

Figure 3

DSS Model Overview Used to Make Potable Water Demand Projection

"With the Plumbing Code"



2.1 Key Inputs to the DSS Model

Table 1 shows the key inputs used in the model. The assumptions having the most dramatic effect on future demands are the natural replacement rate of fixtures, how residential or commercial future use is projected, and finally the percent of estimated real water losses. Following are definitions of terms used in Table 1:

- *Base Year* - This is the starting year for the analysis. For this project, the City selected a base year of 2006 as the appropriate starting point. It was the most recent year for which water billing data was available that appeared to have normal rainfall and not impacted by external factors such as a recession.
- *Average gal/day/acct* - This is the amount of water in gallons that is used per day, per account.
- *Average gal/day/capita* - This is the amount of water in gallons that is used per day, per capita.
- *Indoor/outdoor water use* - This is the amount of water per account split into the percent that is used indoors and outdoors.
- *Consumption by customer class* - This tabulates the annual amount of water used for an entire calendar year, broken down by customer class including Single Family, Multifamily, and Non-Residential (includes Commercial, Institutional, Industrial).
- *Non Revenue Water (also known as Unaccounted for Water or Non-Revenue Water)* - Is the sum of all water input to system that is not billed (metered and unmetered) water consumption, including apparent losses (metering inaccuracy) and real losses (leakage). An average value of 7.3 percent was used for future planning purposes.
- *Water Produced* - This is the total amount of water produced by the City and put into the distribution systems to serve potable and recycled water demand.

Figure 4 shows the water demand projection, as measured by potable and recycled water production.. The graph shows projections for demand *with and without* the plumbing code through 2035. Demand projections are based on the population and employment projections provided by the City (February 2010) Table 2 presents the same water demand projections in table format, at 5-year increments.

The plumbing codes and appliance standards will reduce 2030 demand approximately 920 AF/Yr or 6.2 percent of demand without the plumbing code. Further reductions in demand due to voluntary and regulatory conservation measures are calculated from an end user version of the demands "with plumbing code." That is, the demand "with plumbing code" is used as the baseline from which to calculate water savings from City sponsored conservation measures.

Table 1

List of Baseline Demand Projection Assumptions for DSS Model

Parameter	Model Input Value, Assumptions, and Key References
Base Year	2006
Non Revenue Water, % of Water Production	Non Revenue Water 7.3% assumed from billing and production data
Population and Employment Projection, 2006 to 2036	City of Santa Barbara Water Resources Division, February 2010
Number of Water Accounts for Base Year	2006 Billing Data
Distribution of Water Use Among Categories	2006 Billing Data
Indoor/Outdoor Water Use Split by Category, % of Total	Estimated from Billing Data and Rainfall Records
Residential End Uses, %	AWWARF Report "Residential End Uses of Water" 1999
Non-Residential End Uses, %	Professional judgment and AWWARF Report "Commercial and Institutional End Uses of Water" 1999
Efficient Residential Fixture Current Installation Rates	Census 2005-2007, Housing age by type of dwelling plus natural replacement plus rebate program (if any). Reference "High Efficiency Plumbing Fixtures - Toilets and Urinals" Koeller & Company July 23, 2005. Reference Consortium for Efficient Energy (www.cee1.org)
Water Savings for Fixtures, gal/capita/day	AWWARF Report "Residential End Uses of Water" 1999
Non-Residential Fixture Efficiency Current Installation Rates	Census 2005-2007, assume commercial establishments built at same rate as housing, plus natural replacement
Residential Frequency of Use Data, Toilets, Showers, Washers, Uses/user/day	Estimated based on AWWARF Report "Residential End Uses of Water" 1999
Non-Residential Frequency of Use Data, Toilets and Urinals, Uses/user/day	Estimated based on AWWARF Report "Commercial and Institutional End Uses of Water" 1999
Natural Replacement Rate of Fixtures per year	Residential Toilets 3% (post-1992 toilets), 4% (pre-1992) Commercial Toilets 3% (post-1992 toilets), 4% (pre-1992) Commercial Urinals 3% (less than 1gpf), 4% (greater than 1 gpf) Residential Showers 4% Residential Clothes washers 6.67% Basis of assumptions: A 3% replacement rate corresponds to 33 year life of a new fixture. A 4% replacement rate corresponds to a 25 year life of a new fixture. 4% replacement rate is a CUWCC number from the 2002 MOU. A 6.67% replacement rate corresponds to 15 year washer life based on "Bern Clothes Washer Study, Final Report, Energy Division, Oak Ridge National Laboratory, for U.S. Department of Energy, March 1998, Internet address: www.energystar.gov
Future Residential Water Use	Increases Based on Population Projection
Future Non-Residential Water Use	Increases Based on Employment Projection
Future Recycled Water Use	Increases Based on Total Population

Figure 4

Baseline Annual Demand Projections for City of Santa Barbara
(Potable and Recycled Production)

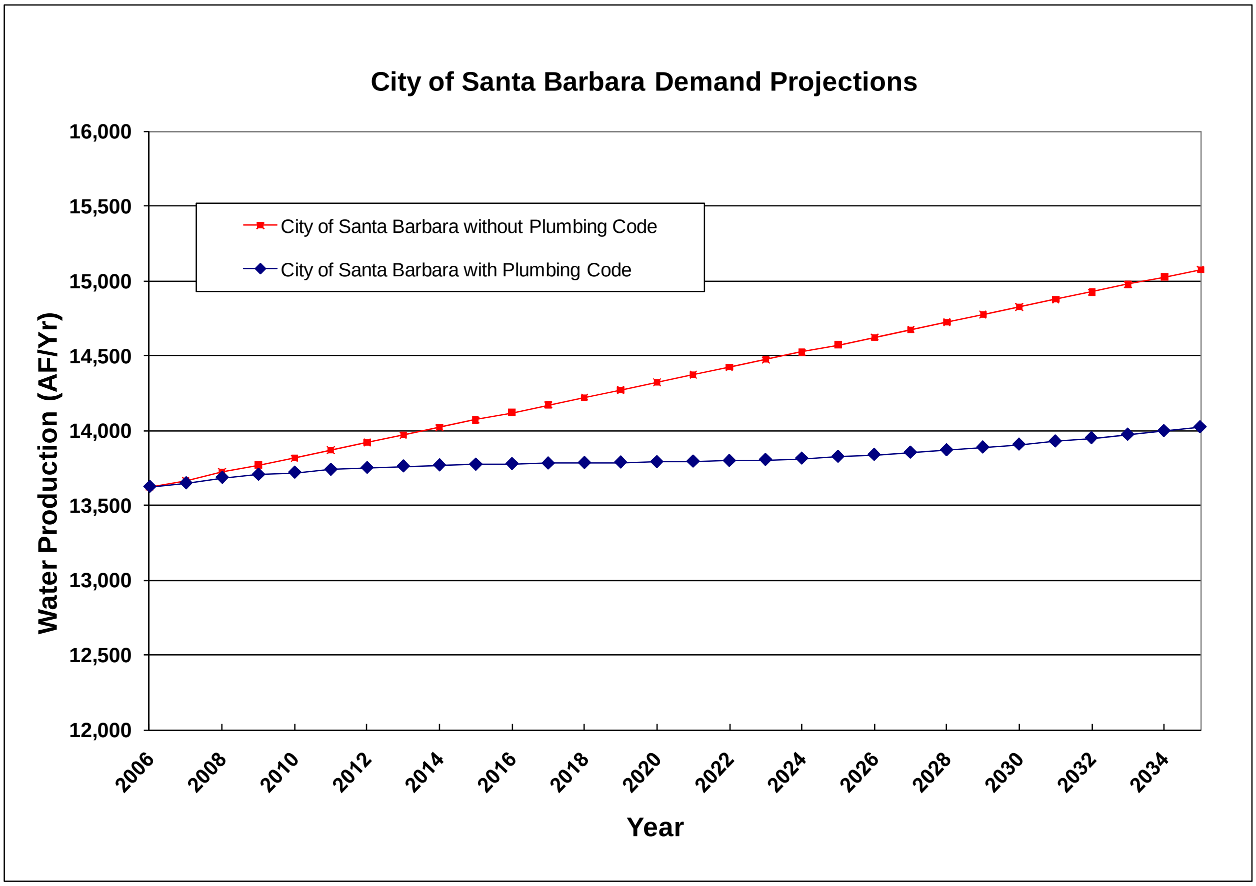


Table 2

Baseline Annual Demand Projections for City of Santa Barbara

Data Source for Population Projection	Plumbing Code	Annual Water Demand, (AF/Yr)*						
		2006	2010	2015	2020	2025	2030	2035
City of Santa Barbara, Water Resources Division, 2010	Not Included	13,623	13,816	14,071	14,322	14,574	14,825	15,077
City of Santa Barbara, Water Resources Division, 2010	Included	13,623	13,719	13,772	13,789	13,824	13,906	14,023

*Baseline demand projection assumes no conservation of any type is implemented. Plumbing code only assumes that the national and State of California plumbing code is implemented over time. Water Demand is total system input including potable plus recycled water.

3. COMPARISON OF INDIVIDUAL CONSERVATION MEASURES

3.1 Selecting Conservation Measures to be Evaluated (Conservation Measure Screening)

An important step in updating the water conservation program is the review and screening of new water conservation measures. A list of 92 potential conservation measures considered potentially appropriate for the City service area was developed by MWM. The list was comprised of known technology and services that included water saving devices or programs (e.g., such as a new high-efficiency toilet). Descriptions of the potential conservation measures were developed to address the methods through which a device or program would be implemented, including the distribution method that would be used to activate the device or program. The full list of conservation measures was provided in the "Results of Demand Management Measure Screening Workshop" Technical Memorandum dated March 26, 2010.

A screening process was undertaken to reduce the number of measures and eliminate those measures that overlap each other to avoid double counting, or are not as well suited to the Santa Barbara service area. Potential new measures were screened based on the workshop participants' evaluation of each individual measure. The screening was completed by the City and selected local stakeholders at a workshop that was facilitated by Maddaus Water Management. The following criteria were used:

- *Technology/Market Maturity* – Is the necessary technology available commercially and supported by the local service industry? For example, a device may be screened out if it is not yet commercially available in the region.
- *Service Area Match* - Is the technology appropriate for the area's climate, building stock, or lifestyle? For example, promoting Water Wise gardens for high density multifamily or commercial sites may not be appropriate where water use analysis indicates little outdoor irrigation.
- *Customer Acceptance/Equity* - Are customers willing to implement measures? If not, the market penetration rates (and thus the water savings) would be too low to be of value. Measures should also be equitable (i.e. one category of customers should not benefit while another pays the costs without receiving benefits). Customer acceptance may be based on:
  - Convenience
  - Economics
  - Perceived fairness
  - Aesthetics
- *Systemic Benefit* - A qualitative ranking taking account of (non quantifiable) benefits external to those considered in the economic evaluation.

The Screening Workshop attendees were provided a copy of the table of all 92 measures. The rating was completed as a group. Maddaus Water Management (MWM) described each measure prior to the rating and answered questions about its applicability, potential savings and costs. MWM did not recommend that any measure be included or excluded.

The results of the screening process and the measures selected for the cost-benefit analysis were provided to the City for a final review. The list of measures was further reviewed by City staff, where additional measures were added and others adjusted to reflect the City service area demographics. As a result of the screening process, 23 measures were selected for quantitative cost benefit evaluation with the DSS Model, and an additional 21 measures will be evaluated qualitatively. The 21 qualitative measures are both ongoing and potential future measures and have been placed into a "Tool Kit" for considerations by the City. Table 3 describes the 23 conservation measures evaluated in the DSS Model by MWM. Table 3A describes the 21 measures in the Tool Kit. Assumptions for the individual quantifiable measures are described in the next section and Appendix A.

SB 407: MWM has included the new California Law SB 407 as Measure 4 in the measure description table. It is not part of the State Plumbing Code, so it is modeled as a measure. It requires that, beginning in 2017 new building owners be notified if the building does not have high efficiency fixtures. In the model we have worked carefully such that SB 407 takes into account the overlap with the plumbing code (natural replacement), Cal Green and rebate programs. SB 407 begins from the year 2017 in residential and 2019 in commercial properties. SB 407 program length continues until the model determines that all the older high flush toilets and urinals have been replaced in the service area. The model shows that combined with the plumbing code only 4 years of implementation is needed to ensure that all older toilets and urinals will have been replaced by the end of the analysis period.

Table 3

Conservation Measures Evaluated in the DSS Model
(ND: "New Development")

Measures to be quantitatively evaluated			
No.	**Measures, Device or Program**	**Applicable Category**	**Measure Description**
1	Promote Water Efficiency in Green Buildings	New SF, MF, CII	All staff time to work with local Green Building associations, City Building Division, developers, designers, vendors to promote incorporating water efficiency into building design. Co-sponsor award program.
2	ND Require High Efficiency Toilets	New SF, MF, CII	Revise City's Building Code to require high efficiency toilets (HET) in advance of 2014 state plumbing code requirement. HETs are defined as any toilet to flush 1.28 gpf or less. HETs would be required if a customer needs to get a permit for a remodel or new development.
3	ND Require High Efficiency Faucets and Showerheads	New SF, MF, CII	Revise City's Building Code to require lavatory faucets that flow at no more than 1.5 gpm and showerheads at no more than 2.0 gpm. Plan to require this measure in the year July 2013 before the State Law requiring HETs and HEUs goes into effect in the year 2014. Would be required if a customer needs to get a permit for a remodel or new development.
4	Toilet and Urinal Retrofit prior to Name Change on Water Account (SB 407)	Pre-1994 Existing Accounts	Measure will start in the year 2017 (SF) and 2019 (CII) to coincide with the California State Law SB 407. Work with the real estate industry to require a certificate of compliance be submitted to the City that the property and efficient fixtures where either already there or were installed at the time of sale, before close of escrow. Consider allowing this certification to be made as a part of the conventional private building inspection report process.
5	Financial Incentives for Irrigation and Landscape Upgrades (current program)	SF, MF, CII, IRR	For SF, MF, CII, and IRR customers with landscape, provide a Smart Landscape Rebate Program with rebates towards the purchase and installation of eligible irrigation equipment upgrades including smart controllers, Water Wise plants and mulch, rain sensors, turf removal, hardscape surfaces (material only) etc. Rebate is up to $1,000.

Measures to be quantitatively evaluated			
No.	Measures, Device or Program	Applicable Category	Measure Description
6	Financial incentives for Irrigation and Landscape Upgrades	SF, MF, CII, IRR	Same program as Measure 5, but increased penetration due to increased rebate amounts for CII categories only. CII increased up to $5,000 maximum. Values of $2,500 shown in Appendix A for CII is the average value are based on current program data assuming that each participant does not use the maximum rebate value.
7	Washer Rebates	SF, MF (in unit washers)	Homeowners would be eligible to receive a $150 rebate on a new high efficiency clothes washer. It is assumed that the rebates would remain consistent with relevant state and federal regulations (Department of Energy, Energy Star) and only offer the best available technology. Program would continue to run until CUWCC programs are no longer available. City plans to possibly run high efficiency program after the CUWCC Program ends. Concern over too many free riders for this program. Administration percentage is based on $33 per rebate issued paid to the CUWCC to administer the program.
8	Washer Rebates for High Efficiency Machines	SF, MF (in-unit washers)	Same as above, except that a higher rebate is offered for higher efficiency machines. Assume 2% of accounts take rebates per year. Less of a free rider concern with the higher efficiency machines.
9	High Efficiency Toilet (HET) Rebates	Existing Customers SF, MF	Provide a $100 rebate or voucher for the installation of a high efficiency toilet (HET). HET's are defined as any toilet flushing at 1.28 gpf or less and include dual flush technology. Program will be shorter lived as it is intended to be a market transformation measure and eventually would be stopped as 1.28 gpf units reach saturation. City would continue program for 4 years even after CUWCC programs is no longer available. Low annual market penetration of 0.07% is due to possible high level of saturation of 1.6 gpf toilets. The new California Law will require HETs starting in the year 2014. The program is assumed to run until the year 2015 such that it gives the customers 1 year to adapt to the new law and HET requirement. Note: HET toilets for CII customers are included under measure 23.
10	Single Family Water Check Up	SF	Conventional indoor and outdoor water surveys for existing single-family residential customers. Normally those with high water use are targeted and provided a customized report to the homeowner on how to save water in their home.
11	Multifamily Water Check Up	MF	Indoor and outdoor water surveys for existing multifamily residential customers. Those with high water use are targeted and provided a customized report to owner. Average cost is $150 per MF account. There is an average of 4 dwelling units per MF account, so cost for an average MF account is $150 for all 4 dwelling units.

Measures to be quantitatively evaluated			
No.	**Measures, Device or Program**	**Applicable Category**	**Measure Description**
12	Existing Commercial Washer Rebate	CII	Provide a $400 rebate to commercial laundries and apartment complexes with 5 or more units for efficient washing machines with a common laundry room. It is assumed that the rebates would remain consistent with relevant state and federal regulations (Department of Energy, Energy Star) and only offer the best available technology. Plan to phase out this program as it has been running for 4 years and there is concern over high saturation levels. CUWCC grant program funds 50% of rebate.
13	Cisterns/Rain Catchments	SF, MF	Provide a rebate ($100) to assist a assumed percentage of single family homeowners per year with installation of rain barrels or cisterns.
14	Gray water Retrofit SF	SF	Provide a rebate (up to $200) to assist a certain percentage of single family homeowners per year to install gray water systems. Parts cost approx $200, installation would not be included.
15	Current High Efficiency Urinal Rebate (<0.25 gallon)	Existing CII	Provide a rebate of $300 for high efficiency and waterless urinals to existing high use CII customers (such as restaurants). Discontinue program in 1 year or after CUWCC programs are no longer available. City plans to possibly run high efficiency program after the CUWCC Program ends.
16	ND Require 0.5 gal/flush or less urinals in new buildings	New CII	Revise City's Building Code to require that new buildings are fitted with 0.5 gpf or less (or one liter) urinals rather than the current standard of 1.0-gal/flush models. This measure also includes waterless urinals, or 1 pint (0.125 gpf) urinals. This code revision would be in advance of 2014 State of California plumbing code requirements.
17	School Building Retrofit	CII	Run a program patterned after MWD of Southern California's school retrofit program wherein school receives a grant to replace fixtures and upgrade irrigation systems. City would like to formalize the process. The schools lack funding, so possibly set this up as a Pay for Performance Program. The $3,000 cost assumes an average of 6 HETs installed at $300 each (parts and labor) and one $1,200 irrigation controller installed per school.
18	Irrigation (Landscape) Water Budgets	IRR	Irrigators of landscapes with separate irrigation account (meter) can utilize the California Landscape Budgets Program (CLBP): provides monthly water use reports via www.landscapebudget.com for the properties served by dedicated irrigation meters and compares the usage to a weather-based water allocation calculation. Assume 10% of large accounts receive utilize website tool per year. The current cost is approximately $16,000 per year.
19	Irrigation Water Surveys	CII	All public and private irrigators of landscapes would be eligible for free landscape water surveys and customized report upon request. Normally those with high water use would be targeted. Assume 10 percent of large turf areas are surveyed per year.

Measures to be quantitatively evaluated			
No.	**Measures, Device or Program**	**Applicable Category**	**Measure Description**
20	Mulch Program	SF, MF, CII	Free mulch program. City will subsidize delivery charges (currently $25 or $40 dollars) for mulch currently offered for free by the County and other sources, so as to make it completely free to customers. Goal would be to keep irrigation and storm water on site and reduce runoff and keep water from evaporating. The water savings benefit would be to keep the soil moist for 2 to 3 weeks per year in the spring and fall and increase water conservation throughout the year.
21	CII Water Check Up Level 1	CII	All CII customers would be offered a free water survey/evaluation, i.e. "water checkup" that would evaluate ways for the business to save water and money. The Level 1 CII surveys (accounts that use less than 5,000 gallons of water per day) would be for the simpler CII such as hotels, restaurants, and small schools conducted by City staff.
22	CII Water Check Up Level 2	CII	For Level 2, the 100 highest CII water users would be offered a free water survey/evaluation, i.e. "water checkup" that would evaluate ways for the business to save water and money. The Level 2 audits would be performed by a trained technical professional. Marketing would be focused to target the high water using accounts (complex sites with higher than 10,000 gallons of water use per day). This may include sights such as hospital, zoo, and commercial laundries. These Level 2 sites would most likely be done by a contractor and would include a high level of follow up communication and assistance to encourage use of rebates. Program would work with the business individually to build relationships. Goal would be to encourage business to continue to take actions even after the survey to improve site water use efficiency. Publish success stories on City website and in papers. For hotel laundries can recommend things such as adjusting the programming on laundry machines.
23	Customized CII Incentive Program	CII	Provides financial incentives for CII accounts that have participated in the City's free "Water Check Up" Program. After the free water use assessment has been completed at site, the City will analyze the recommendations on the findings report that is provided and determine if site qualifies for a financial incentive. Financial incentives will be provided after analyzing the cost benefit ratio of each proposed project. Incentives are tailored to each individual site as each site has varying water savings potentials. Incentives will be granted at the sole discretion of the City while funding lasts. The program is intended to provide financial incentives for unique or site specific items (for example localized recycling systems for commercial laundries and high efficiency toilets for hotels). Assume half of sites that participate in a water check up will request financial assistance.

Table 3A – "Tool Kit" Conservation Measures Not Included in DSS Model
(Reserved for qualitative consideration)

Measures to be qualitatively considered by the City of Santa Barbara			
No.	**Measures, Device or Program**	**Applicable Category**	**Measure Description**
TK-1	Media Campaign:	ALL	Determine appropriate media campaign message with marketing study/focus groups/customer phone survey and revise media campaign and marketing of measures based on study and revisions to WC Program.
TK-2	Prohibit Water Waste and Practices	CII	City Ordinance No. 4558, adopted on February 1989, prohibits the waste of water defined as gutter flooding and failure to repair leaks in a timely manner.
TK-3	Public Information Program	SF	Public information programs are used to raise awareness of conservation measures available to customers. Programs could continue efforts including school programs, poster contests, speakers to community groups, conservation hotline, website, video loan, radio and television time, demonstration gardens and printed educational material such as bill inserts, etc. Could also consider increasing current City efforts possibly adding cell phone apps, Face book, interactive kiosk with view screen, etc. Program would continue indefinitely.
TK-4	Efficient Outdoor Use Education and Training Programs	SF	City would continue to offer, organize and sponsor a series of educational workshops or other means for educating homeowners in efficient landscaping and irrigation principals. Utilize guest speakers, demonstration gardens, incentives, such as a nursery plant coupon. Current programs include Green Gardener Program, SBCC Adult Ed workshops, Garden Wise Guys television show, and participation in other organizations'/business' events. Consider increasing current program.
TK-5	ND Require Plumbing for Future Gray Water Use	SF	Require that the drain lines in new single-family homes be plumbed for future installation of gray water systems. City recommends further research before establishing a full program.
TK-6	Water Wise Demonstration Gardens	ALL	City would continue funding and coordinating demonstration gardens on City property displaying living examples of water wise gardens. The City would continue to provide signs and brochures to educate those people visiting the garden.
TK-7	Distribute Retrofit Kits	SF	Provide owners of pre-1992 homes with retrofit kits that contain easy-to-install low flow showerheads, faucet aerators. Update kits with 1.25 gpm or 1.75 gpm showerheads. Research saturation of current showerheads.

Measures to be qualitatively considered by the City of Santa Barbara			
No.	**Measures, Device or Program**	**Applicable Category**	**Measure Description**
TK-8	Toilet Leak Detection	SF	Distribute leak detection tablets for homeowners to test toilets for leaks; offer advice on toilet leak repair.
TK-9	ND Enforce Landscape and Irrigation Requirements	ALL	Enforce current City of Santa Barbara Landscape Design Standards for Water Conservation Resolution No. 08-083. Standards specifies that development projects subject to design review be landscaped with water wise plant, appropriate turf ratios, plant selection, efficient irrigation systems and smart irrigation controllers. Enforcement is the key.
TK-10	Landscape Watering Calculator and Watering Index	ALL	Increase marketing and promoting on Landscape Watering Calculator and Watering Index. Consider cell phone app with Watering Index, following up in person with large landscape customers on a frequent basis to encourage use of WI. Need to increase number of weather stations. Upgrade CIMIS stations to get better coverage. Possibly finance a weather station.
TK-11	Train Landscape Maintenance Workers (Green Gardener Program)	CII	City would continue to sponsor bilingual training for gardeners in landscape maintenance methods that will save irrigation water, which is the Green Gardener Program of Santa Barbara www.greengardener.org. Consider requiring this with business licenses as a short course of required classes. This element needs additional research.
TK-12	MLS Listing for water efficiency	SF	Require real estate MLS listing service to have a blank list to include items such as a water efficient rating of homes. This could list a scoring system where showerheads are listed in gallons per minute (gpm), toilets in gallons per flush (gpf), and washers in gallons per load (gpl)
TK-13	ND Require Hot Water on Demand/Structured Plumbing	SF	Require developers to equip new homes or buildings with efficient hot water on demand systems such as structured plumbing systems. These systems use a pump placed under the sink to recycle water sitting in the hot water pipes to the water heater or to move the water heater into the center of the house and/or reduce hot water waiting times by having a an on-demand pump on a recirculation line. City recommends to promote this item but not require. Use LEED building requirements.
TK-14	Require or Rebate Swimming Pool Covers	SF, MF	Provide a $100 rebate through pool equipment supply stores for purchase of a swimming pool cover. Require on new residential homes.
TK-15	Require Irrigation Designers/Installer be Certified by IA	CII	Require design and installation of irrigation systems that are efficient and installed by trained/certified contractors. Certification to be done by Irrigation Association (IA). Model after Cary North Carolina's program.

Measures to be qualitatively considered by the City of Santa Barbara			
No.	**Measures, Device or Program**	**Applicable Category**	**Measure Description**
TK-16	New Home Award Programs (Patterned after WaterSense)	SF	Provide annual awards to developers that are "Green Builders" and offer homes for sale that meet certain criteria such as EPA's new Water Sense program for new homes. This could be combined with energy efficient homes. Provide awards to homeowners for existing homes as well. Highlight awards with ceremony with Mayor, press release, customer profile in news sources, etc. Support this measure with permits. Fast track the permit process.
TK-17	Award Programs for Water Savings by Businesses	CII	Providers would sponsor an annual awards program for businesses that significantly reduce water use. They would receive a plaque, presented at a lunch with the mayor. Possibly join together with existing Looking Good SB Awards Program. Continue to participate in the Green Business Program.
TK-18	Ordinance to allow for a pilot test for innovative water generating systems		Model after Seattle program to reduce hurdles to customers who want to develop innovative buildings that may include a self generation of water on site.
TK-19	Green Building State Support	ALL	Consider supporting the State legislation on Green buildings introduced in January 2010.
TK-20	Survey water utility customers	SF	Conduct a brief 2 page written or electronic survey of customers that asks what they currently have in their homes. Goal would be to collect saturation data. The survey would be passed out during farmer's markets, during site surveys for CII or SF and MF, and on the website, and via mailers. The data would be entered into a database that would automatically generate a customize savings letter. The customers would be provided a copy of the "customized letter" that would list current City opportunities for programs and rebates. Would help with the following (a) communication with customers (b) program design to reflect customer needs (c) gathering saturation data from historical programs
TK-21	ND Install AMS	ALL	Fully install Automatic Meter System (AMS) capable of providing hourly consumption data back to City and purchase means of viewing daily consumption inside customers home/business either through the Internet (if available) or separate device. The AMS would, on demand, indicate to the customer and City where and how their water is used thereby facilitating water use reduction. Consider phasing AMS with target customer groups; start with pilot study and/or consultant analysis of options. Installation of meters would be phased over time. Possible investigation of a Wi-Fi system network connection. Also investigate data being available inside homeowner's homes. The AMS system could help to benefit programs such as SF and MF water checkups, CII Surveys updating irrigation water budgets and leak detection.

3.2 Perspectives on Benefits and Costs

The determination of the economic feasibility of water conservation programs involves comparing the costs of the programs to the benefits provided. This analysis was performed using the DSS Model. The DSS Model calculates savings at the end-use level; for example, the model determines the amount of water a toilet rebate program saves in daily toilet use for each single family account.

Present value analysis using constant 2010 dollars and a real discount rate of 3% is used to discount costs and benefits to the base year. From this analysis, benefit-cost ratios of each measure are computed. When measures are put together in programs, the model is set up to avoid double counting savings from multiple measures that act on the same end use of water. For example, multiple measures in a program may target toilet replacements. The model includes assumptions to apportion water savings between multiple measures.

Economic analysis can be performed from several different perspectives, based on which party is affected. For planning water conservation programs for utilities, the perspectives most commonly used for benefit-cost analyses are the "utility" perspective and the "community" perspective. The "utility" benefit-cost analysis is based on the benefits and costs to the water provider. The "community" benefit-cost analysis includes the utility benefit and costs together with account owner/customer benefits and costs. These include customer energy and other capital or operating cost benefits plus costs of implementing the measure, beyond what the utility pays.

The utility perspective offers two advantages. First, it considers only the program costs that will be directly borne by the utility. This enables the utility to fairly compare potential investments for saving versus supplying water. Second, because revenue shifts are treated as transfer payments, which means program participants will have lower water bills and non-participants will have slightly higher water bills so that City revenue needs continue to be met. Therefore, the analysis is not complicated with uncertainties associated with long-term rate projections and retail rate design assumptions. It should be noted that there is a significant difference between the utility's savings from the avoided cost of procuring water and the reduction in retail revenue that results from reduced water sales due to conservation. This budget impact occurs slowly, and can be accounted for in water rate planning. Because it is the water provider's role in developing a conservation plan that is paramount in this study, the utility perspective was primarily used to evaluate elements of the plan.

The community perspective is defined to include the utility and the customer costs and benefits. Costs incurred by the aggregate of all customers striving to save water while participating in conservation programs are considered, as well as the benefits received in terms of reduced energy bills (from water heating costs) and wastewater savings, among others. Water bill savings are not a customer benefit in the aggregate for reasons described above. Other factors external to the utility, such as environmental effects, are often difficult to quantify and are not necessarily under the control of the utility. They are therefore frequently excluded from economic analyses, including this one.

3.3 Present Value Parameters

The time value of money is explicitly considered. The value of all future costs and benefits is discounted to the first year in the DSS Model (the base year, which in this case is 2006), at the real interest rate of 3.0%. The DSS Model calculates this real interest rate, adjusting the current nominal interest rate (assumed to be approximately 6.1%) by the assumed rate of inflation (3.0%). Cash flows discounted in this manner are herein referred to as "Present Value" sums.

3.4 Assumptions about Measure Costs

Costs were determined for each of the measures based on industry knowledge, past experience and data provided by the City. Costs may include incentive costs, usually determined on a per-participant basis; fixed costs, such as marketing; variable costs, such as the costs to staff the measures and to obtain and maintain equipment; and a one-time set-up cost. The set-up cost is for measure design by staff or consultants, any required pilot testing, and preparation of materials that will be used in marketing the measure. The model was run for 30 years, (each year between 2006 and 2036) to encompass the 20-year planning period of 2010 to 2030. Costs were spread over the time period depending on the length of the implementation period for the measure and estimated voluntary customer participation levels.

Lost revenue due to reduced water sales is not included as a cost because the conservation measures evaluated herein generally take effect over a span of time that is sufficient to enable timely rate adjustments, if necessary, to meet fixed cost obligations.

3.5 Assumptions about Avoided Costs

Future benefits from program water savings can be considered to be future costs that are avoided because the water conservation program makes these expenditures unnecessary or delayed in time (creating a savings in the present value of future costs). The City provided the information shown in Table 4 in February 2010 for use in this study. The table shows that the City has many sources of water supply that vary in marginal cost, which is the basis for the avoided costs.

Table 4
Avoided Cost Tabulation - City of Santa Barbara

For Use in the Water Conservation Technical/Economic Evaluation

Assumed Base Supplies (not affected by conservation savings):
SWP Exchange Water as required by agreement
Groundwater as needed for peak demand, distribution water quality, and utilizing safe yield of the basins
Mission Tunnel & Gibraltar as available
Cachuma (including carryover) as needed
Recycled water to meet connected demand

$ 100 = Variable cost of treatment at Cater Water Treatment Plant ($/AF)
$ 500 = Variable cost of treatment at Ortega Groundwater Treatment Plant ($/AF)

Additional supplies as needed, per below:

		Acquisition Cost	Delivery/ Production Cost	Cater Treatment Cost	TOTAL AVOIDED COST ($/AF)
A	Groundwater (wellhead treatment only)		$120		$120
B	State Water Project- Table A Deliveries		$290	$100	$390
C	Groundwater (Ortega Groundwater Treatment Plant)		$610		$610
D	SWP deliveries other than City Table A water (Non-Critical Drought Period)	$300	$300	$100	$700
E	SWP deliveries other than City Table A water (Critical Drought Period)	$600	$300	$100	$1,000
F	Desalination (amortization of $18 million reactivation cost not included here)		$1,470		$1,470

Avoided Cost Conclusion:
Item A is likely to occur regardless of conservation savings; Items E & F are relatively infrequent. Therefore, avoided cost is assumed to be an average of Items B, C, & D.

$600 = Avoided cost of water saved through conservation

For this conservation evaluation it is assumed that the above avoided cost of water will apply to all water saved. Future benefits are discounted to the base year as stated above to compute the Present Value figures reported in this memorandum.

3.6 Measure Assumptions including Unit Costs, Water Savings, and Market Penetrations

In using the DSS model to evaluate the water conservation measures selected by the City, assumptions regarding the following variables were made for each measure:

- Targeted Water User Group; End Use – Water user group (e.g., single-family residential) and end use (e.g., indoor or outdoor water use).
- Utility Unit Cost – Cost of rebates, incentives, and contractors hired (by the utility) to implement measures.
- Retail Customer Unit Cost – Cost for implementing measures that is paid by retail customers (i.e., the remainder of a measure's cost that is not covered by a utility rebate or incentive).
- Utility Administration and Marketing Cost – The cost to the utility for administering the measure, including consultant contract administration, marketing, and participant tracking. The mark-up is sufficient (in total) to cover local agency conservation staff time and general expenses and overhead.

The unit costs vary according to the type of account and implementation method being addressed. For example, a measure might cost a different amount for a residential single family account, than a residential multifamily account, and for a rebate versus an ordinance requirement or a direct installation implementation method. Typically water utilities have found there are increased costs associated with achieving higher market saturation, such as more surveys per year. Appendix A shows the unit costs and other measure assumptions used in the study for each measure analyzed. The model calculates the annual costs based on the number of participants each year. The general formula for calculating annual utility costs is:

Annual Utility Cost = Annual market penetration rate x total accounts in category x unit cost per account x (1+administration and marketing markup percentage)

Annual Customer Cost = Annual number of participants x unit customer cost

Annual Community Cost = Annual utility cost + annual customer cost

3.7 Comparison of Individual Measures

Table 5 presents how much water the measures would save over 20 years, how much they would cost, and what cost of saved water per unit volume *if the measures were implemented on a stand-alone basis (i.e. without interaction or overlap from other measures that might address the same end use(s).* Only the net water savings for overlapping conservation measures was included in each program. Savings from measures which address the same end use(s) are not additive. The model uses impact factors to avoid double counting in estimating the water savings from programs of measures. For example if two measures are planned to address the same end use and both save 10% of the prior water use then the net effect is not the simple sum (20%). Rather it is the cumulative impact of first measure reducing the use to 90% of what is was without the first measure in place and then reducing the use another 10% to result in the use being 89% of what it was originally. In this example the net savings is 19%, not 20%. Using impact factors the model computes the reduction as follows 0.9 x 0.9 = 0.89 or 19% water savings.

Since interaction between measures has not been accounted for in Table 5, it is not appropriate to include totals at the bottom of the table. However, the table is useful to give a close approximation of the cost effectiveness of each individual measure.

Cost categories are defined below:

- Utility Costs - those costs that the City as the water utility would incur to operate the Water Conservation Program, including administrative costs.
- Utility Benefits - the avoided cost of purchasing water at the identified rate of $600/AF.
- Customer Costs - those costs customers would incur to implement a measure in the City's Conservation Program and maintain its effectiveness over the life of the measure.
- Customer Benefits - the savings other than from reduced water/sewer utility bills, such as energy savings resulting from reduced use of hot water. Reduced water and sewer bills are not included because they are a transfer payment among water users and any lost revenue would be made up with an overall rate increase. Conservation program participants would see lower water and sewer bills but overall there would be no net customer benefit.
- Community Costs and Benefits - Community Costs and Benefits include Utility Costs plus Customer Costs, and Utility Benefits plus Customer Benefits, respectively.

The column headings in Table 5, as well as those used later in Table 7, are defined as follows:

- Demand Reduction by 2030 = the reduction in 2030 annual water demand (as measured by water system production) attributable to implementation of a given measure (for Table 5) or a given program (for Table 7) over the 20-year planning period. Expressed either as an AFY reduction or a percentage reduction from the "Without Plumbing Code" baseline demand projection.
- 20-Year Water Savings (AF) = the volume of water in acre-feet that is the sum of the annual demand reductions in each of the 20 years in the planning period.
- Average Annual Program Cost to Utility ($) = the sum of the annual Utility Costs (undiscounted) divided by the 20 years in the planning period.
- Present Value of Utility and Community Costs and Benefits ($) = the present value of the 20-year time stream of annual costs or benefits, discounted to the base year.
- Utility Benefit-Cost ratio = PV of Utility Costs divided by PV of Utility Benefits over 20 years.
- Community Benefit-Cost ratio = PV of Utility Benefits plus PV of customer energy savings) divided by (sum of PV of Utility Costs plus PV of Customer Costs), over 20 years
- Utility Cost of Water Saved ($/AF) = PV of Utility Costs over 20 years divided by the 20-Year Water Savings. This value is compared to the utility's avoided cost of water as one indicator of the cost effectiveness of conservation efforts. It should be noted that the value somewhat undervalues the cost of savings because program costs are discounted to present value and the water benefit is not.

From Table 5 the following observations about the measures can be made:

- There is a considerable range in demand reduction from very small amounts to over 300 AFY in 2030.
- Ten of the 23 measures are cost-effective (BC ratio > 1.0) from the utility perspective.
- Eight of the 23 measures are cost-effective (BC ratio > 1.0) from the community perspective.
- Four of the measures have a utility cost of water saved that is less than the avoided cost of water for the City.
- The measures with the highest water savings target landscape water use.

- The top five measures in terms of demand reduction in 2030 (third column of Table 5) are existing programs or a modification of an existing program (demand reduction by measure ranges from about 40 AFY to over 300 AFY in 2030):
- Customized CII Incentive Program (Measure 23)
- Financial incentives for irrigation upgrades (Measure 6)
- CII Level 1 Checkups (Measure 21)
- CII Level 2 Checkups (Measure 22)
- Irrigation Water Surveys (Measure 19)

The three most expensive measures for the utility (last column in Table 5) over the study period (2011-2030, i.e., 20 years) are:

1. Financial incentives for irrigation upgrades (Measure 6)
2. Customized CII Incentive Program (Measure 23)
3. Washer Rebates for High Efficiency Machines (Measure 8)

Table 5

Conservation Measure Costs and Savings

No.	Measure	Demand Reduction in 2030 (AFY))[1]	Present Value of Utility Costs ($)	Utility Benefit Cost Ratio	Community Benefit Cost Ratio	Utility Cost of Water Saved ($/AF)[2]	Average Annual Cost to the Utility
1	Promote Water Efficiency in Green Buildings	30.92	$ 191,015	0.87	0.25	$ 374	$ 14,469
2	ND Require High Efficiency Toilets	2.66	$ 2,342	10.69	1.50	$ 34	$ 142
3	ND Require High Efficiency Faucets and Showerheads	23.60	$ 8,359	15.21	10.76	$ 21	$ 633
4	Fixture Replacement SB 407	34.16	$ 18,540	10.96	0.85	$ 29	$ 1,351
5	Financial Incentives for Irrigation and Landscape Upgrades (Current)	31.11	$ 607,907	0.27	0.12	$ 1,190	$ 46,201
6	Financial Incentives for Irrigation and Landscape Upgrades	129.90	$ 2,749,478	0.25	0.10	$ 1,292	$ 209,219
7	Washer Rebates	1.49	$ 18,229	0.92	1.77	$ 408	$ 1,057
8	Washer Rebates for High Efficiency Machines	41.65	$ 786,236	0.29	0.88	$ 1,118	$ 60,704
9	High Efficiency Toilet (HET) Rebates	1.75	$ 22,736	0.71	0.40	$ 510	$ 1,179
10	Single Family Water Check Up	28.36	$ 339,647	0.61	0.91	$ 595	$ 25,758
11	Multifamily Water Check Up	17.38	$ 152,262	0.81	1.24	$ 446	$ 11,616
12	Existing Commercial Washer Rebate	6.44	$ 15,739	3.90	10.33	$ 94	$ 913
13	Cisterns/Rain Catchments	11.65	$ 278,395	0.22	0.05	$ 1,453	$ 17,893
14	Gray water Retrofit SF	44.71	$ 165,715	1.44	0.82	$ 225	$ 10,610
15	Current High Efficiency Urinal Rebate (<0.25 gallon)	0.88	$ 14,635	0.70	0.21	$ 541	$ 849
16	ND Require 0.5 gal/flush or less urinals in new buildings	0.14	$ 99	14.68	0.48	$ 25	$ 6
17	School Building Retrofit	22.17	$ 73,880	2.37	2.83	$ 147	$ 4,745
18	Irrigation (Landscape) Water Budgets	34.03	$ 539,376	0.46	0.46	$ 814	$ 41,009
19	Irrigation Water Surveys	44.72	$ 656,500	0.49	0.33	$ 754	$ 49,914
20	Mulch Program	6.87	$ 234,795	0.22	0.07	$ 1,747	$ 17,819
21	CII Water Check Up Level 1	80.33	$ 228,108	1.88	2.12	$ 173	$ 15,678
22	CII Water Check Up Level 2	67.62	$ 253,451	1.43	1.62	$ 228	$ 17,420
23	Customized CII Incentive Program	327.49	$ 1,641,249	1.06	0.60	$ 306	$ 124,786

Notes:

1. Demand Reduction by 2030 is measured from the 14,825 AFY projected 2030 demand without the effects of the Plumbing Code.
2. Utility Cost of Water Saved somewhat undervalues the cost of savings because program costs are discounted to present value and the water benefit is not.

4. RESULTS OF CONSERVATION PROGRAM EVALUATION

4.1 Selection of Measures for Programs

Table 6 provides a summary of which measures are included in each of the three alternative programs. The three packages are designed to illustrate an increasing level of water savings for the City, with the third level (Program C) representing the maximum theoretical level of water savings. The decision of which measures go into each program will be reviewed and finalized by the City staff.

These programs are not intended to be rigid programs but rather to demonstrate the range in savings that could be generated if selected measures were run together. This step of the process accounts for a percent overlap in water savings (and benefits) and estimates combined savings and benefits from packages of measures that form programs.

Each program builds on the prior program. Program A is the least intensive, approximating a continuation of the current City program, and contains 10 measures. Program B includes Program A measures and 7 additional measures. The selection criterion for new measures added to Program B was to include all new measures that had an individual utility benefit to cost ratio equal to or greater than 0.9. Program C has 22 of the 23 measures evaluated. Measure 5 would be replaced by an enhanced version represented by measure 6.

Table 6
Conservation Measures Selected for Programs

No.	Measure Name	Program A	Program B	Program C
1	Promote Water Efficiency in Green Buildings		✓	✓
2	ND Require High Efficiency Toilets		✓	✓
3	ND Require High Efficiency Faucets and Showerheads		✓	✓
4	Fixture Replacement SB 407		✓	✓
5	Financial Incentives for Irrigation and Landscape Upgrades (Current)	✓	✓	
6	Financial Incentives for Irrigation and Landscape Upgrades			✓
7	Washer Rebates	✓	✓	✓
8	Washer Rebates for High Efficiency Machines			✓
9	High Efficiency Toilet (HET) Rebates	✓	✓	✓
10	Single Family Water Check Up	✓	✓	✓
11	Multifamily Water Check Up	✓	✓	✓
12	Existing Commercial Washer Rebate	✓	✓	✓
13	Cisterns/Rain Catchments			✓
14	Gray water Retrofit SF			✓
15	Current High Efficiency Urinal Rebate (<0.25 gallon)	✓	✓	✓
16	ND Require 0.5 gal/flush or less urinals in new buildings		✓	✓
17	School Building Retrofit		✓	✓
18	Irrigation (Landscape) Water Budgets	✓	✓	✓
19	Irrigation Water Surveys	✓	✓	✓
20	Mulch Program			✓
21	CII Water Check Up Level 1	✓	✓	✓
22	CII Water Check Up Level 2		✓	✓
23	Customized CII Incentive Program			✓
	Total Measures in each Program	10	17	22

4.2 Results of Program Evaluation

Figure 5 shows projected annual water demand with no plumbing code effects, plumbing code only, and the three conservation programs. The plumbing code reduces water production (demand) 6.2 percent by 2030. The alternate programs reduce production in 2030 as follows:

- Program A savings are 2.6 percent or, including the plumbing code, 8.8 percent.

  (2.6% Program A+ Plumbing Code 6.2% = Total Savings 8.8%)

- Program B savings are 3.4 percent or, with the plumbing code, 9.6 percent

  (3.4% Program B+ Plumbing Code 6.2% = Total Savings 9.6%)

- Program C savings are 6.7 percent or, with plumbing code, 12.9 percent

  (6.7% Program C+ Plumbing Code 6.2% = Total Savings 12.9%)

The lines in Figure 5 depict the projected demand with the alternative conservation programs and the plumbing code effects.

Figure 5

Long Term Demands with Conservation Programs
(Demand is measured by total water system production, including potable and recycled water)

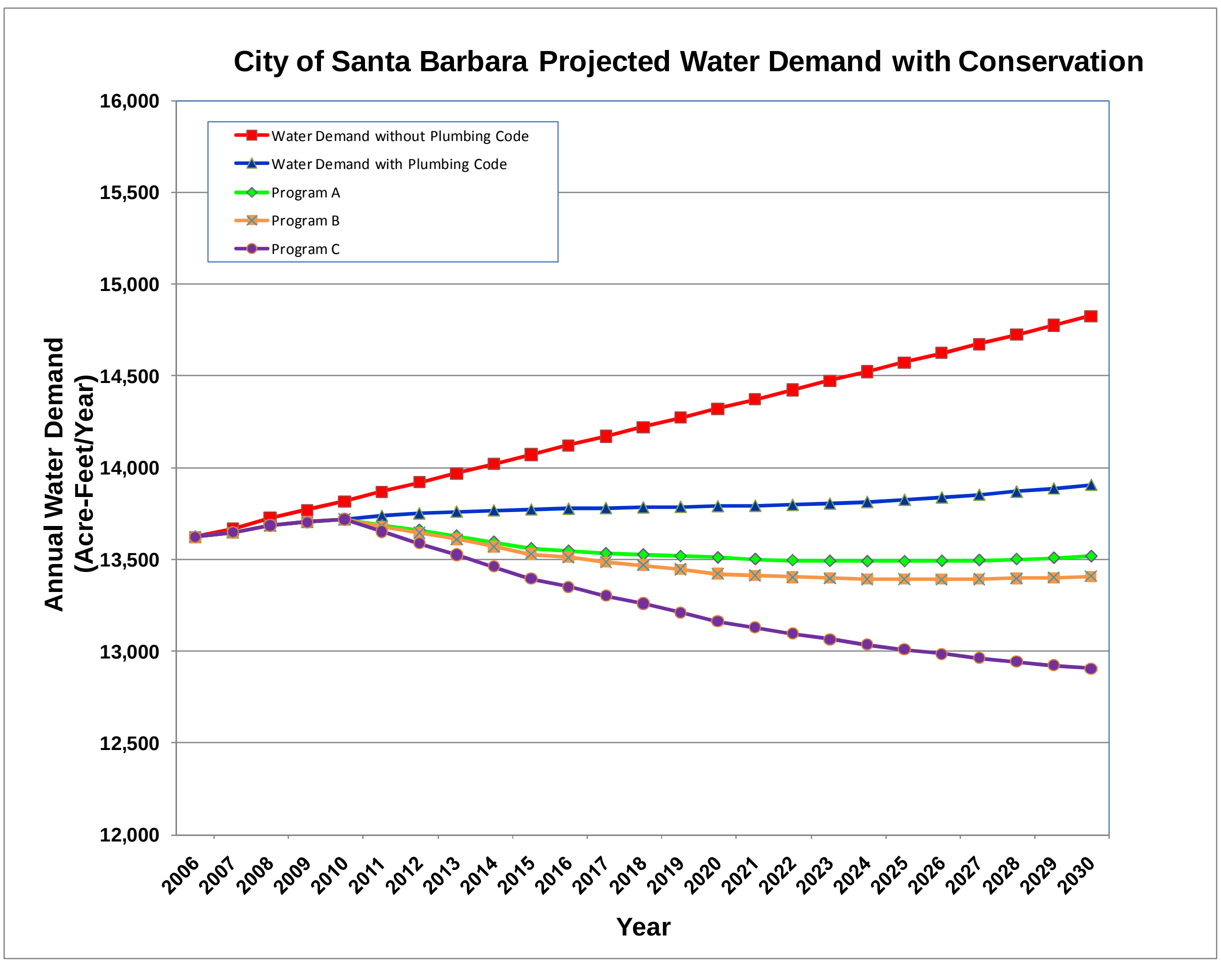


Table 7 presents key evaluation statistics compiled from the DSS Model. Assuming all measures are successfully implemented, projected demand reduction for 2030 in AF is shown, as are the costs of achieving this reduction. These cost values are derived from the annual time stream of utility, customer and community costs, and are expressed two ways:

1. Present value derived benefit-to-cost ratios for the period of analysis, from both the utility and community perspectives,
2. The utility cost of water saved.

The water savings are also expressed two ways:

1. As a percentage reduction of the projected 2030 demand (as measured by total production) compared to the base line demand projection without the effects of the plumbing code,
2. Total volume of water saved over the 20-year period of analysis.

Figure 6 graphically depicts the three programs. Program A reflects continuing the 10 measures that are part of the current program, plus the effects of the plumbing code. The additional measures that create programs B and C produce increasing program costs and savings. After program B the curve flattens, indicating that there are diminishing marginal returns when measures are added to form Program C. That is not to say that extending the water savings to Program C, the theoretical maximum determined in the study, is a poor investment. Whether it is economical to spend the extra money depends on the need to reduce water demand and the cost of the other options to obtain additional water for the City service area, if needed.

Figure 6

Present Value of Utility Costs versus Cumulative Water Saved

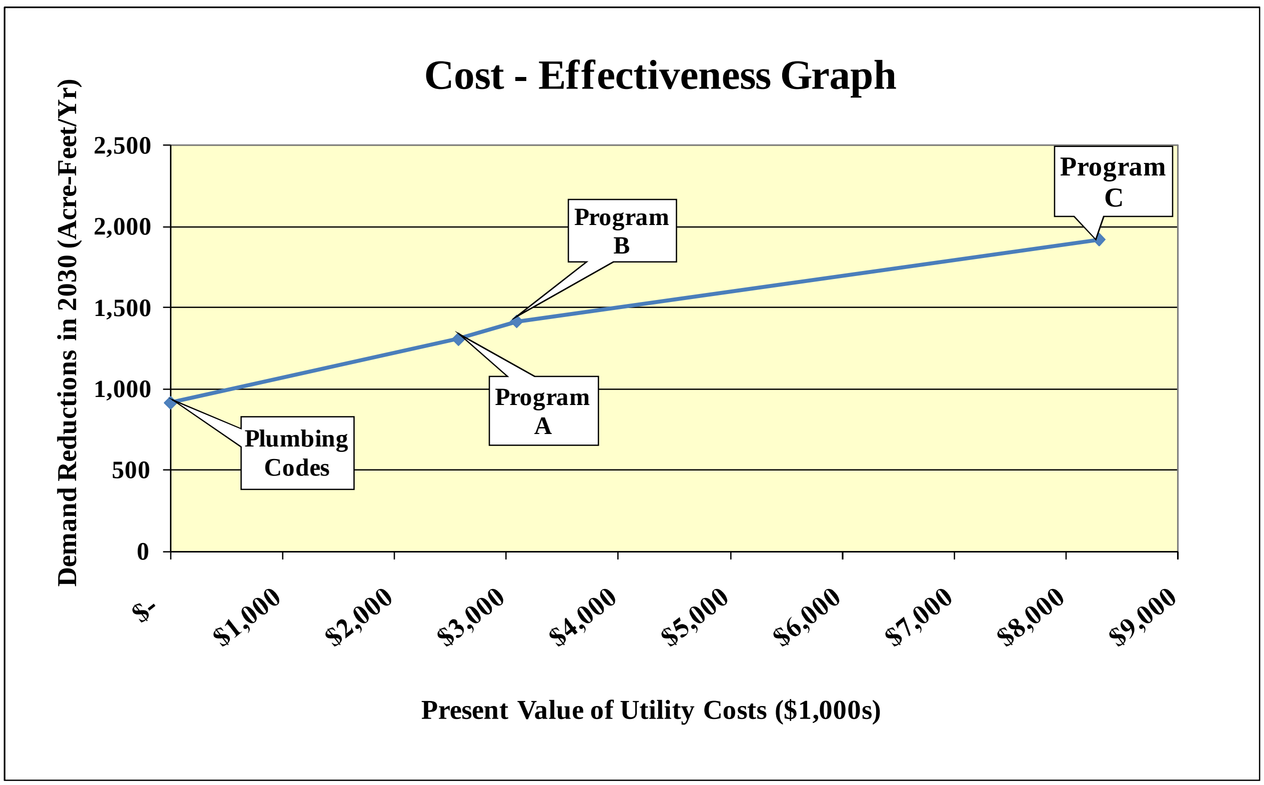


Table 7

Economic Summary of Long-Term Conservation Programs
(Excluding "Tool Kit" Measures)

Conservation Program	Demand Reduction by 2030 (AFY)	Demand Reduction by 2030 (%)	Total Conservation Program Water Savings in 2030 (AF)	Average Annual Program Cost to Utility ($)	Present Value of Utility Benefits ($)	Present Value of Utility Costs ($)	Utility Benefit - Cost Ratio	Community Benefit - Cost Ratio	Utility Cost of Water Saved ($/AF)
Plumbing Code Only	919	6.20%	11,085	NA	NA	NA	NA	NA	NA
Program A + Plumbing Code	1,308	8.80%	16,419	$194,000	$2,455,000	$2,570,000	0.96	0.96	$480
Program B + Plumbing Code	1,417	9.60%	17,801	$233,200	$3,131,000	$3,089,000	1.01	0.92	$460
Program C + Plumbing Code	1,919	13.00%	23,193	$629,400	$5,867,000	$8,287,000	0.71	0.53	$680

Notes:

1. The DSS model is a 30-year model. It was run for 2006 to 2036 to include the base year of 2006 and the 20-year conservation program period of 2011 to 2030.
2. Demand Reduction by 2030 is measured from the 14,825 AFY projected 2030 demand without the effects of the Plumbing Code.
3. Average Annual Program Cost excludes any potential cost associated with the 21 measures in the Tool Kit. Cost is calculated for the years 2011 to 2030.
4. Utility Cost of Water Saved somewhat undervalues the cost of savings because program costs are discounted to present value and the water benefit is not.

5. CONCLUSIONS

5.1 Relative Savings and Cost-Effectiveness of Programs

The City service area has a relatively high proportion of residential water use and a significant amount of outdoor water use. Consequently, residential conservation programs produce significant savings. However, due to lack of historical conservation program penetration in the commercial sector, there are attractive opportunities for savings here as well.. Despite the relatively low avoided cost of new water, water conservation programs are or close to being cost-effective. Overall conclusions are:

- Total savings from Program A + Plumbing Code (continuing the current program) would save approximately 8.8 percent of demand in 2030 (1,308 AF) as shown in Table 7.
- The theoretical maximum savings from the measures analyzed would be that of Program C + Plumbing Code or 1,919 AF in 2030. This equates to a 13.0 percent reduction in 2030 water demand, as shown on Table 7.
- The average utility cost of water saved (present value basis) for all programs ranges from a $460 to $680 per AF. Program A and B costs are less than the $600/AF avoided cost of water used in this analysis, as shown in Table 7.
- The average community cost of water saved ranges from $594 to $1,005 per AF.
- Program B appears to optimize the investment in water conservation, as costs and savings are at the point of diminishing marginal returns, as seen in Figure 6.

Appendix A - Assumptions for Water Conservation Measures Evaluated in the DSS Model

	1	2	3
Measure Name	**Promote Water Efficiency in Green Buildings**	**ND Require High Efficiency Toilets**	**ND Require High Efficiency Faucets and Showerheads**
Applicable Customer Classes	New SF, MF, CII	New SF, MF, CII	New SF, MF, CII
Applicable End Uses	Indoor	Toilet end use	Faucet and shower end use
Market Penetration by End Of Program (%)	10%	75%	75%
Annual Market Penetration (% of accounts)	0.5%	75% of new	75% of new
Water Use Reductions For Targeted End Uses	10%	20%	15%
Evaluation Start Year	2011	2011	2011
Evaluation End Year	2030	2014	2030
Program Length, years	19	3	19
Measure Life, years	Permanent	Permanent	Permanent
Utility Unit Cost for SF accounts, $/unit	$ 75	$ 10	$ 10
Utility Unit Cost for MF accounts, $/unit	$ 150	$ 10	$ 10
Utility Unit Cost for non-Res accounts, $/unit	$ 200	$ 15	$ 15
Customer Unit Cost. $/SF unit	$ 250	$ 75	$ 50
Customer Unit Cost. $/MF unit	$ 500	$ 75	$ 50
Customer Unit Cost. $/CII unit	$ 500	$ 75	$ 50
Annual Utility Admin & Marketing Cost	25%	15%	15%
Affected Units (used for Cost calculations)	Accounts	Toilets	Per Fixture
Measure Description	All staff time to work with local Green Building associations, City Building Division, developers, designers, vendors to promote incorporating water efficiency into building design. Co-sponsor award program.	Revise City's Building Code to require high efficiency toilets (HET). HETs are defined as any toilet to flush 1.28 gpf or less. HETs would be required if a customer needs to get a permit for a remodel or new development.	Revise City's Building Code to require lavatory faucets that flow at no more than 1.5 gpm and showerheads at no more than 2.0 gpm. Currently encourage WaterSense labels in stores. Plan to require this measure in the year July 2013 before the State Law requiring HETs and HEUs goes into effect in the year 2014. Would be required if a customer needs to get a permit for a remodel or new development.
Basis of Water Savings	50% as effective as Water Sense for New Homes	Calculated based on flush volume HET vs. ULFT (1.6gal per flush - 1.28 gallons per flush/1.6gallons per flush)	Based on reduced flow volume when in use; not at maximum flow and a pressure of (60-80 psi).
Basis of Utility Costs	Staff Cost to Promote-Follow-up; Check projection for adequacy.	Cost is for set up of code. Assume inspection done by building department permitting process.	Random staff inspection costs
Basis of Customer Costs	Incremental cost: $75 per toilet, $25 per shower, $25 per lavatory faucet (2 bathrooms totals $250)	Assumed incremental cost of HET vs. ULFT	Incremental costs per sink and shower.

SF = Single Family MF = Multi Family (greater than 2 units) CII= Commercial, Institutional, Industrial

	4	5	6
Measure Name	**Fixture Replacement SB 407**	**Financial Incentives for Irrigation and Landscape Upgrades (Current)**	**Financial Incentives for Irrigation and Landscape Upgrades**
Applicable Customer Classes	Pre-1994 Existing Accounts	SF, MF, CII, IRR	SF, MF, CII, IRR
Applicable End Uses	Toilet, urinal, shower, lavatory faucet	Irrigation	Irrigation
Market Penetration by End Of Program (%)	4% SF, 2% MF and CII	4.0%	4% SF and MF; 22% Other
Annual Market Penetration (% of accounts)	1% 2017-2020 SF, 1% 2019-2020 MF,1% CII 2019-2020	0.2%	0.2 SF, 1.1% Other
Water Use Reductions For Targeted End Uses	Varies	15%	15% all catergories, 30% for COM
Evaluation Start Year	2014	2011	2011
Evaluation End Year	2020	2030	2030
Program Length, years	7	19	19
Measure Life, years	Permanent	Permanent	Permanent
Utility Unit Cost for SF accounts, $/unit	$ 25	$ 560	$ 560
Utility Unit Cost for MF accounts, $/unit	$ 25	$ 840	$ 840
Utility Unit Cost for non-Res accounts, $/unit	$ 25	$ 1,000	$ 2,500
Customer Unit Cost. $/SF unit	Varies	$ 200	$ 200
Customer Unit Cost. $/MF unit	Varies	$ 2,500	$ 2,500
Customer Unit Cost. $/CII unit	Varies	$ 2,500	$ 2,500
Annual Utility Admin & Marketing Cost	25%	$150 per rebate, or 3 hours of staff time at $75 per hour	$150 per rebate, or 3 hours of staff time at $75 per hour
Affected Units (used for Cost calculations)	Dwelling unit or CII account	Accounts	Accounts
Measure Description	Measure will start in the year 2017 (SF) and 2019 (CII) to coincide with the California State Law SB 407. Work with the real estate industry to require a certificate of compliance be submitted to the City that the property and efficient fixtures where either already there or were installed at the time of sale, before close of escrow. Consider allowing this certification to be made as a part of the conventional private building inspection report process.	For SF, MF, CII, and IRR customers with landscape, provide a Smart Landscape Rebate Program with rebates towards the purchase and installation of selected types of irrigation equipment upgrade including smart controllers, water wise plants and mulch, rain sensors, turf removal, hardscape surfaces (material only) etc. Rebate is up to $1,000 for residential accounts and up to 50% more for commercial customers. Increase rebate for large non-residential customers as a percent of overall project.	Same program as Measure 5, but increased penetration due to increased rebate amounts for CII categories only. CII increased up to $5,000 maximum. Values shown of $2,500 for CII is the average value are based on current program data assuming that each participant does not use the maximum rebate value.
Basis of Water Savings	Calculated based on current flow volumes vs. required	Assumed based on average of technologies savings percentages. Average includes technolgies with significant upgrade in system (new sprinkler heads, new controller, etc.)	Assumed based on significant upgrade in system (new sprinkler heads, new controller, etc.)
Basis of Utility Costs	Random staff inspection costs	City cost experience for existing program	City cost experience with increase for CII accounts
Basis of Customer Costs	Use unit costs: HET $150; shower $25, lavatory faucet $25, urinal $400; self installed.	Assumed installation cost of equipment upgrade	Assumed installation cost of equipment upgrade

	7	8	9
Measure Name	**Washer Rebates**	**Washer Rebates for High Efficiency Machines**	**High Efficiency Toilet (HET) Rebates**
Applicable Customer Classes	SF, MF (in unit washers)	SF, MF (in-unit washers)	Existing Customers SF, MF
Applicable End Uses	Laundry	Laundry	Toilets
Market Penetration by End Of Program (%)	0.75% SF, 0.25% MF	14.25% SF, 4.75% MF	0.35%
Annual Market Penetration (% of accounts)	0.75% SF, 0.25% MF	0.75% SF, 0.25% MF	0.07%
Water Use Reductions For Targeted End Uses	35%	50%	63%
Evaluation Start Year	2011	2012	2011
Evaluation End Year	2011	2030	2015
Program Length, years	1	17	4
Measure Life, years	Permanent	Permanent	Permanent
Utility Unit Cost for SF accounts, $/unit	$ 75	$ 200	$ 100
Utility Unit Cost for MF accounts, $/unit	$ 75	$ 200	$ 100
Utility Unit Cost for non-Res accounts, $/unit	$ -	$ -	$ -
Customer Unit Cost. $/SF unit	$ 200	$ 250	$ 100
Customer Unit Cost. $/MF unit	$ 200	$ 250	$ 100
Customer Unit Cost. $/CII unit	$ -	$ -	$ -
Annual Utility Admin & Marketing Cost	$33 per rebate fee + $900/yr staff time	65%	$33 per rebate fee + $900/yr staff time
Affected Units (used for Cost calculations)	Clothes Washer	Clothes Washer	Toilet
Measure Description	Homeowners would be eligible to receive a $150 rebate on a new high efficiency clothes washer. It is assumed that the rebates would remain consistent with relevant state and federal regulations (Department of Energy, Energy Star) and only offer the best available technology. Discontinue program in 1 year or after CUWCC programs are no longer available. City plans to possibly run high efficiency program after the CUWCC Program ends. Concern over too many free riders for this program. Administration percentage is based on $33 per rebate issued paid to the CUWCC as they run the program. CUWCC grant program funds 50% of rebate.	Same as above, except that a higher rebate is offered for higher efficiency machines. Assume 2% of accounts take rebates per year. Less of a free rider concern with the higher efficiency machines.	Provide a $100 rebate or voucher for the installation of a high efficiency toilet (HET). HET's are defined as any toilet flushing at 1.28 gpf or less and include dual flush technology. Rebate amounts would reflect the incremental purchase cost. Program will be shorter lived as it is intended to be a market transformation measure and eventually would be stopped as 1.28 gpf units reach saturation. City would continue program for 4 years even after CUWCC programs is no longer available. Low annual market penetration of 0.07% is due to possible high level of saturation of 1.6 gpf toilets. The new California Law will require HETs starting in the year 2014. The program is assumed to run until the year 2015 such that it gives the customers 1 year to adapt to the new law and HET requirement.
Basis of Water Savings	CUWCC Cost and Savings Study, 2005, pg 2-14.	CUWCC Cost and Savings Study, 2005, pg 2-14 + allowance for more efficient machines (40% lower water factor)	Calculated based on current flush volumes vs. HET (3.5 gallons per flush-1.28 gallons per flush/3.5 gallons per flush)
Basis of Utility Costs	Rebate cost	Rebate cost	Rebate cost
Basis of Customer Costs	Assumed incremental cost of HEW	Assumed incremental cost of higher efficiency HEW	Use unit costs: HET $150 + $50 installation minus rebate = $100.

	10	11	12
Measure Name	**Single Family Water Check Up**	**Multifamily Water Check Up**	**Existing Commercial Washer Rebate**
Applicable Customer Classes	SF	MF	CII
Applicable End Uses	Internal and External	Internal and External	Laundry
Market Penetration by End Of Program (%)	7%	10%	20%
Annual Market Penetration (% of accounts)	1%	1.5%	0.5%
Water Use Reductions For Targeted End Uses	5% indoor, 10% outdoor	5% indoor, 10% outdoor	35%
Evaluation Start Year	2011	2011	2011
Evaluation End Year	2030	2030	2011
Program Length, years	19	19	1
Measure Life, years	7	7	Permanent
Utility Unit Cost for SF accounts, $/unit	$ 150	$ -	$ -
Utility Unit Cost for MF accounts, $/unit	$ -	$ 150	$ -
Utility Unit Cost for non-Res accounts, $/unit	$ -	$ -	$ 200
Customer Unit Cost. $/SF unit	$ 30	$ -	$ -
Customer Unit Cost. $/MF unit	$ -	$ 100	$ -
Customer Unit Cost. $/CII unit	$ -	$ -	$ 200
Annual Utility Admin & Marketing Cost	0%	25%	25%
Affected Units (used for Cost calculations)	Accounts	Accounts	Clothes Washer
Measure Description	Conventional indoor and outdoor water surveys for existing single-family residential customers. Normally those with high water use are targeted and provided a customized report to the homeowner on how to save water in their home. Currently ~450 per year completed.	Indoor and outdoor water surveys for existing multifamily residential customers. Target those with high water use are targeted and provided a customized report to owner. Average cost is $150 per MF account. There is an average of 4 dwelling units per MF account, so cost for an average MF account is $150 for all 4 dwelling units.	Provide a $400rebate to apartment complexes and commercial laundry facilties (5 or more units) for efficient washing machines in buildings over a certain size that has a common laundry room. It is assumed that the rebates would remain consistent with relevant state and federal regulations (Department of Energy, Energy Star) and only offer the best available technology. Plan to phase out this program as it has been running for 4 years and there is concern over high saturation levels. CUWCC grant program funds 50% of rebate.
Basis of Water Savings	CUWCC Cost and Savings Study, 2005, pg 2-47,48 + reduction due to less indoor fixture savings opportunity since water savings evaluated in 1994.	CUWCC Cost and Savings Study, 2005, pg 2-47,48 + reduction due to less indoor fixture savings opportunity since water savings evaluated in 1994.	CUWCC Cost and Savings Study, 2005, pg 2-14.
Basis of Utility Costs	Use current SB Costs (1 hour survey + .5 hr travel time + set-up, .5 hr admin & follow-up)	Use current SB Costs (1 hour survey at $50 per hour for an average of 4 units + $75 for travel time and set-up, follow-up for an average of 4 MF dwelling units)	Rebate cost
Basis of Customer Costs	Assumed average cost of recommended equipment not covered by other conservation programs.	Assumed installation cost of recommended equipment.	Assumed incremental cost of HEW

	13	14
Measure Name	**Cisterns/Rain Catchments**	**Gray water Retrofit SF**
Applicable Customer Classes	SF, MF	SF
Applicable End Uses	Irrigation	Irrigation
Market Penetration by End Of Program (%)	5%	5%
Annual Market Penetration (% of accounts)	0.5%	0.25%
Water Use Reductions For Targeted End Uses	4.4%	40%
Evaluation Start Year	2011	2011
Evaluation End Year	2030	2030
Program Length, years	19	19
Measure Life, years	Permanent	Permanent
Utility Unit Cost for SF accounts, $/unit	$ 100	$ 200
Utility Unit Cost for MF accounts, $/unit	$ 200	$ -
Utility Unit Cost for non-Res accounts, $/unit	$ -	$ -
Customer Unit Cost. $/SF unit	$ 500	$ 200
Customer Unit Cost. $/MF unit	$ 750	$ -
Customer Unit Cost. $/CII unit	$ -	$ -
Annual Utility Admin & Marketing Cost	25%	30%
Affected Units (used for Cost calculations)	Accounts	Accounts
Measure Description	Provide a rebate ($100) to assist a certain percentage of single family homeowners per year with installation of rain barrels or cisterns.	Provide a rebate (up to $200) to assist a certain percentage of single family homeowners per year to install gray water systems. Parts cost approx $200, installation would not be included.
Basis of Water Savings	SB County Estiamte of savings are 720 gal/account/year or ~2 gpd/account. This level of saving is 2.2% of irrigation use of a typical home. Then we assume added behavioral change by homeowner doubles the savings to 4.4%	Assume reduces summer irrigation 25% and spring/fall irrigation 60%; overall annual 40% reduction.
Basis of Utility Costs	Rebate cost	Cost of rebate for storage, filters, pump.
Basis of Customer Costs	Assumed added purchase and installation cost of needed equipment.	Installation cost

	15	16	17
Measure Name	**Current High Efficiency Urinal Rebate (<0.25 gallon)**	**ND Require 0.5 gal/flush or less urinals in new buildings**	**School Building Retrofit**
Applicable Customer Classes	Existing CII	New CII	CII
Applicable End Uses	Urinals	Urinals	Indoor and Outdoor use
Market Penetration by End Of Program (%)	20%	75% of New	Plan to do an average of 3 schools per year (3 schools per year based on data from City)
Annual Market Penetration (% of accounts)	2%	varies	varies
Water Use Reductions For Targeted End Uses	88%	75%	15%
Evaluation Start Year	2011	2011	2011
Evaluation End Year	2011	2014	2030
Program Length, years	1	4	19
Measure Life, years	Permanent	Permanent	Permanent
Utility Unit Cost for SF accounts, $/unit	$ -	$ 10	$ -
Utility Unit Cost for MF accounts, $/unit	$ -	$ -	$ -
Utility Unit Cost for non-Res accounts, $/unit	$ 150	$ 10	$ 3,000
Customer Unit Cost. $/SF unit	$ -	$ -	$ -
Customer Unit Cost. $/MF unit	$ -	$ -	$ -
Customer Unit Cost. $/CII unit	$ 400	$ 400	$ 3,000
Annual Utility Admin & Marketing Cost	$33 per rebate fee + $900/yr staff time	15%	30%
Affected Units (used for Cost calculations)	Urinal	Urinal	Accounts
Measure Description	Provide a rebate of $300 for high efficiency and waterless urinals to existing high use CII customers (such as restaurants). Discontinue program in 1 year or after CUWCC programs are no longer available. City plans to possibly run high efficiency program after the CUWCC Program ends.	Revise City's Building Code to require that new buildings are fitted with 0.5 gpf or less (or one liter) urinals rather than the current standard of 1.0-gal/flush models. This measure includes waterless urinals, or 1 pint (0.125 gpf) urinals.	Run a program patterned after MWD of Southern California's school retrofit program wherein school receives a grant to replace fixtures and upgrade irrigation systems. City would like to formalize the process. The Schools lack funding $, so possibly set this up as a Pay for Performance Program. The $3,000 cost assumes an average of 6 HETs installed at $300 each (parts and labor) and one $1,200 irrigation controller installed per school.
Basis of Water Savings	Calculated based on current flush volumes vs. HEU (2 gal-0.25 gal/ 2 gal)	Calculated based on current flush volumes vs. HEU (1 gal-0.25 gal/ 1 gal)	5% of total use due to replacing high use toilets + 10% of total use for irrigation system upgrade.
Basis of Utility Costs	Rebate cost	Rebate cost	Rebate cover 6 HETs for staff restrooms (6 @ $300 installed) + new irrigation controller ($800 + $400 installation cost)
Basis of Customer Costs	Use unit costs: HEU $400 + $100 installation minus rebate = $400.	Use unit costs: HEU $400 + $100 installation minus rebate = $400.	Assumed incremental cost of 6 additional HETs for staff restrooms (6 @ $300) + other irrigation upgrades (sprinklers, drip systems, etc.)

	18	19	20
Measure Name	**Irrigation (Landscape) Water Budgets**	**Irrigation Water Surveys**	**Mulch Program**
Applicable Customer Classes	IRR	CII	SF, MF, CII
Applicable End Uses	Irrigation	Irrigation	Irrigation
Market Penetration by End Of Program (%)	90%	19%	19%
Annual Market Penetration (% of accounts)	10%	1%	1%
Water Use Reductions For Targeted End Uses	10%	15%	10%
Evaluation Start Year	2011	2011	2011
Evaluation End Year	2030	2030	2030
Program Length, years	19	19	19
Measure Life, years	5	5	2
Utility Unit Cost for SF accounts, $/unit	$ -	$ -	$ 40
Utility Unit Cost for MF accounts, $/unit	$ -	$ -	$ 75
Utility Unit Cost for non-Res accounts, $/unit	$ 500	$ 1,500	$ 75
Customer Unit Cost. $/SF unit	$ -	$ -	$ 100
Customer Unit Cost. $/MF unit	$ -	$ -	$ 200
Customer Unit Cost. $/CII unit	$ -	$ 1,000	$ 300
Annual Utility Admin & Marketing Cost	15%	30%	30%
Affected Units (used for Cost calculations)	Large Landscape Accounts	Large Landscape Accounts	Accounts
Measure Description	Irrigators of landscapes with separate irrigation account (meter) can utilize the California Landscape Budgets Program (CLBP): provides monthly water use reports via www.landscapebudget.com for the properties served by dedicated irrigation meters and compares the usage to a weather-based water allocation calculation. Assume 10% of large accounts receive utilize website tool per year. The current cost is approximately $16,000 per year.	All public and private irrigators of landscapes would be eligible for free landscape water surveys upon request. Normally those with high water use would be targeted and provided a customized report. Assume 10 percent of large turf areas are surveyed per year. Increase cost is for more outreach and marketing efforts to increase participation.	Free mulch program. City will subsidize delivery charges which are currently $25 or $40 dollars for free mulch currently offered by the County and other sources, so it is completely free to customers. Goal would be to keep irrigation and storm water on site and reduce runoff and keep water from evaporating. The benefit water savings would be to keep the soil moist for 2 to 3 weeks per year in the spring and fall and increase water conservation throughout the year.
Basis of Water Savings	CUWCC Cost and Savings Study, 2005, pg 2-102-105 + Tampa Bay Water pilot project for SWFWMD (2000).	CUWCC Cost and Savings Study, 2005, pg 2-102-105.	Assume savings of 20 days of irrigation in spring and fall out of an irrigation season of 200 days or 10% savings.
Basis of Utility Costs	Total cost was $32K, half for $16K for consultant + Staff budget preparation cost and follow-up every five years.	Assume 3 acres at $500/acre cost; repeated every five years (CUWCC Cost and Savings Study, 2005, pg 2-102-105).	Free delivery cost (one load).
Basis of Customer Costs	Assume simple adjustments to irrigation schedules made by landscape contractor at no extra cost.	Assume adjustments to irrigation system to improve uniformity + scheduling at $1,000/site.	Installation costs by homeowner or contractor.

	21	22	23
Measure Name	**CII Water Check Up Level 1**	**CII Water Check Up Level 2**	**Customized CII Incentive Program**
Applicable Customer Classes	CII	CII	CII
Applicable End Uses	All	All	Process water use
Market Penetration by End Of Program (%)	30.0%	2.0%	14%
Annual Market Penetration (% of accounts)	1.5%	0.1%	0.75%
Water Use Reductions For Targeted End Uses	10%	10%	20%
Evaluation Start Year	2011	2011	2011
Evaluation End Year	2030	2030	2030
Program Length, years	19	19	19
Measure Life, years	Permanent	Permanent	Permanent
Utility Unit Cost for SF accounts, $/unit	$ -	$ -	$ -
Utility Unit Cost for MF accounts, $/unit	$ -	$ -	$ -
Utility Unit Cost for non-Res accounts, $/unit	$ 300	$ 5,000	$ 5,000
Customer Unit Cost. $/SF unit	$ -	$ -	$ -
Customer Unit Cost. $/MF unit	$ -	$ -	$ -
Customer Unit Cost. $/CII unit	$ 300	$ 5,000	$ 5,000
Annual Utility Admin & Marketing Cost	15%	15%	30%
Affected Units (used for Cost calculations)	Accounts	Accounts	Accounts
Measure Description	All CII customers would be offered a free water survey/evaluation, i.e. "water checkup" that would evaluate ways for the business to save water and money. The Level 1 CII surveys (accounts that use less than 5,000 gallons of water per day) would be for the simpler CII such as hotels, restaurants, and small schools.	The top 100 CII customers would be offered a free water survey/evaluation, i.e. "water checkup" that would evaluate ways for the business to save water and money. The Level 2 CII surveys (accounts that use more than 5,000 gallons of water per day) would be for the simpler CII such as hotels, restaurants, and small schools. The Level 2 audits would be performed by a trained technical professional. Marketing would be focused to target the high water using accounts (complex sites with higher than 10,000 gallons of water use per day). This may include sights such as hospital, zoo, and commercial laundries. These Level 2 sites would most likely be done by a contractor and would include a high level of follow up communication and assistance to encourage use of rebates. Program would work with the business individually to build relationships. Goal would be to encourage business to continue to take actions even after the survey to improve site water use efficiency. Example of a Level 2 survey can be the zoo or ice cream factory. Publish success stories on City website and in papers. For hotel laundries can recommend things such as adjusting the programming on laundry machines.	Provides financial incentives for CII accounts that have participated in the City's free Water Use "Check Up" Program. After the free water use assessment has been completed at site, the City will analyze the recommendations on the findings report that is provided and determine if site qualifies for a financial incentive. Financial incentives will be provided after analyzing the cost benefit ratio of each proposed project. Incentives are tailored to each individual site as each site has varying water savings potentials. Incentives will be granted at the sole discretion of the City while funding lasts. The program is intended to provide financial incentives for unique or site specific items (for example localized recycling systems for commercial laundries). Assume half of sites that participate in a water check up will request financial assistance.
Basis of Water Savings	Assume 30% potential and 35% compliance, CUWCC Cost and Savings Study, 2005, pg 2-66-68.	Assume 30% potential and 35% compliance, CUWCC Cost and Savings Study, 2005, pg 2-66-68.	Assume participants who take rebate use it to achieve savings identified in surveys or by CII site manager.
Basis of Utility Costs	Average Level I survey ($300)	Average Level II survey ($3,000)	Rebate cost.
Basis of Customer Costs	Assumed customer implementation costs.	Assumed customer implementation costs.	Added installation cost for substantial equipment such as ice machine, steamer, toilets, etc.

Appendix 2B

STORAGE CAPACITY ANALYSIS

Table 1 2019 System Storage Analysis (2019 Projected Use)

Pressure Zone	Existing Gravity Storage and Transfer Facilities without Gravity Stroage	HGL (ft)	Existing Storage Capacity (MG)	Existing ADD[1] (mgd)	Existing MDD[2] (mgd)	Operational Storage[3] (MG)	Emergency Storage[4] (MG)	Maximum Fireflow Required In Zone (gpm)	Fireflow Duration (hours)	Fire Storage[5] (MG)	Total Storage Required (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer Description (with Gravity Storage)/*Recommended Storage*	Zone Transfer (MG)	Proposed Storage Capacity (MG)	Surplus with Recommendations and Transfers (MG)
Skofield Grouped Zone																
Skofield	Skofield Reservoir	1,396	0.47	0.01	0.02	0.01	0.011	750	2				Storage for El Cielito Tunnel via Bypass[6]	0.00		
Skofield El Cielito	Skofield PRV			0.00	0.01	0.00	0.004	750	2							
Skofield Grouped Zone Subtotal		***n/a***	***0.47***	***0.02***	***0.03***	***0.01***	***0.02***	***750***	***2***	***0.09***	***0.11***	***0.36***		***0.00***	***0.00***	***0.36***
El Cielito Tunnel Grouped Zone																
El Cielito Tunnel	El Cielito Reservoir	1,058	0.98	0.45	0.81	0.20	0.45	1,250	4				Storage from Skofield via Bypass[6]	0.00		
	Tunnel Reservoir	1,058	0.76										Storage for Sheffield via PRV[7]	0.00		
Upper Tunnel Rd	Tunnel Rd PS			0.03	0.05	0.01	0.03	750	2							
Mission Canyon Heights	Tunnel Rd & Montrose PRV Palomino PRV			0.11	0.20	0.05	0.11	750	2							
Conejo	Conejo Rd PRV			0.01	0.02	0.01	0.01	750	2							
Mission Ranchos	Las Canoas PRV			0.01	0.03	0.01	0.01	750	2							
Northridge	Northridge PRV			0.04	0.08	0.02	0.04	750	2							
El Cielito Tunnel Grouped Zone Subtotal		***n/a***	***1.74***	***0.66***	***1.19***	***0.30***	***0.66***	***1,250***	***4***	***0.30***	***1.25***	***0.49***		***0.00***	***0.00***	***0.49***
Hope Grouped Zone																
Hope	Hope Reservoir	613	0.72	0.06	0.10	0.03	0.06	750	2							
Campanil Hills	Campanil Hills PS			0.03	0.06	0.02	0.03	750	2							
Hope Grouped Zone Subtotal		***n/a***	***0.72***	***0.09***	***0.16***	***0.04***	***0.09***	***750***	***2***	***0.09***	***0.22***	***0.50***		***0.00***	***0.00***	***0.50***
Sheffield Grouped Zone																
Sheffield	McLaughlin Reservoir	661	5.34	0.84	1.51	0.38	0.84	2,500	4				Storage from El Cielito Tunnel via PRV[7]	0.00		
	Hoover Reservoir	661	5.34										Storage for Lauro via PRV[8]	0.00		
													Storage for Low Level via PRV[9]	0.00		
Sheffield Grouped Zone Subtotal		***n/a***	***10.68***	***0.84***	***1.51***	***0.38***	***0.84***	***2,500***	***4***	***0.60***	***1.81***	***8.87***		***0.00***	***0.00***	***8.87***
Bothin Zone																
Bothin	East Reservoir	586	0.58	0.13	0.24	0.06	0.13	750	2							
Bothin Zone Subtotal		***n/a***	***0.58***	***0.13***	***0.24***	***0.06***	***0.13***	***750***	***2***	***0.09***	***0.28***	***0.30***		***0.00***	***0.00***	***0.30***
Lauro Grouped Zone																
Lauro	Cater Clearwell	492	1.70	1.26	2.27	0.57	1.26	2,500	4				Storage from Sheffield via PRV[8]	0.00		
	Vic Trace Reservoir	492	10.01										Storage for Low Level via PRV[10]	-3.57		
													Storage for La Vista via PRV[11]	0.00		
Escondido La Coronilla	La Coronillla PS Escondido PS			0.19	0.34	0.08	0.19	1,250	4							
Lauro Grouped Zone Subtotal		***n/a***	***11.71***	***1.44***	***2.61***	***0.65***	***1.44***	***2,500***	***4***	***0.60***	***2.69***	***9.01***		***-3.57***	***0.00***	***5.44***
La Vista Zone																
La Vista	La Vista Reservoir	440	2.25	1.07	1.94	0.49	1.07	1,250	4				Storage from Lauro via PRV[11]	0.00		
													Storage for Low Level via PRV[12]	0.00		
La Vista Zone Subtotal		***n/a***	***2.25***	***1.07***	***1.94***	***0.49***	***1.07***	***1,250***	***4***	***0.30***	***1.86***	***0.39***		***0.00***	***0.00***	***0.39***
Low Level Zone																
Low Level	Reservoir #1	356	0.75	4.69	8.48	2.12	4.69	2,500	4				Storage from Sheffield via PRV[9]	0.00		
	Reservoir #2	356	1.58										Storage from Lauro via PRV[10]	3.57		
	La Mesa Reservoir	356	1.50										Storage from La Vista via PRV[12]	0.00		
Low Zone Subtotal		***n/a***	***3.84***	***4.69***	***8.48***	***2.12***	***4.69***	***2,500***	***4***	***0.60***	***7.41***	***-3.57***		***3.57***	***0.00***	***0.00***
Total		n/a	32.0	8.93	16.16	4.04	8.93	n/a	n/a	2.67	15.64	16.35	n/a	0.00	0.00	16.35

Notes:
(1) The estimated 2019 Average Day Demand is 10,002 AFY per the City's demand projection estimates.
(2) MDD Peaking factor is assumed to be 1.8.
(3) Operational Storage is calculated as 25% of MDD.
(4) Emergency Storage is calculated as 100% ADD .
(5) Fire Flow Storage is calculated as largest required fire flow times the duration of required fire flow.
(6) Zone Transfer Facility: Bypass valve at Skofield PS
(7) Zone Transfer Facilities: Las Alturas PRV, Ontare Rd PRV, and San Roque PRV
(8) Zone Transfer Facility: Foothill PRV
(9) Zone Transfer Facilies: Sycamore Canyon PRV, and Reservoir #1 valve
(10) Zone Transfer Facilities: Garden Street PRV, Robbins & Pedregosa PRV, La Vista Del Oceano PRV
(11) Zone Transfer Facility: State St PRV
(12) Zone Transfer Facility: Calle De Los Amigos PRV

Table 2 2050 System Storage Analysis (2050 Projected Use)

Pressure Zone	Existing Gravity Storage and Transfer Facilities without Gravity Stroage	HGL (ft)	Existing Storage Capacity (MG)	Future ADD[1] (mgd)	Future MDD[2] (mgd)	Operational Storage[3] (MG)	Emergency Storage[4] (MG)	Maximum Fireflow Required In Zone (gpm)	Fireflow Duration (hours)	Fire Storage[5] (MG)	Total Storage Required (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer Description (with Gravity Storage)/*Recommended Storage*	Zone Transfer (MG)	Proposed Storage Capacity (MG)	Surplus with Recommendations and Transfers (MG)
Skofield Grouped Zone																
Skofield	Skofield Reservoir	1,396	0.47	0.01	0.03	0.01	0.01	750	2				Storage for El Cielito Tunnel via Bypass[6]	0.00		
Skofield El Cielito				0.01	0.01	0.00	0.01	750	2							
Skofield Grouped Zone Subtotal		***n/a***	***0.47***	***0.02***	***0.04***	***0.01***	***0.02***	***750***	***2***	***0.09***	***0.12***	***0.35***		***0.00***	***0.00***	***0.35***
El Cielito Tunnel Grouped Zone																
El Cielito Tunnel	El Cielito Reservoir	1,058	0.98	0.58	1.05	0.26	0.58	1,250	4				Storage from Skofield via Bypass[6]	0.00		
	Tunnel Reservoir	1,058	0.76										Storage for Sheffield via PRV[7]	0.00		
Upper Tunnel Rd	Tunnel Rd PS			0.04	0.06	0.02	0.04	750	2							
Mission Canyon Heights	Tunnel Rd & Montrose PRV Palomino PRV			0.15	0.27	0.07	0.15	750	2							
Conejo	Conejo Rd PRV			0.02	0.03	0.01	0.02	750	2							
Mission Ranchos	Las Canoas PRV			0.02	0.03	0.01	0.02	750	2							
Northridge	Northridge PRV			0.05	0.10	0.02	0.05	750	2							
El Cielito Tunnel Grouped Zone Subtotal		***n/a***	***1.74***	***0.85***	***1.54***	***0.39***	***0.85***	***1,250***	***4***	***0.30***	***1.54***	***0.20***		***0.00***	***0.00***	***0.20***
Hope Grouped Zone																
Hope	Hope Reservoir	613	0.72	0.07	0.14	0.03	0.07	750	2							
Campanil Hills	Campanil Hills PS			0.04	0.08	0.02	0.04	750	2							
Hope Grouped Zone Subtotal		***n/a***	***0.72***	***0.12***	***0.21***	***0.05***	***0.12***	***750***	***2***	***0.09***	***0.26***	***0.46***		***0.00***	***0.00***	***0.46***
Sheffield Grouped Zone																
Sheffield	McLaughlin Reservoir	661	5.34	1.09	1.97	0.49	1.09	2,500	4				Storage from El Cielito Tunnel via PRV[7]	0.00		
	Hoover Reservoir	661	5.34										Storage for Lauro via PRV[8]	0.00		
													Storage for Low Level via PRV[9]	0.00		
Sheffield Grouped Zone Subtotal		***n/a***	***10.68***	***1.09***	***1.97***	***0.49***	***1.09***	***2,500***	***4***	***0.60***	***2.18***	***8.50***		***0.00***	***0.00***	***8.50***
Bothin Zone																
Bothin	East Reservoir	586	0.58	0.17	0.31	0.08	0.17	750	2							
Bothin Zone Subtotal		***n/a***	***0.58***	***0.17***	***0.31***	***0.08***	***0.17***	***750***	***2***	***0.09***	***0.34***	***0.24***		***0.00***	***0.00***	***0.24***
Lauro Grouped Zone																
Lauro	Cater Clearwell	492	1.70	1.63	2.96	0.74	1.63	2,500	4				Storage from Sheffield via PRV[8]	0.00		
	Vic Trace Reservoir	492	10.01										Storage for Low Level via PRV[10]	-5.62		
													Storage for La Vista via PRV[11]	-0.08		
Escondido La Coronilla	La Coronillla PS Escondido PS			0.24	0.44	0.11	0.24	1,250	4							
Lauro Grouped Zone Subtotal		***n/a***	***11.71***	***1.88***	***3.39***	***0.85***	***1.88***	***2,500***	***4***	***0.60***	***3.32***	***8.38***		***-5.70***	***0.00***	***2.68***
La Vista Zone																
La Vista	La Vista Reservoir	440	2.25	1.40	2.53	0.63	1.40	1,250	4				Storage from Lauro via PRV[11]	0.08		
													Storage for Low Level via PRV[12]	0.00		
La Vista Zone Subtotal		***n/a***	***2.25***	***1.40***	***2.53***	***0.63***	***1.40***	***1,250***	***4***	***0.30***	***2.33***	***-0.08***		***0.08***	***0.00***	***0.00***
Low Level Zone																
Low Level	Reservoir #1	356	0.75	6.10	11.04	2.76	6.10	2,500	4				Storage from Sheffield via PRV[9]	0.00		
	Reservoir #2	356	1.58										Storage from Lauro via PRV[10]	5.62		
	La Mesa Reservoir	356	1.50										Storage from La Vista via PRV[12]	0.00		
Low Zone Subtotal		***n/a***	***3.84***	***6.10***	***11.04***	***2.76***	***6.10***	***2,500***	***4***	***0.60***	***9.46***	***-5.62***		***5.62***	***0.00***	***0.00***
Total		n/a	32.0	11.62	21.03	5.26	11.62	n/a	n/a	2.67	19.54	12.45	n/a	0.00	0.00	12.45

Notes:

(1) The estimated 2050 Average Day Demand is 13,013 AFY per the City's demand projection estimates.
(2) MDD Peaking factor is assumed to be 1.8.
(3) Operational Storage is calculated as 25% of MDD.
(4) Emergency Storage is calculated as 100% ADD .
(5) Fire Flow Storage is calculated as largest required fire flow times the duration of required fire flow.
(6) Zone Transfer Facility: Bypass valve at Skofield PS
(7) Zone Transfer Facilities: Las Alturas PRV, Ontare Rd PRV, and San Roque PRV
(8) Zone Transfer Facility: Foothill PRV
(9) Zone Transfer Facilies: Sycamore Canyon PRV, and Reservoir #1 valve
(10) Zone Transfer Facilities: Garden Street PRV, Robbins & Pedregosa PRV, La Vista Del Oceano PRV
(11) Zone Transfer Facility: State St PRV
(12) Zone Transfer Facility: Calle De Los Amigos PRV

Table 3 2050 System Storage Analysis, Res. 1 O.O.S. (2050 Projected Use)

Pressure Zone	Existing Gravity Storage and Transfer Facilities without Gravity Stroage	HGL (ft)	Existing Storage Capacity (MG)	Future ADD(1) (mgd)	Future MDD(2) (mgd)	Operational Storage(3) (MG)	Emergency Storage(4) (MG)	Maximum Fireflow Required In Zone (gpm)	Fireflow Duration (hours)	Fire Storage(5) (MG)	Total Storage Required (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer Description (with Gravity Storage)/*Recommended Storage*	Zone Transfer (MG)	Proposed Storage Capacity (MG)	Surplus with Recommendations and Transfers (MG)
Skofield Grouped Zone																
Skofield	Skofield Reservoir	1,396	0.47	0.01	0.03	0.01	0.01	750	2				Storage for El Cielito Tunnel via Bypass(6)	0.00		
Skofield El Cielito				0.01	0.01	0.00	0.01	750	2							
Skofield Grouped Zone Subtotal		*n/a*	*0.47*	*0.02*	*0.04*	*0.01*	*0.02*	*750*	*2*	*0.09*	*0.12*	*0.35*		*0.00*	*0.00*	*0.35*
El Cielito Tunnel Grouped Zone																
El Cielito Tunnel	El Cielito Reservoir	1,058	0.98	0.58	1.05	0.26	0.58	1,250	4				Storage from Skofield via Bypass(6)	0.00		
	Tunnel Reservoir	1,058	0.76										Storage for Sheffield via PRV(7)	0.00		
Upper Tunnel Rd	Tunnel Rd PS			0.04	0.06	0.02	0.04	750	2							
Mission Canyon Heights	Tunnel Rd & Montrose PRV Palomino PRV			0.15	0.27	0.07	0.15	750	2							
Conejo	Conejo Rd PRV			0.02	0.03	0.01	0.02	750	2							
Mission Ranchos	Las Canoas PRV			0.02	0.03	0.01	0.02	750	2							
Northridge	Northridge PRV			0.05	0.10	0.02	0.05	750	2							
El Cielito Tunnel Grouped Zone Subtotal		*n/a*	*1.74*	*0.85*	*1.54*	*0.39*	*0.85*	*1,250*	*4*	*0.30*	*1.54*	*0.20*		*0.00*	*0.00*	*0.20*
Hope Grouped Zone																
Hope	Hope Reservoir	613	0.72	0.07	0.14	0.03	0.07	750	2							
Campanil Hills	Campanil Hills PS			0.04	0.08	0.02	0.04	750	2							
Hope Grouped Zone Subtotal		*n/a*	*0.72*	*0.12*	*0.21*	*0.05*	*0.12*	*750*	*2*	*0.09*	*0.26*	*0.46*		*0.00*	*0.00*	*0.46*
Sheffield Grouped Zone																
Sheffield	McLaughlin Reservoir	661	5.34	1.09	1.97	0.49	1.09	2,500	4				Storage from El Cielito Tunnel via PRV(7)	0.00		
	Hoover Reservoir	661	5.34										Storage for Lauro via PRV(8)	0.00		
													Storage for Low Level via PRV(9)	0.00		
Sheffield Grouped Zone Subtotal		*n/a*	*10.68*	*1.09*	*1.97*	*0.49*	*1.09*	*2,500*	*4*	*0.60*	*2.18*	*8.50*		*0.00*	*0.00*	*8.50*
Bothin Zone																
Bothin	East Reservoir	586	0.58	0.17	0.31	0.08	0.17	750	2							
Bothin Zone Subtotal		*n/a*	*0.58*	*0.17*	*0.31*	*0.08*	*0.17*	*750*	*2*	*0.09*	*0.34*	*0.24*		*0.00*	*0.00*	*0.24*
Lauro Grouped Zone																
Lauro	Cater Clearwell	492	1.70	1.63	2.96	0.74	1.63	2,500	4				Storage from Sheffield via PRV(8)	0.00		
	Vic Trace Reservoir	492	10.01										Storage for Low Level via PRV(10)	-6.37		
													Storage for La Vista via PRV(11)	-0.08		
Escondido La Coronilla	La Coronillla PS Escondido PS			0.24	0.44	0.11	0.24	1,250	4							
Lauro Grouped Zone Subtotal		*n/a*	*11.71*	*1.88*	*3.39*	*0.85*	*1.88*	*2,500*	*4*	*0.60*	*3.32*	*8.38*		*-6.45*	*0.00*	*1.93*
La Vista Zone																
La Vista	La Vista Reservoir	440	2.25	1.40	2.53	0.63	1.40	1,250	4				Storage from Lauro via PRV(11)	0.08		
													Storage for Low Level via PRV(12)	0.00		
La Vista Zone Subtotal		*n/a*	*2.25*	*1.40*	*2.53*	*0.63*	*1.40*	*1,250*	*4*	*0.30*	*2.33*	*-0.08*		*0.08*	*0.00*	*0.00*
Low Level Zone																
Low Level	Reservoir #1 OOS	0	0.00	6.10	11.04	2.76	6.10	2,500	4				Storage from Sheffield via PRV(9)	0.00		
	Reservoir #2	356	1.58										Storage from Lauro via PRV(10)	6.37		
	La Mesa Reservoir	356	1.50										Storage from La Vista via PRV(12)	0.00		
Low Zone Subtotal		*n/a*	*3.08*	*6.10*	*11.04*	*2.76*	*6.10*	*2,500*	*4*	*0.60*	*9.46*	*-6.37*		*6.37*	*0.00*	*0.00*
Total		n/a	31.2	11.62	21.03	5.26	11.62	n/a	n/a	2.67	19.54	11.69	n/a	0.00	0.00	11.69

Notes:
(1) The estimated 2050 Average Day Demand is 13,013 AFY per the City's demand projection estimates.
(2) MDD Peaking factor is assumed to be 1.8.
(3) Operational Storage is calculated as 25% of MDD.
(4) Emergency Storage is calculated as 100% ADD .
(5) Fire Flow Storage is calculated as largest required fire flow times the duration of required fire flow.
(6) Zone Transfer Facility: Bypass valve at Skofield PS
(7) Zone Transfer Facilities: Las Alturas PRV, Ontare Rd PRV, and San Roque PRV
(8) Zone Transfer Facility: Foothill PRV
(9) Zone Transfer Facilies: Sycamore Canyon PRV, and Reservoir #1 valve
(10) Zone Transfer Facilities: Garden Street PRV, Robbins & Pedregosa PRV, La Vista Del Oceano PRV
(11) Zone Transfer Facility: State St PRV
(12) Zone Transfer Facility: Calle De Los Amigos PRV

Table 4 2050 System Storage Analysis, Res. 2 O.O.S. (2050 Projected Use)

Pressure Zone	Existing Gravity Storage and Transfer Facilities without Gravity Stroage	HGL (ft)	Existing Storage Capacity (MG)	Future ADD[1] (mgd)	Future MDD[2] (mgd)	Operational Storage[3] (MG)	Emergency Storage[4] (MG)	Maximum Fireflow Required In Zone (gpm)	Fireflow Duration (hours)	Fire Storage[5] (MG)	Total Storage Required (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer Description (with Gravity Storage)/*Recommended Storage*	Zone Transfer (MG)	Proposed Storage Capacity (MG)	Surplus with Recommendations and Transfers (MG)
Skofield Grouped Zone																
Skofield	Skofield Reservoir	1,396	0.47	0.01	0.03	0.01	0.01	750	2				Storage for El Cielito Tunnel via Bypass[6]	0.00		
Skofield El Cielito				0.01	0.01	0.00	0.01	750	2							
Skofield Grouped Zone Subtotal		*n/a*	*0.47*	*0.02*	*0.04*	*0.01*	*0.02*	*750*	*2*	*0.09*	*0.12*	*0.35*		*0.00*	*0.00*	*0.35*
El Cielito Tunnel Grouped Zone																
El Cielito Tunnel	El Cielito Reservoir	1,058	0.98	0.58	1.05	0.26	0.58	1,250	4				Storage from Skofield via Bypass[6]	0.00		
	Tunnel Reservoir	1,058	0.76										Storage for Sheffield via PRV[7]	0.00		
Upper Tunnel Rd	Tunnel Rd PS			0.04	0.06	0.02	0.04	750	2							
Mission Canyon Heights	Tunnel Rd & Montrose PRV Palomino PRV			0.15	0.27	0.07	0.15	750	2							
Conejo	Conejo Rd PRV			0.02	0.03	0.01	0.02	750	2							
Mission Ranchos	Las Canoas PRV			0.02	0.03	0.01	0.02	750	2							
Northridge	Northridge PRV			0.05	0.10	0.02	0.05	750	2							
El Cielito Tunnel Grouped Zone Subtotal		*n/a*	*1.74*	*0.85*	*1.54*	*0.39*	*0.85*	*1,250*	*4*	*0.30*	*1.54*	*0.20*		*0.00*	*0.00*	*0.20*
Hope Grouped Zone																
Hope	Hope Reservoir	613	0.72	0.07	0.14	0.03	0.07	750	2							
Campanil Hills	Campanil Hills PS			0.04	0.08	0.02	0.04	750	2							
Hope Grouped Zone Subtotal		*n/a*	*0.72*	*0.12*	*0.21*	*0.05*	*0.12*	*750*	*2*	*0.09*	*0.26*	*0.46*		*0.00*	*0.00*	*0.46*
Sheffield Grouped Zone																
Sheffield	McLaughlin Reservoir	661	5.34	1.09	1.97	0.49	1.09	2,500	4				Storage from El Cielito Tunnel via PRV[7]	0.00		
	Hoover Reservoir	661	5.34										Storage for Lauro via PRV[8]	0.00		
													Storage for Low Level via PRV[9]	0.00		
Sheffield Grouped Zone Subtotal		*n/a*	*10.68*	*1.09*	*1.97*	*0.49*	*1.09*	*2,500*	*4*	*0.60*	*2.18*	*8.50*		*0.00*	*0.00*	*8.50*
Bothin Zone																
Bothin	East Reservoir	586	0.58	0.17	0.31	0.08	0.17	750	2							
Bothin Zone Subtotal		*n/a*	*0.58*	*0.17*	*0.31*	*0.08*	*0.17*	*750*	*2*	*0.09*	*0.34*	*0.24*		*0.00*	*0.00*	*0.24*
Lauro Grouped Zone																
Lauro	Cater Clearwell	492	1.70	1.63	2.96	0.74	1.63	2,500	4				Storage from Sheffield via PRV[8]	0.00		
	Vic Trace Reservoir	492	10.01										Storage for Low Level via PRV[10]	-7.20		
													Storage for La Vista via PRV[11]	-0.08		
Escondido La Coronilla	La Coronillla PS Escondido PS			0.24	0.44	0.11	0.24	1,250	4							
Lauro Grouped Zone Subtotal		*n/a*	*11.71*	*1.88*	*3.39*	*0.85*	*1.88*	*2,500*	*4*	*0.60*	*3.32*	*8.38*		*-7.28*	*0.00*	*1.10*
La Vista Zone																
La Vista	La Vista Reservoir	440	2.25	1.40	2.53	0.63	1.40	1,250	4				Storage from Lauro via PRV[11]	0.08		
													Storage for Low Level via PRV[12]	0.00		
La Vista Zone Subtotal		*n/a*	*2.25*	*1.40*	*2.53*	*0.63*	*1.40*	*1,250*	*4*	*0.30*	*2.33*	*-0.08*		*0.08*	*0.00*	*0.00*
Low Level Zone																
Low Level	Reservoir #1	356	0.75	6.10	11.04	2.76	6.10	2,500	4				Storage from Sheffield via PRV[9]	0.00		
	Reservoir #2 OOS	0	0.00										Storage from Lauro via PRV[10]	7.20		
	La Mesa Reservoir	356	1.50										Storage from La Vista via PRV[12]	0.00		
Low Zone Subtotal		*n/a*	*2.25*	*6.10*	*11.04*	*2.76*	*6.10*	*2,500*	*4*	*0.60*	*9.46*	*-7.20*		*7.20*	*0.00*	*0.00*
Total		n/a	30.4	11.62	21.03	5.26	11.62	n/a	n/a	2.67	19.54	10.86	n/a	0.00	0.00	10.86

Notes:
(1) The estimated 2050 Average Day Demand is 13,013 AFY per the City's demand projection estimates.
(2) MDD Peaking factor is assumed to be 1.8.
(3) Operational Storage is calculated as 25% of MDD.
(4) Emergency Storage is calculated as 100% ADD .
(5) Fire Flow Storage is calculated as largest required fire flow times the duration of required fire flow.
(6) Zone Transfer Facility: Bypass valve at Skofield PS
(7) Zone Transfer Facilities: Las Alturas PRV, Ontare Rd PRV, and San Roque PRV
(8) Zone Transfer Facility: Foothill PRV
(9) Zone Transfer Facilies: Sycamore Canyon PRV, and Reservoir #1 valve
(10) Zone Transfer Facilities: Garden Street PRV, Robbins & Pedregosa PRV, La Vista Del Oceano PRV
(11) Zone Transfer Facility: State St PRV
(12) Zone Transfer Facility: Calle De Los Amigos PRV

Table 5 2050 System Storage Analysis, Vic Trace Temporarily O.O.S. (2050 Projected Use)

Pressure Zone	Existing Gravity Storage and Transfer Facilities without Gravity Stroage	HGL (ft)	Existing Storage Capacity (MG)	Future ADD[1] (mgd)	Future MDD[2] (mgd)	Operational Storage[3] (MG)	Emergency Storage[4] (MG)	Maximum Fireflow Required In Zone (gpm)	Fireflow Duration (hours)	Fire Storage[5] (MG)	Total Storage Required (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer Description (with Gravity Storage)/*Recommended Storage*	Zone Transfer (MG)	Proposed Storage Capacity (MG)	Surplus with Recommendations and Transfers (MG)
Skofield Grouped Zone																
Skofield	Skofield Reservoir	1,396	0.47	0.01	0.03	0.01	0.01	750	2				Storage for El Cielito Tunnel via Bypass[6]	0.00		
Skofield El Cielito				0.01	0.01	0.00	0.01	750	2							
Skofield Grouped Zone Subtotal		*n/a*	*0.47*	*0.02*	*0.04*	*0.01*	*0.02*	*750*	*2*	*0.09*	*0.12*	*0.35*		*0.00*	*0.00*	*0.35*
El Cielito Tunnel Grouped Zone																
El Cielito Tunnel	El Cielito Reservoir	1,058	0.98	0.58	1.05	0.26	0.58	1,250	4				Storage from Skofield via Bypass[6]	0.00		
	Tunnel Reservoir	1,058	0.76										Storage for Sheffield via PRV[7]	0.00		
Upper Tunnel Rd	Tunnel Rd PS			0.04	0.06	0.02	0.04	750	2							
Mission Canyon Heights	Tunnel Rd & Montrose PRV Palomino PRV			0.15	0.27	0.07	0.15	750	2							
Conejo	Conejo Rd PRV			0.02	0.03	0.01	0.02	750	2							
Mission Ranchos	Las Canoas PRV			0.02	0.03	0.01	0.02	750	2							
Northridge	Northridge PRV			0.05	0.10	0.02	0.05	750	2							
El Cielito Tunnel Grouped Zone Subtotal		*n/a*	*1.74*	*0.85*	*1.54*	*0.39*	*0.85*	*1,250*	*4*	*0.30*	*1.54*	*0.20*		*0.00*	*0.00*	*0.20*
Hope Grouped Zone																
Hope	Hope Reservoir	613	0.72	0.07	0.14	0.03	0.07	750	2							
Campanil Hills	Campanil Hills PS			0.04	0.08	0.02	0.04	750	2							
Hope Grouped Zone Subtotal		*n/a*	*0.72*	*0.12*	*0.21*	*0.05*	*0.12*	*750*	*2*	*0.09*	*0.26*	*0.46*		*0.00*	*0.00*	*0.46*
Sheffield Grouped Zone																
Sheffield	McLaughlin Reservoir	661	5.34	1.09	1.97	0.49	1.09	2,500	4				Storage from El Cielito Tunnel via PRV[7]	0.00		
	Hoover Reservoir	661	5.34										Storage for Lauro via PRV[8]	-1.70		
													Storage for Low Level via PRV[9]	-5.62		
Sheffield Grouped Zone Subtotal		*n/a*	*10.68*	*1.09*	*1.97*	*0.49*	*1.09*	*2,500*	*4*	*0.60*	*2.18*	*8.50*		*-7.32*	*0.00*	*1.18*
Bothin Zone																
Bothin	East Reservoir	586	0.58	0.17	0.31	0.08	0.17	750	2							
Bothin Zone Subtotal		*n/a*	*0.58*	*0.17*	*0.31*	*0.08*	*0.17*	*750*	*2*	*0.09*	*0.34*	*0.24*		*0.00*	*0.00*	*0.24*
Lauro Grouped Zone																
Lauro	Cater Clearwell	492	1.70	1.63	2.96	0.74	1.63	2,500	4				Storage from Sheffield via PRV[8]	1.70		
	Vic Trace Reservoir OOS	0	0.00										Storage for Low Level via PRV[10]	0.00		
													Storage for La Vista via PRV[11]	-0.08		
Escondido La Coronilla	La Coronillla PS Escondido PS			0.24	0.44	0.11	0.24	1,250	4							
Lauro Grouped Zone Subtotal		*n/a*	*1.70*	*1.88*	*3.39*	*0.85*	*1.88*	*2,500*	*4*	*0.60*	*3.32*	*-1.62*		*1.62*	*0.00*	*0.00*
La Vista Zone																
La Vista	La Vista Reservoir	440	2.25	1.40	2.53	0.63	1.40	1,250	4				Storage from Lauro via PRV[11]	0.08		
													Storage for Low Level via PRV[12]	0.00		
La Vista Zone Subtotal		*n/a*	*2.25*	*1.40*	*2.53*	*0.63*	*1.40*	*1,250*	*4*	*0.30*	*2.33*	*-0.08*		*0.08*	*0.00*	*0.00*
Low Level Zone																
Low Level	Reservoir #1	356	0.75	6.10	11.04	2.76	6.10	2,500	4				Storage from Sheffield via PRV[9]	5.62		
	Reservoir #2	356	1.58										Storage from Lauro via PRV[10]	0.00		
	La Mesa Reservoir	356	1.50										Storage from La Vista via PRV[12]	0.00		
Low Zone Subtotal		*n/a*	*3.84*	*6.10*	*11.04*	*2.76*	*6.10*	*2,500*	*4*	*0.60*	*9.46*	*-5.62*		*5.62*	*0.00*	*0.00*
Total		n/a	22.0	11.62	21.03	5.26	11.62	n/a	n/a	2.67	19.54	2.44	n/a	0.00	0.00	2.44

Notes:

(1) The estimated 2050 Average Day Demand is 13,013 AFY per the City's demand projection estimates.
(2) MDD Peaking factor is assumed to be 1.8.
(3) Operational Storage is calculated as 25% of MDD.
(4) Emergency Storage is calculated as 100% ADD .
(5) Fire Flow Storage is calculated as largest required fire flow times the duration of required fire flow.
(6) Zone Transfer Facility: Bypass valve at Skofield PS
(7) Zone Transfer Facilities: Las Alturas PRV, Ontare Rd PRV, and San Roque PRV
(8) Zone Transfer Facility: Foothill PRV
(9) Zone Transfer Facilies: Sycamore Canyon PRV, and Reservoir #1 valve
(10) Zone Transfer Facilities: Garden Street PRV, Robbins & Pedregosa PRV, La Vista Del Oceano PRV
(11) Zone Transfer Facility: State St PRV
(12) Zone Transfer Facility: Calle De Los Amigos PRV

Table 6 2050 System Storage Analysis, Cater Clearwell Not Considered (2050 Projected Use)

Pressure Zone	Existing Gravity Storage and Transfer Facilities without Gravity Stroage	HGL (ft)	Existing Storage Capacity (MG)	Future ADD[1] (mgd)	Future MDD[2] (mgd)	Operational Storage[3] (MG)	Emergency Storage[4] (MG)	Maximum Fireflow Required In Zone (gpm)	Fireflow Duration (hours)	Fire Storage[5] (MG)	Total Storage Required (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer Description (with Gravity Storage)/*Recommended Storage*	Zone Transfer (MG)	Proposed Storage Capacity (MG)	Surplus with Recommendations and Transfers (MG)
Skofield Grouped Zone																
Skofield	Skofield Reservoir	1,396	0.47	0.01	0.03	0.01	0.01	750	2				Storage for El Cielito Tunnel via Bypass[6]	0.00		
Skofield El Cielito				0.01	0.01	0.00	0.01	750	2							
Skofield Grouped Zone Subtotal		***n/a***	***0.47***	***0.02***	***0.04***	***0.01***	***0.02***	***750***	***2***	***0.09***	***0.12***	***0.35***		***0.00***	***0.00***	***0.35***
El Cielito Tunnel Grouped Zone																
El Cielito Tunnel	El Cielito Reservoir	1,058	0.98	0.58	1.05	0.26	0.58	1,250	4				Storage from Skofield via Bypass[6]	0.00		
	Tunnel Reservoir	1,058	0.76										Storage for Sheffield via PRV[7]	0.00		
Upper Tunnel Rd	Tunnel Rd PS			0.04	0.06	0.02	0.04	750	2							
Mission Canyon Heights	Tunnel Rd & Montrose PRV Palomino PRV			0.15	0.27	0.07	0.15	750	2							
Conejo	Conejo Rd PRV			0.02	0.03	0.01	0.02	750	2							
Mission Ranchos	Las Canoas PRV			0.02	0.03	0.01	0.02	750	2							
Northridge	Northridge PRV			0.05	0.10	0.02	0.05	750	2							
El Cielito Tunnel Grouped Zone Subtotal		***n/a***	***1.74***	***0.85***	***1.54***	***0.39***	***0.85***	***1,250***	***4***	***0.30***	***1.54***	***0.20***		***0.00***	***0.00***	***0.20***
Hope Grouped Zone																
Hope	Hope Reservoir	613	0.72	0.07	0.14	0.03	0.07	750	2							
Campanil Hills	Campanil Hills PS			0.04	0.08	0.02	0.04	750	2							
Hope Grouped Zone Subtotal		***n/a***	***0.72***	***0.12***	***0.21***	***0.05***	***0.12***	***750***	***2***	***0.09***	***0.26***	***0.46***		***0.00***	***0.00***	***0.46***
Sheffield Grouped Zone																
Sheffield	McLaughlin Reservoir	661	5.34	1.09	1.97	0.49	1.09	2,500	4				Storage from El Cielito Tunnel via PRV[7]	0.00		
	Hoover Reservoir	661	5.34										Storage for Lauro via PRV[8]	0.00		
													Storage for Low Level via PRV[9]	0.00		
Sheffield Grouped Zone Subtotal		***n/a***	***10.68***	***1.09***	***1.97***	***0.49***	***1.09***	***2,500***	***4***	***0.60***	***2.18***	***8.50***		***0.00***	***0.00***	***8.50***
Bothin Zone																
Bothin	East Reservoir	586	0.58	0.17	0.31	0.08	0.17	750	2							
Bothin Zone Subtotal		***n/a***	***0.58***	***0.17***	***0.31***	***0.08***	***0.17***	***750***	***2***	***0.09***	***0.34***	***0.24***		***0.00***	***0.00***	***0.24***
Lauro Grouped Zone																
Lauro	Cater Clearwell OOS	0	0.00	1.63	2.96	0.74	1.63	2,500	4				Storage from Sheffield via PRV[8]	0.00		
	Vic Trace Reservoir	492	10.01										Storage for Low Level via PRV[10]	-5.62		
													Storage for La Vista via PRV[11]	-0.08		
Escondido La Coronilla	La Coronillla PS Escondido PS			0.24	0.44	0.11	0.24	1,250	4							
Lauro Grouped Zone Subtotal		***n/a***	***10.01***	***1.88***	***3.39***	***0.85***	***1.88***	***2,500***	***4***	***0.60***	***3.32***	***6.68***		***-5.70***	***0.00***	***0.98***
La Vista Zone																
La Vista	La Vista Reservoir	440	2.25	1.40	2.53	0.63	1.40	1,250	4				Storage from Lauro via PRV[11]	0.08		
													Storage for Low Level via PRV[12]	0.00		
La Vista Zone Subtotal		***n/a***	***2.25***	***1.40***	***2.53***	***0.63***	***1.40***	***1,250***	***4***	***0.30***	***2.33***	***-0.08***		***0.08***	***0.00***	***0.00***
Low Level Zone																
Low Level	Reservoir #1	356	0.75	6.10	11.04	2.76	6.10	2,500	4				Storage from Sheffield via PRV[9]	0.00		
	Reservoir #2	356	1.58										Storage from Lauro via PRV[10]	5.62		
	La Mesa Reservoir	356	1.50										Storage from La Vista via PRV[12]	0.00		
Low Zone Subtotal		***n/a***	***3.84***	***6.10***	***11.04***	***2.76***	***6.10***	***2,500***	***4***	***0.60***	***9.46***	***-5.62***		***5.62***	***0.00***	***0.00***
Total		n/a	30.3	11.62	21.03	5.26	11.62	n/a	n/a	2.67	19.54	10.75	n/a	0.00	0.00	10.75

Notes:

(1) The estimated 2050 Average Day Demand is 13,013 AFY per the City's demand projection estimates.
(2) MDD Peaking factor is assumed to be 1.8.
(3) Operational Storage is calculated as 25% of MDD.
(4) Emergency Storage is calculated as 100% ADD .
(5) Fire Flow Storage is calculated as largest required fire flow times the duration of required fire flow.
(6) Zone Transfer Facility: Bypass valve at Skofield PS
(7) Zone Transfer Facilities: Las Alturas PRV, Ontare Rd PRV, and San Roque PRV
(8) Zone Transfer Facility: Foothill PRV
(9) Zone Transfer Facilies: Sycamore Canyon PRV, and Reservoir #1 valve
(10) Zone Transfer Facilities: Garden Street PRV, Robbins & Pedregosa PRV, La Vista Del Oceano PRV
(11) Zone Transfer Facility: State St PRV
(12) Zone Transfer Facility: Calle De Los Amigos PRV

Table 7 Future System Storage Analysis - Scenario 10 (2050 Projected Use)

Pressure Zone	Existing Gravity Storage and Transfer Facilities without Gravity Stroage	HGL (ft)	Existing Storage Capacity (MG)	Future ADD[1] (mgd)	Future MDD[2] (mgd)	Operational Storage[3] (MG)	Emergency Storage[4] (MG)	Maximum Fireflow Required In Zone (gpm)	Fireflow Duration (hours)	Fire Storage[5] (MG)	Total Storage Required (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer Description (with Gravity Storage)/*Recommended Storage*	Zone Transfer (MG)	Proposed Storage Capacity (MG)	Surplus with Recommendations and Transfers (MG)
Skofield Grouped Zone																
Skofield	Skofield Reservoir	1,396	0.47	0.01	0.03	0.01	0.01	750	2				Storage for El Cielito Tunnel via Bypass[6]	0.00		
Skofield El Cielito				0.01	0.01	0.00	0.01	750	2							
Skofield Grouped Zone Subtotal		*n/a*	*0.47*	*0.02*	*0.04*	*0.01*	*0.02*	*750*	*2*	*0.09*	*0.12*	*0.35*		*0.00*	*0.00*	*0.35*
El Cielito Tunnel Grouped Zone																
El Cielito Tunnel	El Cielito Reservoir	1,058	1.00	0.58	1.05	0.26	0.58	1,250	4				Storage from Skofield via Bypass[6]	0.00		
	Tunnel Reservoir	1,058	0.76										Storage for Sheffield via PRV[7]	0.00		
Upper Tunnel Rd	Tunnel Rd PS			0.04	0.06	0.02	0.04	750	2							
Mission Canyon Heights	Tunnel Rd/Montrose PRV															
	Palomino PRV			0.15	0.27	0.07	0.15	750	2							
Conejo	Conejo Rd PRV			0.02	0.03	0.01	0.02	750	2							
Mission Ranchos	Las Canoas PRV			0.02	0.03	0.01	0.02	750	2							
Northridge	Northridge PRV			0.05	0.10	0.02	0.05	750	2							
El Cielito Tunnel Grouped Zone Subtotal		*n/a*	*1.76*	*0.85*	*1.54*	*0.39*	*0.85*	*1,250*	*4*	*0.30*	*1.54*	*0.22*		*0.00*	*0.00*	*0.22*
Hope Grouped Zone																
Hope	Hope Reservoir	613	0.72	0.07	0.14	0.03	0.07	750	2							
Campanil Hills	Campanil Hills PS			0.04	0.08	0.02	0.04	750	2							
Hope Grouped Zone Subtotal		*n/a*	*0.72*	*0.12*	*0.21*	*0.05*	*0.12*	*750*	*2*	*0.09*	*0.26*	*0.46*		*0.00*	*0.00*	*0.46*
Sheffield Grouped Zone																
Sheffield	McLaughlin Reservoir	661	5.34	1.09	1.97	0.49	1.09	2,500	4				Storage from El Cielito Tunnel via PRV[7]	0.00		
	Hoover Reservoir	661	5.34										Storage for Lauro via PRV[8]	-2.49		
													Storage for Low Level via PRV[9]	-0.42		
Bothin	Bothin PS			0.17	0.31	0.08	0.17	750	2							
Sheffield Grouped Zone Subtotal		*n/a*	*10.68*	*1.26*	*2.28*	*0.57*	*1.26*	*2,500*	*4*	*0.60*	*2.43*	*8.26*		*-2.91*	*0.00*	*5.35*
Lauro Grouped Zone																
Lauro	Cater Clearwell	492	2.20	1.42	2.57	0.64	1.42	2,500	4				Storage from Sheffield via PRV[8]	2.49		
													Storage for Low Level via PRV[10]	0.00		
La Vista				1.40	2.53	0.63	1.40	1,250	4							
Lauro Grouped Zone Subtotal		*n/a*	*2.20*	*2.82*	*5.10*	*1.27*	*2.82*	*2,500*	*4*	*0.60*	*4.69*	*-2.49*		*2.49*	*0.00*	*0.00*
Vic Trace Grouped Zone																
Vic Trace Zone	Vic Trace Reservoir	492	10.00	0.21	0.39	0.10	0.21	750	2				Storage for Low Level via PRV[11]	-9.04		
Escondido La Coronilla	La Coronillla PS															
	Escondido PS			0.24	0.44	0.11	0.24	1,250	4							
La Vista Zone Subtotal		*n/a*	*10.00*	*0.45*	*0.82*	*0.21*	*0.45*	*1,250*	*4*	*0.30*	*0.96*	*9.04*		*-9.04*	*0.00*	*0.00*
Low Level Zone																
Low Level				6.10	11.04	2.76	6.10	2,500	4				Storage from Sheffield via PRV[9]	0.42		
													Storage from Lauro via PRV[10]	0.00		
													Storage from Vic Trace via PRV[11]	9.04		
Low Zone Subtotal		*n/a*	*0.00*	*6.10*	*11.04*	*2.76*	*6.10*	*2,500*	*4*	*0.60*	*9.46*	*-9.46*		*9.46*	*0.00*	*0.00*
Total		n/a	25.84	11.62	21.03	5.26	11.62	n/a	n/a	2.58	19.45	6.38	n/a	0.00	0.00	6.38

Notes:
(1) The estimated 2050 Average Day Demand is 13,013 AFY per the City's demand projection estimates.
(2) MDD Peaking factor is assumed to be 1.8.
(3) Operational Storage is calculated as 25% of MDD.
(4) Emergency Storage is calculated as 100% ADD .
(5) Fire Flow Storage is calculated as largest required fire flow times the duration of required fire flow.
(6) Zone Transfer Facility: Bypass valve at Skofield PS
(7) Zone Transfer Facilities: Las Alturas PRV, Ontare Rd PRV, and San Roque PRV
(8) Zone Transfer Facility: Foothill PRV
(9) Zone Transfer Facilies: Sycamore Canyon PRV, and Reservoir #1 valve
(10) Zone Transfer Facilities: Calle De Los Amigos PRV
(11) Zone Transfer Facilities: Robbins & Pedregosa PRV, La Vista Del Oceano PRV, and Garden Street PRV

Table 8 Future System Storage Analysis - Scenario 10, Cater Clearwell Not Considered, & Hoover Reservoir Out of Service (2050 Projected Use)

Pressure Zone	Existing Gravity Storage and Transfer Facilities without Gravity Stroage	HGL (ft)	Existing Storage Capacity (MG)	Future ADD[1] (mgd)	Future MDD[2] (mgd)	Operational Storage[3] (MG)	Emergency Storage[4] (MG)	Maximum Fireflow Required In Zone (gpm)	Fireflow Duration (hours)	Fire Storage[5] (MG)	Total Storage Required (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer Description (with Gravity Storage)/*Recommended Storage*	Zone Transfer (MG)	Proposed Storage Capacity (MG)	Surplus with Recommendations and Transfers (MG)
Skofield Grouped Zone																
Skofield	Skofield Reservoir	1,396	0.47	0.01	0.03	0.01	0.01	750	2				Storage for El Cielito Tunnel via Bypass[6]	0.00		
Skofield El Cielito				0.01	0.01	0.00	0.01	750	2							
Skofield Grouped Zone Subtotal		***n/a***	***0.47***	***0.02***	***0.04***	***0.01***	***0.02***	***750***	***2***	***0.09***	***0.12***	***0.35***		***0.00***	***0.00***	***0.35***
El Cielito Tunnel Grouped Zone																
El Cielito Tunnel	El Cielito Reservoir	1,058	1.00	0.58	1.05	0.26	0.58	1,250	4				Storage from Skofield via Bypass[6]	0.00		
	Tunnel Reservoir	1,058	0.76										Storage for Sheffield via PRV[7]	0.00		
Upper Tunnel Rd	Tunnel Rd PS			0.04	0.06	0.02	0.04	750	2							
Mission Canyon Heights	Tunnel Rd/Montrose PRV Palomino PRV			0.15	0.27	0.07	0.15	750	2							
Conejo	Conejo Rd PRV			0.02	0.03	0.01	0.02	750	2							
Mission Ranchos	Las Canoas PRV			0.02	0.03	0.01	0.02	750	2							
Northridge	Northridge PRV			0.05	0.10	0.02	0.05	750	2							
El Cielito Tunnel Grouped Zone Subtotal		***n/a***	***1.76***	***0.85***	***1.54***	***0.39***	***0.85***	***1,250***	***4***	***0.30***	***1.54***	***0.22***		***0.00***	***0.00***	***0.22***
Hope Grouped Zone																
Hope	Hope Reservoir	613	0.72	0.07	0.14	0.03	0.07	750	2							
Campanil Hills	Campanil Hills PS			0.04	0.08	0.02	0.04	750	2							
Hope Grouped Zone Subtotal		***n/a***	***0.72***	***0.12***	***0.21***	***0.05***	***0.12***	***750***	***2***	***0.09***	***0.26***	***0.46***		***0.00***	***0.00***	***0.46***
Sheffield Grouped Zone																
Sheffield	McLaughlin Reservoir	661	5.34	1.09	1.97	0.49	1.09	2,500	4				Storage from El Cielito Tunnel via PRV[7]	0.00		
	Hoover Reservoir OOS	661	0.00										Storage for Lauro via PRV[8]	-2.50		
													Storage for Low Level via PRV[9]	-0.42		
Bothin	Bothin PS			0.17	0.31	0.08	0.17	750	2							
Sheffield Grouped Zone Subtotal		***n/a***	***5.34***	***1.26***	***2.28***	***0.57***	***1.26***	***2,500***	***4***	***0.60***	***2.43***	***2.92***		***-2.92***	***0.00***	***0.00***
Lauro Grouped Zone																
Lauro	Cater Clearwell	492	0.00	1.42	2.57	0.64	1.42	2,500	4				Storage from Sheffield via PRV[8]	2.50		
													Storage for Low Level via PRV[10]	0.00		
La Vista				1.40	2.53	0.63	1.40	1,250	4							
Lauro Grouped Zone Subtotal		***n/a***	***0.00***	***2.82***	***5.10***	***1.27***	***2.82***	***2,500***	***4***	***0.60***	***4.69***	***-4.69***		***2.50***	***0.00***	***-2.19***
Vic Trace Grouped Zone																
Vic Trace Zone	Vic Trace Reservoir	492	10.00	0.21	0.39	0.10	0.21	750	2				Storage for Low Level via PRV[11]	-9.04		
Escondido La Coronilla	La Coronillla PS Escondido PS			0.24	0.44	0.11	0.24	1,250	4							
La Vista Zone Subtotal		***n/a***	***10.00***	***0.45***	***0.82***	***0.21***	***0.45***	***1,250***	***4***	***0.30***	***0.96***	***9.04***		***-9.04***	***0.00***	***0.00***
Low Level Zone																
Low Level				6.10	11.04	2.76	6.10	2,500	4				Storage from Sheffield via PRV[9]	0.42		
													Storage from Lauro via PRV[10]	0.00		
													Storage from Vic Trace via PRV[11]	9.04		
Low Zone Subtotal		***n/a***	***0.00***	***6.10***	***11.04***	***2.76***	***6.10***	***2,500***	***4***	***0.60***	***9.46***	***-9.46***		***9.46***	***0.00***	***0.00***
Total		n/a	18.30	11.62	21.03	5.26	11.62	n/a	n/a	2.58	19.45	-1.16	n/a	0.00	0.00	-1.16

Notes:

(1) The estimated 2050 Average Day Demand is 13,013 AFY per the City's demand projection estimates.
(2) MDD Peaking factor is assumed to be 1.8.
(3) Operational Storage is calculated as 25% of MDD.
(4) Emergency Storage is calculated as 100% ADD .
(5) Fire Flow Storage is calculated as largest required fire flow times the duration of required fire flow.
(6) Zone Transfer Facility: Bypass valve at Skofield PS
(7) Zone Transfer Facilities: Las Alturas PRV, Ontare Rd PRV, and San Roque PRV
(8) Zone Transfer Facility: Foothill PRV
(9) Zone Transfer Facilies: Sycamore Canyon PRV, and Reservoir #1 valve
(10) Zone Transfer Facilities: Calle De Los Amigos PRV
(11) Zone Transfer Facilities: Robbins & Pedregosa PRV, La Vista Del Oceano PRV, and Garden Street PRV

Table 9 Future System Storage Analysis - Scenario 10, Cater Clearwell Not Considered, & Vic Trace Reservoir Operating at Half Capacity (2050 Projected Use)

Pressure Zone	Existing Gravity Storage and Transfer Facilities without Gravity Stroage	HGL (ft)	Existing Storage Capacity (MG)	Future ADD[1] (mgd)	Future MDD[2] (mgd)	Operational Storage[3] (MG)	Emergency Storage[4] (MG)	Maximum Fireflow Required In Zone (gpm)	Fireflow Duration (hours)	Fire Storage[5] (MG)	Total Storage Required (MG)	Zone Deficit/ Surplus (MG)	Zone Transfer Description (with Gravity Storage)/*Recommended Storage*	Zone Transfer (MG)	Proposed Storage Capacity (MG)	Surplus with Recommendations and Transfers (MG)
Skofield Grouped Zone																
Skofield	Skofield Reservoir	1,396	0.47	0.01	0.03	0.01	0.01	750	2				Storage for El Cielito Tunnel via Bypass[6]	0.00		
Skofield El Cielito				0.01	0.01	0.00	0.01	750	2							
Skofield Grouped Zone Subtotal		***n/a***	***0.47***	***0.02***	***0.04***	***0.01***	***0.02***	***750***	***2***	***0.09***	***0.12***	***0.35***		***0.00***	***0.00***	***0.35***
El Cielito Tunnel Grouped Zone																
El Cielito Tunnel	El Cielito Reservoir	1,058	1.00	0.58	1.05	0.26	0.58	1,250	4				Storage from Skofield via Bypass[6]	0.00		
	Tunnel Reservoir	1,058	0.76										Storage for Sheffield via PRV[7]	0.00		
Upper Tunnel Rd	Tunnel Rd PS			0.04	0.06	0.02	0.04	750	2							
Mission Canyon Heights	Tunnel Rd/Montrose PRV Palomino PRV			0.15	0.27	0.07	0.15	750	2							
Conejo	Conejo Rd PRV			0.02	0.03	0.01	0.02	750	2							
Mission Ranchos	Las Canoas PRV			0.02	0.03	0.01	0.02	750	2							
Northridge	Northridge PRV			0.05	0.10	0.02	0.05	750	2							
El Cielito Tunnel Grouped Zone Subtotal		***n/a***	***1.76***	***0.85***	***1.54***	***0.39***	***0.85***	***1,250***	***4***	***0.30***	***1.54***	***0.22***		***0.00***	***0.00***	***0.22***
Hope Grouped Zone																
Hope	Hope Reservoir	613	0.72	0.07	0.14	0.03	0.07	750	2							
Campanil Hills	Campanil Hills PS			0.04	0.08	0.02	0.04	750	2							
Hope Grouped Zone Subtotal		***n/a***	***0.72***	***0.12***	***0.21***	***0.05***	***0.12***	***750***	***2***	***0.09***	***0.26***	***0.46***		***0.00***	***0.00***	***0.46***
Sheffield Grouped Zone																
Sheffield	McLaughlin Reservoir	661	5.34	1.09	1.97	0.49	1.09	2,500	4				Storage from El Cielito Tunnel via PRV[7]	0.00		
	Hoover Reservoir	661	5.34										Storage for Lauro via PRV[8]	-2.84		
													Storage for Low Level via PRV[9]	-5.42		
Bothin	Bothin PS			0.17	0.31	0.08	0.17	750	2							
Sheffield Grouped Zone Subtotal		***n/a***	***10.68***	***1.26***	***2.28***	***0.57***	***1.26***	***2,500***	***4***	***0.60***	***2.43***	***8.26***		***-8.26***	***0.00***	***0.00***
Lauro Grouped Zone																
Lauro	Cater Clearwell	492	0.00	1.42	2.57	0.64	1.42	2,500	4				Storage from Sheffield via PRV[8]	2.84		
													Storage for Low Level via PRV[10]	0.00		
La Vista				1.40	2.53	0.63	1.40	1,250	4							
Lauro Grouped Zone Subtotal		***n/a***	***0.00***	***2.82***	***5.10***	***1.27***	***2.82***	***2,500***	***4***	***0.60***	***4.69***	***-4.69***		***2.84***	***0.00***	***-1.85***
Vic Trace Grouped Zone																
Vic Trace Zone	Vic Trace Reservoir (50%)	492	5.00	0.21	0.39	0.10	0.21	750	2				Storage for Low Level via PRV[11]	-4.04		
Escondido La Coronilla	La Coronillla PS Escondido PS			0.24	0.44	0.11	0.24	1,250	4							
La Vista Zone Subtotal		***n/a***	***5.00***	***0.45***	***0.82***	***0.21***	***0.45***	***1,250***	***4***	***0.30***	***0.96***	***4.04***		***-4.04***	***0.00***	***0.00***
Low Level Zone																
Low Level				6.10	11.04	2.76	6.10	2,500	4				Storage from Sheffield via PRV[9]	5.42		
													Storage from Lauro via PRV[10]	0.00		
													Storage from Vic Trace via PRV[11]	4.04		
Low Zone Subtotal		***n/a***	***0.00***	***6.10***	***11.04***	***2.76***	***6.10***	***2,500***	***4***	***0.60***	***9.46***	***-9.46***		***9.46***	***0.00***	***0.00***
Total		n/a	18.64	11.62	21.03	5.26	11.62	n/a	n/a	2.58	19.45	-0.82	n/a	0.00	0.00	-0.82

Notes:

(1) The estimated 2050 Average Day Demand is 13,013 AFY per the City's demand projection estimates.
(2) MDD Peaking factor is assumed to be 1.8.
(3) Operational Storage is calculated as 25% of MDD.
(4) Emergency Storage is calculated as 100% ADD .
(5) Fire Flow Storage is calculated as largest required fire flow times the duration of required fire flow.
(6) Zone Transfer Facility: Bypass valve at Skofield PS
(7) Zone Transfer Facilities: Las Alturas PRV, Ontare Rd PRV, and San Roque PRV
(8) Zone Transfer Facility: Foothill PRV
(9) Zone Transfer Facilies: Sycamore Canyon PRV, and Reservoir #1 valve
(10) Zone Transfer Facilities: Calle De Los Amigos PRV
(11) Zone Transfer Facilities: Robbins & Pedregosa PRV, La Vista Del Oceano PRV, and Garden Street PRV

Appendix 2C
PUMP STATION CAPACITY ANALYSIS

Table 1 Existing Sytem Pump Station Analysis (2019 Projected Use)

Discharge Pressure Zone	Zone with Gravity Storage?	Existing Pump Station and Supply Facilities	Pump Station Capacity[1][2] Design Capacity (gpm)	Firm Capacity (gpm)	Existing ADD (gpm)	Existing MDD[3] (gpm)	Existing PHD[3] (gpm)	Max Zone Fire Flow (FF) (gpm)	Governing Size Criteria	Required Capacity (gpm)	Existing Capacity Balance (gpm)	Zone Transfer Description/ *Recommended Improvement*	Zone Transfer (mgd)	Existing Capacity Balance w/ Improvements (gpm)
Skofield Grouped Zone														
Skofield	Yes	Skofield Inside PS	510	210	8	14	23	750						
		Skofield Outside PS	700	350										
Skofield El Cielito	No				3	5	9	750						
Skofield Zone Grouped Subtotal			***1,210***	***560***	***11***	***19***	***32***	***750***	***MDD***	***19***	***541***		***0***	***541***
Upper Tunnel Rd Zone														
Upper Tunnel Rd	No	Tunnel Road PS	1,125	750	19	34	57	750						
Upper Tunnel Rd Subtotal			***1,125***	***750***	***19***	***34***	***57***	***750***	***MDD+FF***	***784***	***-34***		***0***	***-34***
El Cielito Tunnel Grouped Zone														
El Cielito Tunnel	Yes	Cater Cross-Tie PS	3,975	2,650	311	562	945	1,250				Supply for Sheffield via PRVs		
		El Cielito PS	3,300	2,200										
		Rocky Nook PS	1,200	800										
Mission Canyon Heights	No				78	142	238	750						
Conejo	No				8	15	25	750						
Mission Ranchos	No				10	18	30	750						
Northridge	No				29	52	96	750						
El Cielito Tunnel Zone Grouped Subtotal			***8,475***	***5,650***	***436***	***789***	***1,334***	***1,250***	***MDD***	***789***	***4,861***		***0***	***4,861***
Sheffield Zone														
Sheffield	Yes	Sheffield PS	1,700	1,700	580	1,050	1,765	2,500				Supply from El Cielito Tunnel via PRVs	0	
Sheffield Zone Grouped Subtotal			***1,700***	***1,700***	***580***	***1,050***	***1,765***	***2,500***	***MDD***	***1,050***	***650***		***0***	***650***
Bothin Zone														
Bothin	No	Bothin PS	2,520	1,680	91	164	276	750						
Bothin Subtotal			***2,520***	***1,680***	***91***	***164***	***276***	***750***	***MDD+FF***	***914***	***766***		***0***	***766***
Campanil Hills Zone														
Campanil Hills	No	Campanil PS	1,725	900	23	42	71	750						
Campanil Hills Subtotal			***1,725***	***900***	***23***	***42***	***71***	***750***	***MDD+FF***	***792***	***108***		***0***	***108***
Escondido La Coronilla Zone														
Escondido La Coronilla	No	Escondido PS	2,925	1,950	129	234	393	1,250						
		La Coronilla PS	645	0										
Escondido La Coronilla Subtotal			***3,570***	***1,950***	***129***	***234***	***393***	***1,250***	***MDD+FF***	***1,484***	***466***		***0***	***466***
Hope Zone														
Hope	Yes	Hope PS	1,000	500	40	72	122	750						
Hope Subtotal			***1,000***	***500***	***40***	***72***	***122***	***750***	***MDD***	***72***	***428***		***0***	***428***
Lauro Grouped Zone														
Lauro	Yes	Cater WTP	25,694	15,417	872	1,578	2,651	2,500				Supply for Low Level via PRVs	-2,241	
		Padre PS	1,000	500										
La Vista	Yes	Hope Well	250	250	745	1,349	1,888	1,250						
		Los Robles Well	70	70										
Lauro Zone Grouped Subtotal			***27,014***	***16,237***	***1,617***	***2,927***	***4,539***	***2,500***	***MDD***	***2,927***	***13,310***		***-2,241***	***11,069***
Low Level Zone														
Low Level	Yes	Ortega GWTP	1,160	1,160	3,255	5,891	9,898	2,500				Supply from Lauro via PRVs	2,241	
		Desalination Plant	2,100	2,100										
		San Roque Well	390	390										
Low Level Subtotal			***3,650***	***3,650***	***3,255***	***5,891***	***9,898***	***2,500***	***MDD***	***5,891***	***-2,241***		***2,241***	***0***
Total	n/a	n/a	51,989	33,577	6,201	11,224	18,486	n/a	n/a	14,724	18,853			18,853
System Wide Supply				19,387						14,724	4,663			

Notes:

(1) Source: Design capacities and firm capacities based on City records.

(2) MDD Peaking factor is assumed to be 1.8.

(3) PHD Peaking factor ranges from 1.4 to 1.8. PHD PF is multiplied by MDD to obtain PHD.

(4) If gravity storage then MDD, and if no gravity storage than MDD+FF.

Table 2 Future Sytem Pump Station Analysis (2050 Projected Use)

Discharge Pressure Zone	Zone with Gravity Storage?	Existing Pump Station and Supply Facilities	Pump Station Capacity[1][2]		Future ADD (gpm)	Future MDD[3] (gpm)	Future PHD[3] (gpm)	Max Zone Fire Flow (FF) (gpm)	Governing Size Criteria	Required Capacity (gpm)	Future Capacity Balance (gpm)	Zone Transfer Description/ *Recommended Improvement*	Zone Transfer (mgd)	Future Capacity Balance w/ Improvements (gpm)
			Design Capacity (gpm)	Firm Capacity (gpm)										
Skofield Grouped Zone														
Skofield	Yes	Skofield Inside PS	510	210	10	18	30	750						
		Skofield Outside PS	700	350										
Skofield El Cielito	No				4	7	11	750						
Skofield Zone Grouped Subtotal			***1,210***	***560***	***14***	***25***	***42***	***750***	*MDD*	*25*	*535*		*0*	*535*
Upper Tunnel Rd Zone														
Upper Tunnel Rd	No	Tunnel Road PS	1,125	750	25	44	75	750						
Upper Tunnel Rd Subtotal			***1,125***	***750***	***25***	***44***	***75***	***750***	*MDD+FF*	*794*	*-44*		*0*	*-44*
El Cielito Tunnel Grouped Zone														
El Cielito Tunnel	Yes	Cater Cross-Tie PS	3,975	2,650	404	732	1,229	1,250						
		El Cielito PS	3,300	2,200										
		Rocky Nook PS	1,200	800										
Mission Canyon Heights	No				102	184	309	750						
Conejo	No				11	19	33	750						
Mission Ranchos	No				13	23	39	750						
Northridge	No				38	68	125	750						
El Cielito Tunnel Zone Grouped Subtotal			***8,475***	***5,650***	***567***	***1,027***	***1,736***	***1,250***	*MDD*	*1,027*	*4,623*		*0*	*4,623*
Sheffield Zone														
Sheffield	Yes	Sheffield PS	1,700	1,700	755	1,367	2,296	2,500						
Sheffield Zone Grouped Subtotal			***1,700***	***1,700***	***755***	***1,367***	***2,296***	***2,500***	*MDD*	*1,367*	*333*		*0*	*333*
Bothin Zone														
Bothin	No	Bothin PS	2,520	1,680	118	214	359	750						
Bothin Subtotal			***2,520***	***1,680***	***118***	***214***	***359***	***750***	*MDD+FF*	*964*	*716*		*0*	*716*
Campanil Hills Zone														
Campanil Hills	No	Campanil PS	1,725	900	30	55	92	750						
Campanil Hills Subtotal			***1,725***	***900***	***30***	***55***	***92***	***750***	*MDD+FF*	*805*	*95*		*0*	*95*
Escondido La Coronilla Zone														
Escondido La Coronilla	No	Escondido PS	2,925	1,950	168	304	511	1,250						
		La Coronilla PS	645	0										
Escondido La Coronilla Subtotal			***3,570***	***1,950***	***168***	***304***	***511***	***1,250***	*MDD+FF*	*1,554*	*396*		*0*	*396*
Hope Zone														
Hope	Yes	Hope PS	1,000	500	52	94	158	750						
Hope Subtotal			***1,000***	***500***	***52***	***94***	***158***	***750***	*MDD*	*94*	*406*		*0*	*406*
Lauro Grouped Zone														
Lauro	Yes	Cater WTP	25,694	15,417	1,134	2,053	3,449	2,500				Supply for Low Level via PRVs	-4,015	
		Padre PS	1,000	500										
La Vista	Yes	Hope Well	250	250	970	1,755	2,457	1,250						
		Los Robles Well	70	70										
Lauro Zone Grouped Subtotal			***27,014***	***16,237***	***2,104***	***3,808***	***5,906***	***2,500***	*MDD*	*3,808*	*12,429*		*-4,015*	*8,413*
Low Level Zone														
Low Level	Yes	Ortega GWTP	1,160	1,160	4,235	7,665	12,878	2,500				Supply from Lauro via PRVs	4,015	
		Desalination Plant	2,100	2,100								Supply from Sheffield via PRVs		
		San Roque Well	390	390										
Low Level Subtotal			***3,650***	***3,650***	***4,235***	***7,665***	***12,878***	***2,500***	*MDD*	*7,665*	*-4,015*		*4,015*	*0*
Total	**n/a**	**n/a**	**51,989**	**33,577**	**8,068**	**14,603**	**24,052**	**n/a**	**n/a**	**18,103**	**15,474**			**15,474**
System Wide Supply				**19,387**						**18,103**	**1,284**			

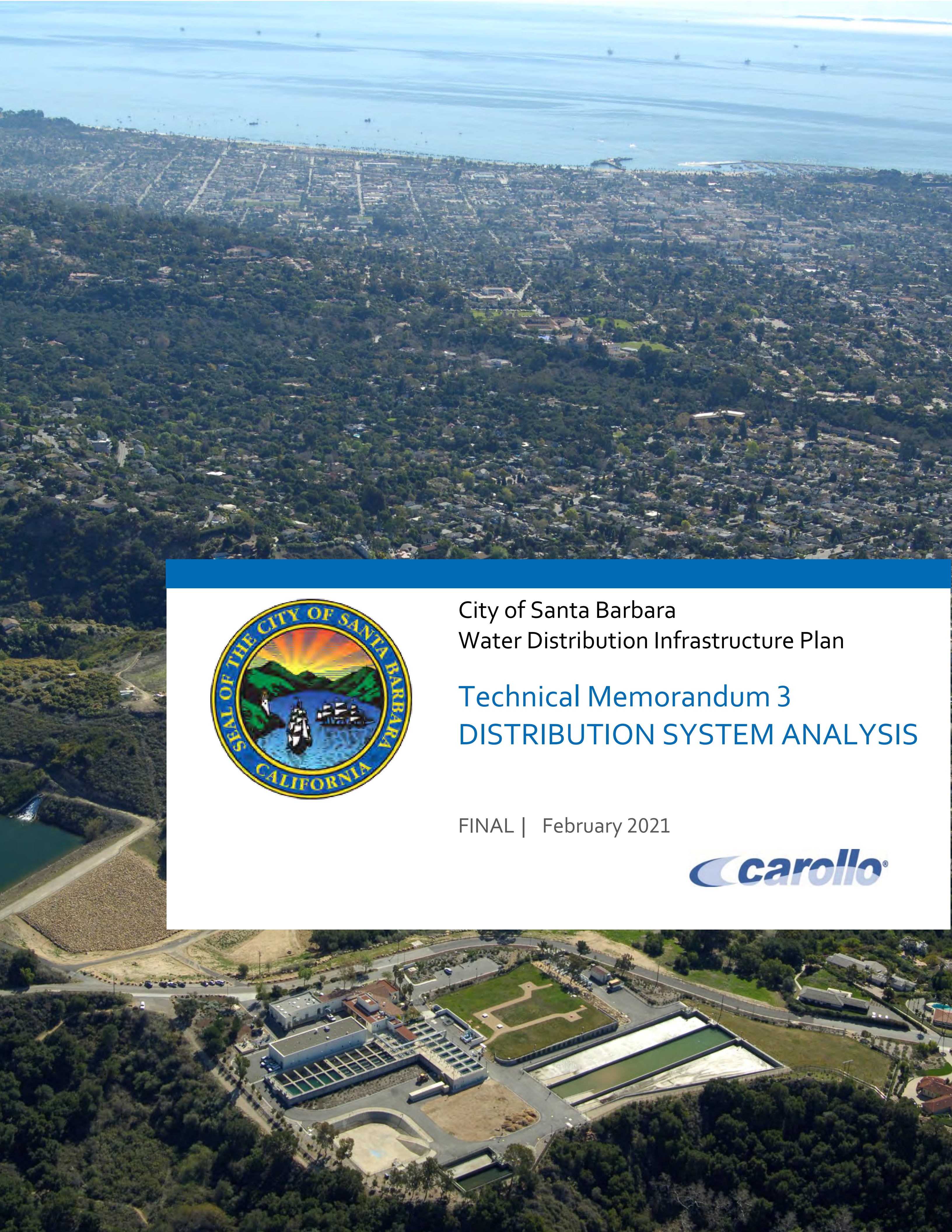
Notes:

(1) Source: Design capacities and firm capacities based on City records.

(2) MDD Peaking factor is assumed to be 1.8.

(3) PHD Peaking factor ranges from 1.4 to 1.8. PHD PF is multiplied by MDD to obtain PHD.

(4) If gravity storage then MDD, and if no gravity storage than MDD+FF.



City of Santa Barbara
Water Distribution Infrastructure Plan

Technical Memorandum 3
DISTRIBUTION SYSTEM ANALYSIS

FINAL | February 2021

carollo®

City of Santa Barbara
Water Distribution Infrastructure Plan

Technical Memorandum 3
DISTRIBUTION SYSTEM ANALYSIS

FINAL | February 2021

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Abbreviations

%	percent
ADD	average day demand
AWWA	American Water Works Association
AWWA M-32	Manual on Distribution Network Analysis of Water Utilities
Carollo	Carollo Engineers, Inc.
CIP	Capital Improvement Plan
City	City of Santa Barbara
fps	feet per second
ft	feet
gpm	gallons per minute
in	inch
MDD	maximum day demand
MB	million gallons
mgd	million gallons per day
MinDD	minimum day demand
PHD	peak hour demand
PRV	pressure-reducing valve
psi	pounds per square inch
ROW	right of way
TM	Technical Memorandum
TM	Transmission Main
WDIP	Water Distribution Infrastructure Plan
WTP	Water Treatment Plant

Technical Memorandum 3

DISTRIBUTION SYSTEM ANALYSIS

3.1 Introduction

The goal of the distribution system analysis is to evaluate the distribution system under various operating conditions and demand conditions. The existing distribution system is shown on Figure 3.1. Benchmark analyses were completed to predict the distribution system performance under normal operating conditions. The benchmark results are used to develop benchmark improvement projects and are compared to the system's performance during stress scenarios. The stress scenarios predict the system's resiliency and efficiency when key transmission mains and/or facilities are no longer in service. The purpose of the stress scenarios is to identify operational strategies and projects to improve the distributions system's reliability and capital improvement needs. Evaluation criteria were developed and utilized to predict distribution system's performance for benchmark analyses and stress scenarios.

The City of Santa Barbara (City) faces costly replacement and/or rehabilitation of aging infrastructure, including many reservoirs. The City has excess storage capacity proven by the desktop storage analysis, which is found in Technical Memorandum (TM) 2 of this Water Distribution Infrastructure Plan (WDIP). The excess storage gives the City the opportunity to take certain reservoirs out of service and strategically invest capital elsewhere, improving reliability and resiliency of the water system as a whole. The distribution system analysis was used to confirm the findings of the desktop storage analysis.

The following topics are included in TM 3:

- Distribution system evaluation criteria
- Benchmark distribution system analysis
- Ten stress analysis scenarios

TM 3 concludes with a summary of recommendations to mitigate potential deficiencies based on the analyses mentioned above.

3.2 Distribution System Evaluation Criteria

The City's distribution system was evaluated under a range of normal demand conditions during the planning period of the WDIP. The normal demand conditions are:

- Average Day Demand (ADD)
- Minimum Day Demand (MinDD)
- Maximum Day Demand (MDD), including Peak Hour Demand (PHD)

The planning horizon of this WDIP is year 2050, also referred to as future demand conditions, while existing demand conditions reflect year 2019 demands. The benchmark analysis and stress scenarios were evaluated using 2019 demand conditions, with the exception of Stress Scenario 10, which used 2050 demand conditions. The existing and future demands used for the distribution system analysis were developed in TM 2 of the WDIP.

Distribution system evaluation criteria are required to determine the performance of the City's distribution system under the range of operating conditions as discussed above and to identify system deficiencies and improvement projects. Under each operating condition, the capacities and performance of the water system are compared to the evaluation criteria to determine which pipelines or water facilities need to be upgraded or replaced. The evaluation criteria for the distribution system consist of system pressures and pipeline velocity. In addition to pressure and velocity deficiencies, reservoir levels within a 72-hour period are also evaluated to determine the reservoir's ability to cycle under ADD and MDD conditions. The evaluation criteria used for the evaluation of the City's distribution system is summarized in Table 3.1. Detailed descriptions for each evaluation criteria are provided following the table.

Table 3.1 Distribution System Evaluation Criteria Summary

Description	Criteria	
Maximum Desired Pressure[(1)]		
Average Day Demand	150 psi	
Minimum Day Demand	150 psi	
Minimum Desired Pressure		
Peak Hour Demand	35 psi	
Maximum Day Demand plus Fire Flow	20 psi	
Pipeline Criteria		
Maximum Velocity of Existing Pipelines under ADD	5 fps	
Maximum Velocity of Existing Pipelines under PHD	8 fps	
Target Velocity of New Pipelines ($\leq$ 12-inch diameter) under PHD	5 fps	
Target Velocity of New Pipelines ($\geq$ 16-inch diameter) under PHD	4 fps	
Fire Flow Criteria		
Foothill Residential	750 gpm	2 hours
Low Density Residential	750 gpm	2 hours
Medium Density Residential	750 gpm	2 hours
High Density Residential	1,250 gpm	4 hours
Commercial	1,250 gpm	4 hours
Industrial	2,500 gpm	4 hours
Public Facilities	1,250 gpm	4 hours
Open Space	750 gpm	2 hours

Notes:
(1) The maximum desired pressure of 150 psi can be exceeded as long the pipelines are meet the appropriate pressure classification and have historically not been problematic as customer connections in these locations are typically equipped with an individual (privately owned) pressure regulator to reduce pressures to about 80-90 psi

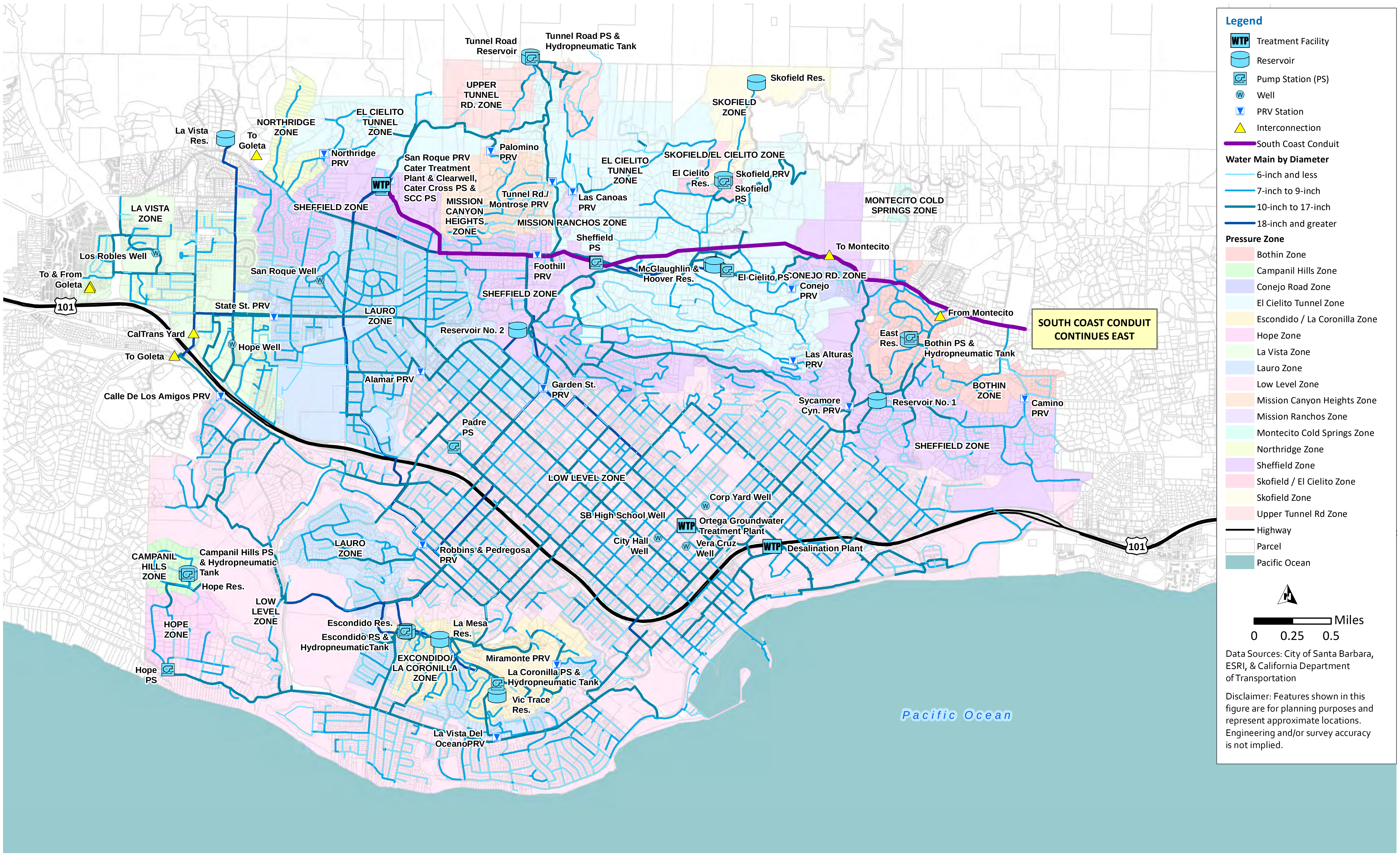


Figure 3.1 Existing Water Distribution System

3.2.1 System Pressures

The California Code of Regulations (CCR) 64602 states "each distribution system shall be operated in a manner to assure that the minimum operating pressure in the water main at the user service line connection throughout the distribution system is not less than 20 pounds per square inch at all times." This standard is typically applied to somewhat extreme conditions that are temporary in nature such as fire flow events. The American Water Works Association (AWWA) Manual on Distribution Network Analysis of Water Utilities (AWWA M-32), indicates that pressures between 30 pounds per square inch (psi) and 90 psi are generally expected during the range of system water demands. The City's goal has been historically to maintain a minimum pressure of at least 35 psi under normal demand conditions, while 20 psi is used as the minimum pressure criterion for fire flow conditions. For the purposes of the distribution system analysis, system pressures criteria were developed for various demand conditions, as summarized below.

- ADD: The maximum desired pressure of 150 psi is exceeded in various places in the distribution system due to the range in topography within some of the pressure zones. The maximum desired pressure can be exceeded as long the pipelines are meet the appropriate pressure classification. Moreover, the areas with high pressures have historically not been problematic as customer connections in these locations are typically equipped with an individual (privately owned) pressure regulator to reduce pressures to about 80-90 psi. These pressure regulators are a common, simple, and cost-effective solution. It is cost-prohibitive to create separate pressure zones, which also increases operational complexity and can lead to reduced reliability due to single feed area. While this high pressure criterion does not necessarily indicate that a capital project should be implemented, it is recommended that the City monitor pressures in these areas for an unusual amount of water main breaks and/or leaks.
- MinDD: Similar to ADD conditions, it is recommended that the City monitor the areas where the pressures exceed 150 psi.
- PHD: To provide adequate system pressures, it is recommended that the City maintains a minimum system pressure of 35 psi during a typical MDD and PHD condition.
- MDD + Fire Flow: To provide adequate system pressures during a fire flow event, it is recommended that the City maintains a minimum system pressure of 20 psi during a MDD plus fire flow conditions.

3.2.2 Distribution Mains

High velocities may cause damage to the pipes and to their appurtenances. Normally, velocities of 10 feet per second (fps) (AWWA M-32), or higher, do not cause ill effects if they occur for a limited duration. It is common industry practice to limit pipe velocities to no more than 8 fps on a continuous basis. In some cases a pipeline might exceed the maximum velocity criteria but for a short duration thus it is not considered continuous. A sustained velocity above 8 fps was chosen instead of 10 fps to limit the headloss through the system. As shown in Table 3.1, this study used a maximum pipeline velocity of 5 fps to size new distribution/transmission system pipelines 12-inches in diameter or less, while a criterion of 4 fps was used for new distribution system pipelines 16-inches in diameter and larger. For the purpose of the distribution system analysis, the maximum velocity criteria were developed for various demand conditions, as summarized below:

- Existing Pipelines under ADD Conditions: It is recommended that an existing pipeline's velocity does not exceed 5 fps during a typical ADD condition.
- Existing Pipelines under MDD Conditions: It is recommended that an existing pipeline's velocity does not exceed 8 fps during a typical MDD condition.
- New Pipelines with a Pipeline Diameter of 12-inches or Smaller under MDD Conditions: It is good practice that the new pipeline's velocity does not exceed 5 fps during a typical MDD condition.
- New Pipelines with a Pipeline Diameter Greater than 12-inches under MDD Conditions: It is good practice that the new pipeline's velocity does not exceed 4 fps during a typical MDD condition.

Ideally, all transmission and distribution pipelines should have a maximum velocity less than 8 fps to minimize head loss. However, higher velocities in existing pipelines are not, by itself, sufficient justification for pipeline replacement or parallel pipelines.

3.3 Fire Flow Analysis

A fire flow analysis was completed utilizing the evaluation criteria listed in Table 3.1. Based on these criteria, the existing fire flow system was evaluated with the hydraulic model to verify that a minimum pressure of 20 psi was met under MDD while maintaining a flow ranging from 750 gallons per minute (gpm) to 1,250 gpm within the corresponding land use category. Fire flow demands were added to model nodes that represent hydrant locations. It should be noted that each fire hydrant has a dedicated demand node, but not all demand nodes in the model represent hydrants. The areas with deficient fire flow availability at the minimum pressure criterion of 20 psi are shown on Figure 3.2.

There are 63 hydrant nodes in the model that did not meet the minimum residual pressure criterion of 20 psi under MDD conditions. With a total of 2,240 hydrants city-wide, this equates to approximately 3 percent of the City's hydrants. Of these 63 hydrants, 5 were classified as "Dead End Hydrants", 3 were classified as "Split Fire Flow Hydrants", and the remaining 55 were classified as "Deficient Fire Flow Hydrants". The locations of these deficient hydrants are depicted on Figure 3.2, while the classifications are defined as follows:

- Split Fire Flow Hydrants – In some cases, the required fire flow demand (1,250 gpm or 2,500 gpm) could potentially be met by flowing half of the demand with another adjacent hydrant. Only hydrant nodes requiring a flow of 1,250 gpm or greater were attempted to split. Hydrant nodes with the fire flow demand of 750 gpm were not candidates for fire flow splitting as it is expected that most hydrants are capable of achieving this flow rate.
- Dead End Hydrant – The City has expressed concern with upsizing or replacing pipelines that feed dead end hydrants due to water quality concerns. The City's future plans involve removing dead end hydrants and using hydrants downstream up the dead ends for fire protection. A model node was considered a dead end hydrant and removed from the deficient hydrant list if there was another hydrant (which meets the fire flow pressure criteria for the hydrant in question) within 500 feet of the model node and surrounding parcels, which the hydrant is providing fire protection for. Not all hydrants on dead end streets met this criteria.

- Deficient Fire Flow Hydrants – Any hydrant node that did not meet minimum pressure criterion of 20 psi, and was not considered a Split Hydrant or a Dead End Hydrant, was grouped into this category.

The Split Hydrants, and Dead End Hydrants were removed from the list of deficient model nodes, resulting in only 55 model nodes not meeting the minimum residual pressure criterion of 20 psi. Subsequently, City staff went out in the field and conducted 49 fire flow tests between June 3 and June 15, 2020 to verify that the hydrants closest to these model nodes could not meet the minimum fire flow demand at 20 psi. Based on field testing, 33 locations were found to meet pressure and flow requirements under the demand conditions present on June 3, 2020. This resulted in 22 fire hydrant locations requiring system improvements. A total of 13 fire flow improvements projects were identified to mitigate the 22 deficiencies. These 13 fire flow projects are listed in Table 3.2 and depicted on Figure 3.3.

Table 3.2 Fire Flow Improvements

Fire Flow CIP ID	Pressure Zone	Location(2)	Type	Existing Diameter (in)	Replacement Diameter (in)	Pipeline Length (ft)
FF-1	Conejo	Conejo Road and Orizaba Lane	Replace	6	8	950
FF-2	Bothin	Sycamore Vista Road and Canon View Road	Replace	2	4	150
FF-3	Sheffield	N Ontare Road and Langlo Terrace	Replace	4 6	6 8	500 300
FF-4	Lauro	La Cima Road	Replace New	4 n/a	6 6	100 350
FF-5	Low Level	La Marina and Cliff Drive	Replace	6	8	1,750
FF-6	Low Level	Arroyo Burro Beach	Replace	4	6	400
FF-7	Low Level	De La Vista Avenue and North Salsipuedes Street	Replace	4	6	250
FF-8	Low Level	East De La Guerra Street and Chiquita Road	Replace	4	6	750
FF-9	Low Level	Harbor View Drive and Old Coast Highway	Replace	6	8	600
FF-10	El Cielito Tunnel	Mira Vista Avenue and San Carlos Road	Replace	4	6	1,050
FF-11	Sheffield	Alston Road and Summit Road	Replace	6	8	1,450
FF-12	Sheffield	Alameda Padre Serra and Knoll Circle Drive	Replace	6	8	1,550
FF-13	El Cielito Tunnel	Holly Road(2)	New	n/a	6	100
Total Length (ft)						**10,250**

Notes:
(1) Connect deficient hydrant to higher-pressure zone.(2) Location description from initial model analysis. Actual improvement location and pipeline length should be verified and adjusted as needed to incorporate site constraints.
(2) Reconnect hydrant lateral FHV-EO2-00 from El Cielito Tunnel Zone to Upper Tunnel Road Zone.

As shown in Table 3.2, 13 fire flow improvements have been proposed involving replacing and upsizing existing pipelines, completing pipeline loops, and connecting hydrants to higher pressure zones. Approximately 450 feet new pipeline is proposed. Additionally, approximately, 9,800 feet or 1.9 miles of pipeline is proposed to be replaced. The proposed projects are preliminary recommendations. Each of these recommended projects need evaluation of site-specific solutions (e.g. consider unstable soil, easements, etc.) in the design stage, prior to construction. The general locations of the recommended improvement projects are shown on Figure 3.3 and a description of their locations is included in Table 3.2 and in the Capital Improvement Plan (CIP) represented in the Executive Summary of this report.

3.4 Benchmark Analysis

The benchmark analyses help predict the distributions systems performance under normal operating conditions. The goal of the benchmark analysis is to evaluate the existing distribution system utilizing the evaluation criteria summarized in Table 3.1. This section presents the assumptions and results of the benchmark analysis, which include an evaluation of system pressure and pipeline velocity. The benchmark analysis uses the hydraulic model to identify pressure deficiencies, water main velocity deficiencies, and reservoir levels under existing ADD, MinDD, and MDD conditions. It should be noted that the hydraulic model is the only tool used to help predict the water distribution system's performance and that any recommendations need to be verified during feasibility study and design phases for proper sizing and system operations.

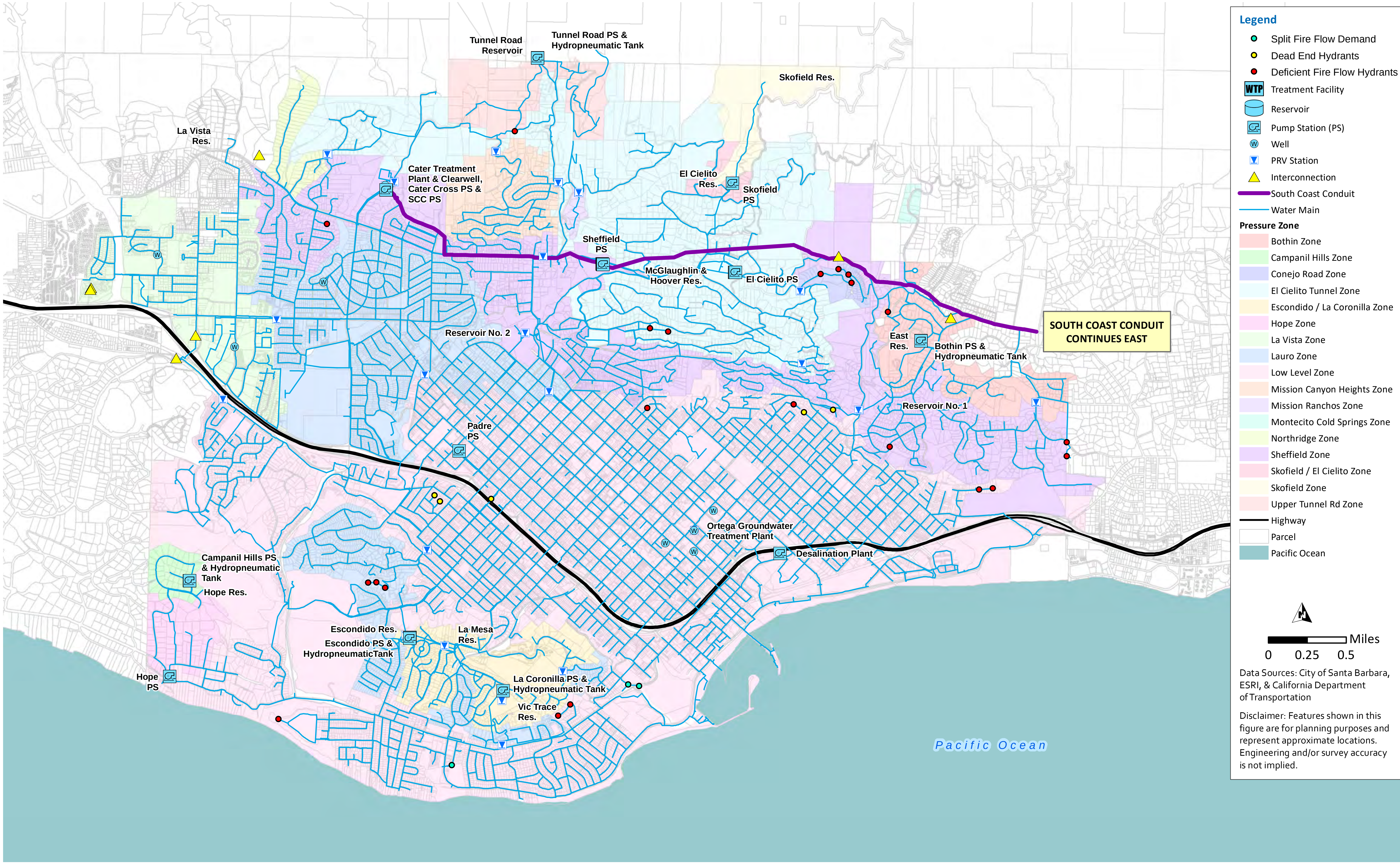


Figure 3.2 Fire Flow Deficient Hydrants - 2019 MDD (Average Hour)

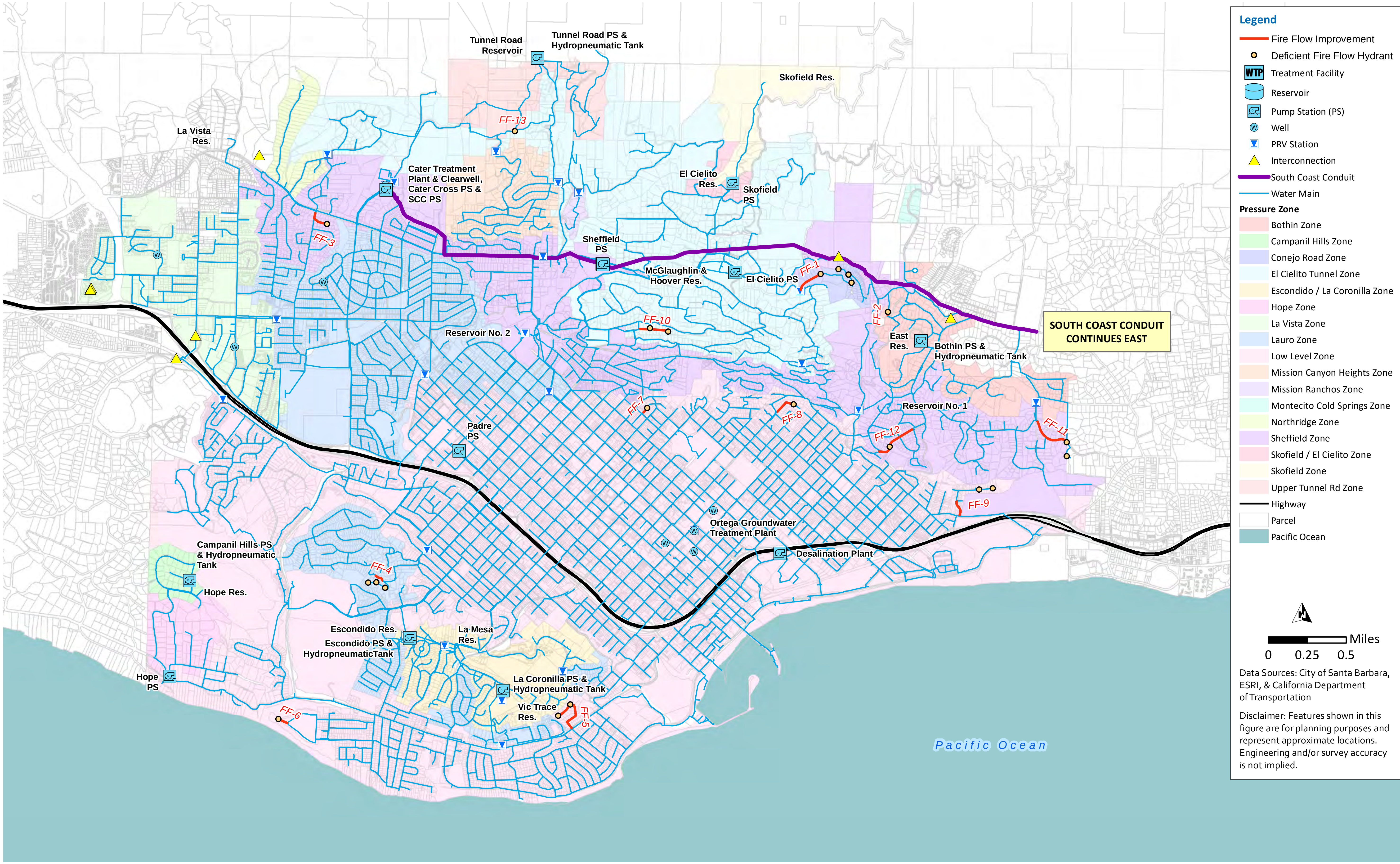


Figure 3.3 Fire Flow Improvement Projects - 2019 MDD (Average Hour)

3.4.1 Analysis Assumptions

This section summarizes the active facilities and supply distribution assumptions used for the distribution system analysis. The calibrated hydraulic model was updated to include the benchmark scenarios. More details on the hydraulic model update and calibration is discussed in TM 1. It should be noted that the Sycamore Canyon pressure-reducing valve (PRV) was out of service during the hydraulic model calibration but came back online on July 22, 2019. For the analysis it is assumed to be out of service unless otherwise stated.

A summary of the assumed supply capacity of the City's supply facilities under the various demand conditions is listed in Table 3.3. The production varied between 16,100 gpm under MinDD conditions to 23,100 gpm under MDD conditions.

Table 3.3 Distribution Analysis Supply Assumptions

Supply Facility	ADD (gpm)	MinDD (gpm)	MDD (gpm)
Ortega WTP(1,2)	1,350	1,350	1,350
Desal Plant	2,100	2,100	2,100
Cater WTP(3)	13,000	12,000	19,000
Hope Well	200	200	200
Low Robles Well	70	70	70
San Roque Well	380	380	380
Total	**17,100**	**16,100**	**23,100**

Abbreviations:
Ortega WTP: Ortega Groundwater Treatment Plant
Desal Plant: Charles Meyer Desalination Plant
Cater WTP: William B. Cater Water Treatment Plant

Notes:
(1) Ortega Groundwater Treatment Plant controlled by Ortega Clearwell level.
(2) The Ortega Groundwater Treatment Plant is assumed to deliver directly into the proposed 24-inch diameter Desal Transmission Main (TM) for the scenarios that include this TM and remain current delivery into the Low Level Zone for all other scenarios.
(3) Cater Treatment Plant controlled by Cater Clearwell level.

3.4.2 System Pressures Analysis

Based on the evaluation criteria listed in Section 3.2 of this TM, the system pressures were evaluated for the distribution system under existing demand conditions. The hydraulic model was used to identify areas that exceeded the maximum pressure criteria under ADD and MinDD conditions, as well as areas that fell below the minimum pressure criteria under MDD conditions. The results from this pressure analysis were predicted by the model.

Based on evaluation criteria described in Section 3.2.1, a maximum pressure criteria of 150 psi is used to identify areas of the City's existing system that should be supplied through pipelines with a pressure class rating exceeding P150 and are recommended to have individual pressure regulators at customer connections to protect interior plumbing and appliances. These high pressure areas should be monitored for an unusual amount of main breaks and leaks. It should be noted that main breaks can be attributed to many factors such as pipeline age, material, soil compaction during construction, ground movement and others.

ADD Maximum Pressure Analysis

Under 2019 ADD conditions, the hydraulic model identified several areas with pressures greater than 150 psi. Based on the hydraulic analysis, approximately 91 percent of the model nodes are predicted to have system pressures below 150 psi, which are shown in green on Figure 3.4, and approximately 9 percent of the modeled system nodes exceed 150 psi, as shown in red on Figure 3.4. Most of the high system pressures are within the El Cielito Tunnel Zone and the Sheffield Zone are in areas with high static head due to relatively low ground elevations. It is not recommended to change pressure zone boundaries unless an unusual amount of water main breaks and/or leaks would start occurring in these areas.

MinDD Maximum Pressure Analysis

Based on evaluation criteria described in Section 3.2.1, a maximum pressure criteria of 150 psi under MinDD conditions is used to identify areas of the City's existing system that should be monitored for an unusual amount of main breaks/leaks. Under 2019 MinDD conditions, the hydraulic model identified several areas with pressures greater than 150 psi, which are presented on Figure 3.5. Based on the hydraulic analysis, approximately 10 percent of the modeled system nodes exceed 150 psi, as shown in red on Figure 3.5.

As observed during ADD conditions, the high-system pressures within El Cielito Tunnel Zone and Sheffield Zone are caused by high static head. The hydraulic analysis shows an increase in high system pressures within the Low Level Zone under MinDD conditions.

MDD Minimum Pressure Analysis

Based on evaluation criteria described in Section 3.2.1, a minimum pressure criteria of 35 psi is used to evaluate the City's existing system under MDD conditions. Under existing MDD conditions, the hydraulic model identified some isolated areas with pressures less than 35 psi, which are presented on Figure 3.6.

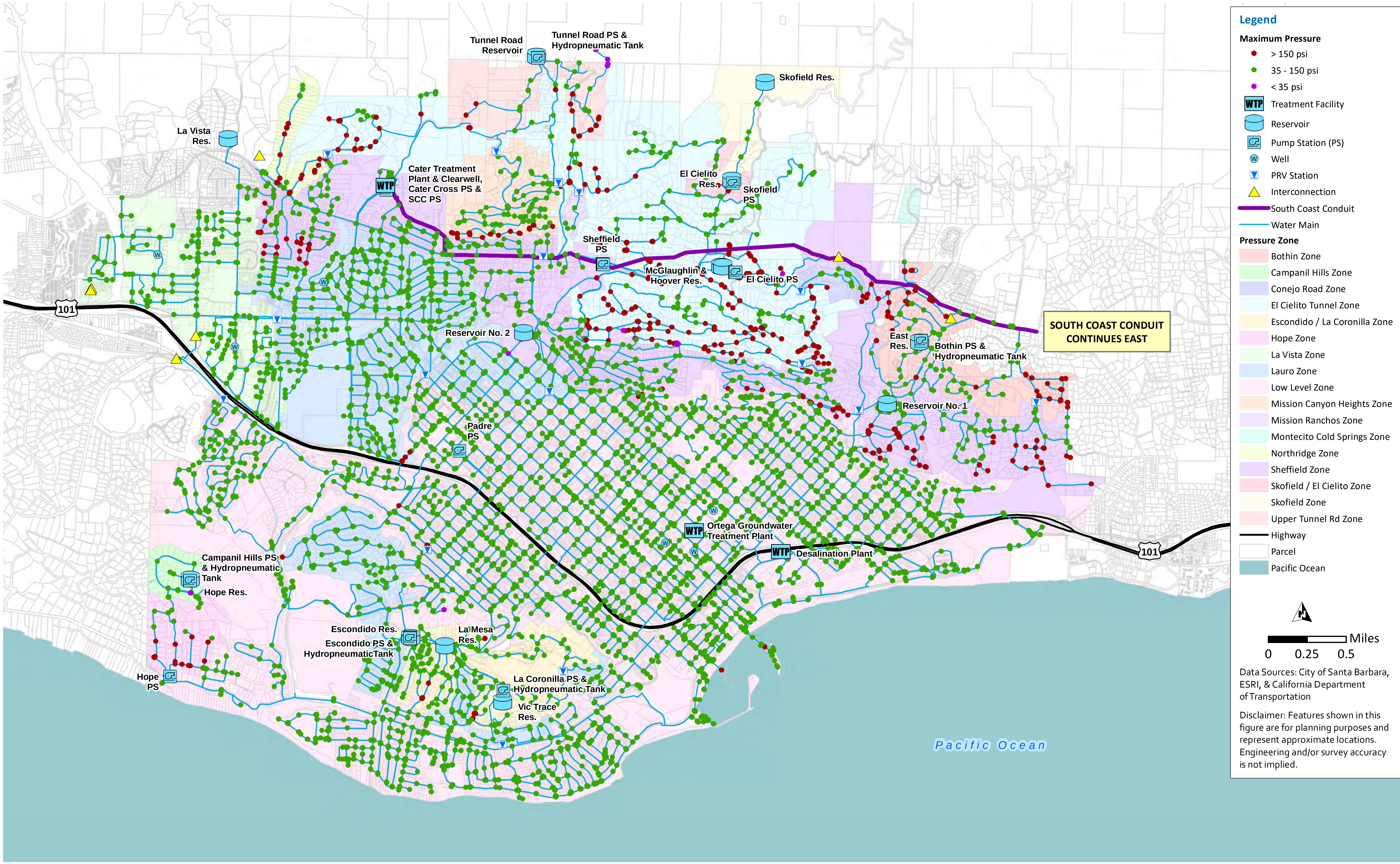


Figure 3.4 Maximum Pressure Analysis Benchmark - 2019 ADD

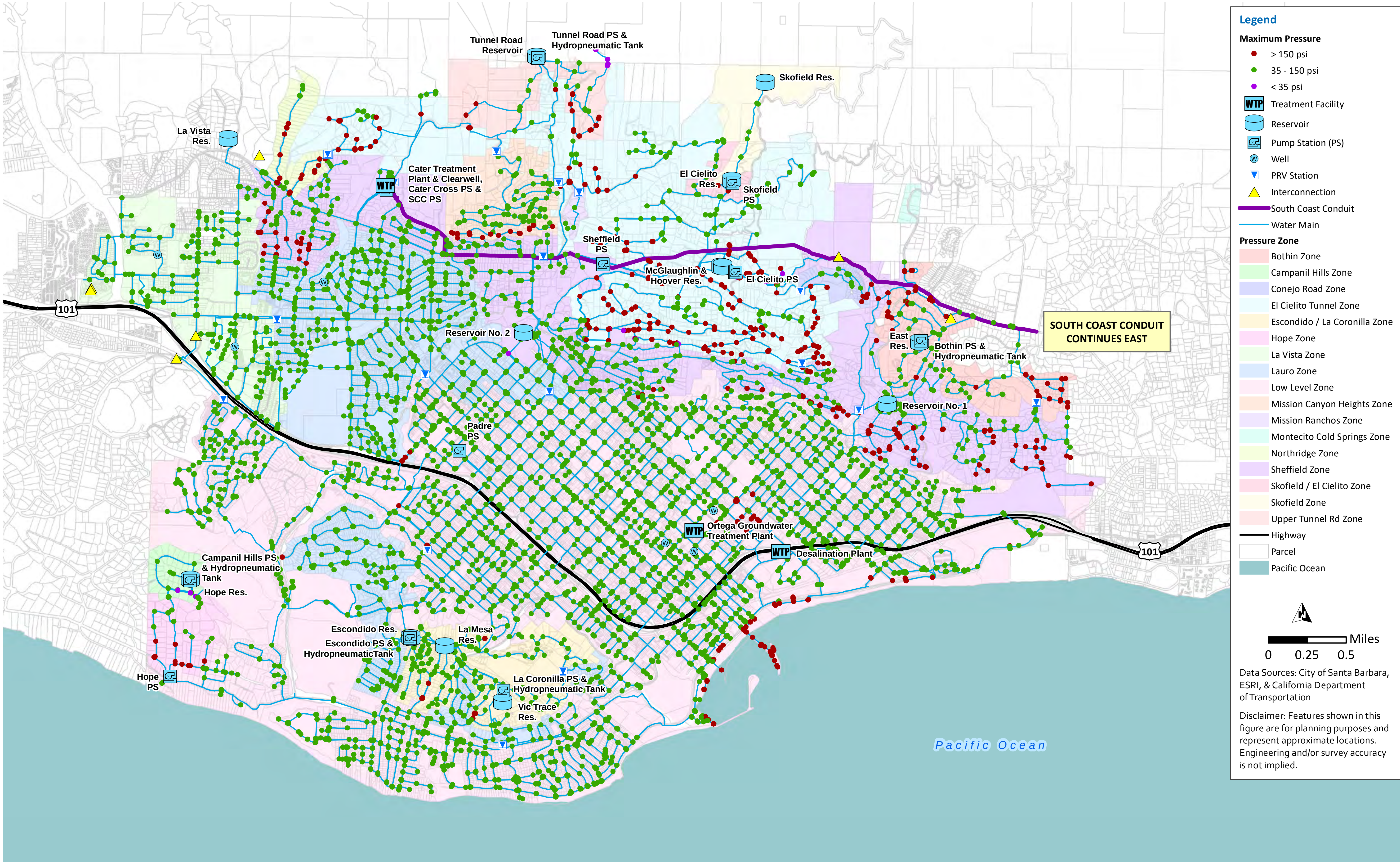


Figure 3.5 Maximum Pressure Analysis Benchmark - 2019 MinDD

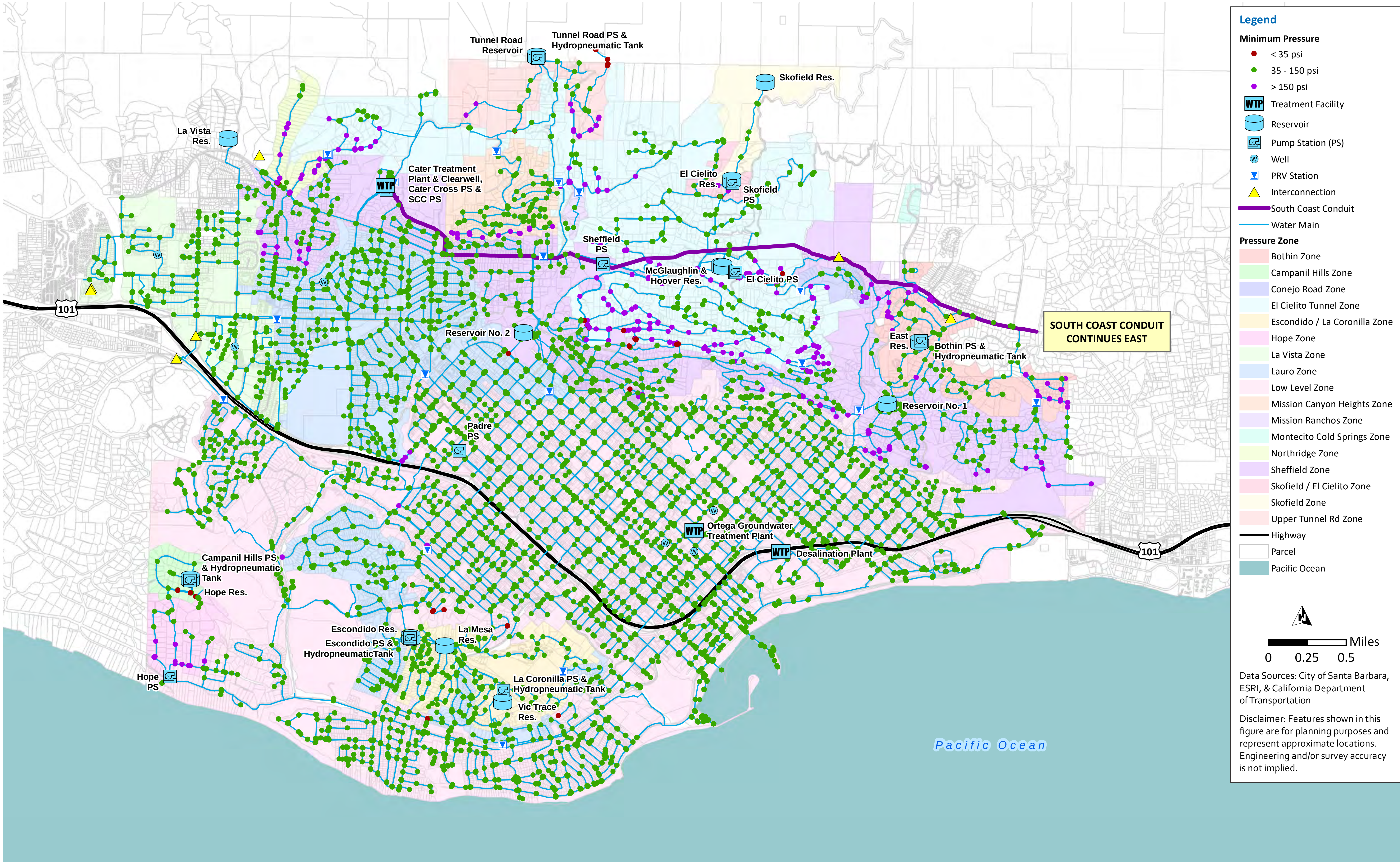


Figure 3.6 Minimum Pressure Analysis Benchmark - 2019 MDD

Some of the low pressures are caused by insufficient static head. As discussed above, it is not recommended to change pressure zone boundaries.

The majority of the low system pressures occur within the Sheffield Zone. No specific near-term or rezoning projects are recommended to increase system pressures as these system pressures are primarily driven by low static head. As system demands have declined in the past decade due to conservation, system pressures are likely to have either remained stable or improved slightly. Generally, these low pressures have not posed any significant issues, making rezoning projects unwarranted at this time. Instead replacing the aging infrastructure and/or upsizing small diameter water mains in Sheffield Zone has the potential to improve low system pressure not caused by insufficient static head.

It is recommended that the City replace water mains that reach the end of their useful life and generally upsize small diameter water mains (less than 8 inches) with a minimum of 8-inch diameter pipeline. This pipeline replacement criteria should typically be applied to the main water distribution grid only. Smaller diameters can be more appropriate in dead-end mains and other mains where water age is a concern. Therefore, the minimum water main replacement diameter recommendation of 8-inches can be reduced, as appropriate, on a case-by-case basis.

3.4.3 Distribution Main Analysis

The hydraulic model was used to evaluate pipeline velocities in the existing system under existing ADD and MDD conditions. As listed in Table 3.1, the pipeline velocity analysis was performed to identify pipelines within the distribution system with velocities that exceed 5 fps and 8 fps under ADD and MDD conditions, respectively. Maximum modeled system velocities under 2019 ADD and MDD conditions are shown on Figure 3.7 and Figure 3.8, respectively.

Approximately 6,500-feet (or 1.2 miles) of pipeline exceeded the maximum allowable velocity of 5 fps under existing ADD conditions. The locations of these pipes are depicted in red on Figure 3.7. In addition, approximately 1,800 feet of pipelines exceeded the maximum allowable velocity of 8 fps under existing MDD conditions. The locations of these pipes are depicted in red on Figure 3.8.

The following summarizes the velocity deficiencies and recommendations:

- Approximately 950 feet of 12-inch diameter pipeline near Hoover and McLaughlin Reservoirs exceeds the maximum velocity of 8 fps under existing MDD conditions. Based on the location of the pipeline, the high velocities are likely a result of operational conditions of the reservoirs. No improvements are recommended to mitigate the high velocities.
- Approximately 600 feet of 17-inch diameter pipeline near Hoover and McLaughlin Reservoirs exceeds the maximum velocity of 5 fps under existing ADD conditions. Based on the location of the pipeline, the high velocities are likely a result of operational conditions of the reservoirs. No improvements are recommended to mitigate the high velocities.
- Approximately 200 feet of 6-inch diameter pipeline segment along a right of way (ROW) between Surf View Drive and Calle Cortita within Escondido La Coronilla Zone exceeds the maximum velocity criteria of 5 fps under existing ADD conditions. It is recommended that a new pipeline be constructed along Sun Rise Vista Way that will

create a loop. This project consists of approximately 600 feet of new 8-inch diameter pipeline (Project TM-5).

- Approximately 3,500 feet of 8-inch, 10-inch, 12-inch, and 14-inch diameter pipelines along Los Olivos Street and Mission Canyon Road between Alameda Padre Serra and Foothill Road within Sheffield Zone exceeds the maximum velocity criteria of 5 fps under existing ADD conditions are caused by temporary fill cycles of Reservoir 2 from the Sheffield Zone. Due to the temporary nature and the lack of associated pressure deficiencies, no recommendation was made to mitigate this velocity deficiency.

3.4.4 Reservoir Level Analysis

The reservoir level analysis demonstrates the reservoir's ability to cycle over an extended period. The hydraulic model was used to predict reservoir levels over a 72-hour period under existing ADD and MDD conditions and shown on Figure 3.9 and Figure 3.10, respectively. The hydraulic analysis shows that the reservoirs are able to cycle using benchmark operations under existing ADD and MDD conditions. The hydraulic model shows Reservoir 1 empties under MDD conditions. The City confirmed that it is typical for Reservoir 1 to operate this way. The City has reviewed this operating condition with the State Department of Drinking Water and determined this mode of operation is acceptable.

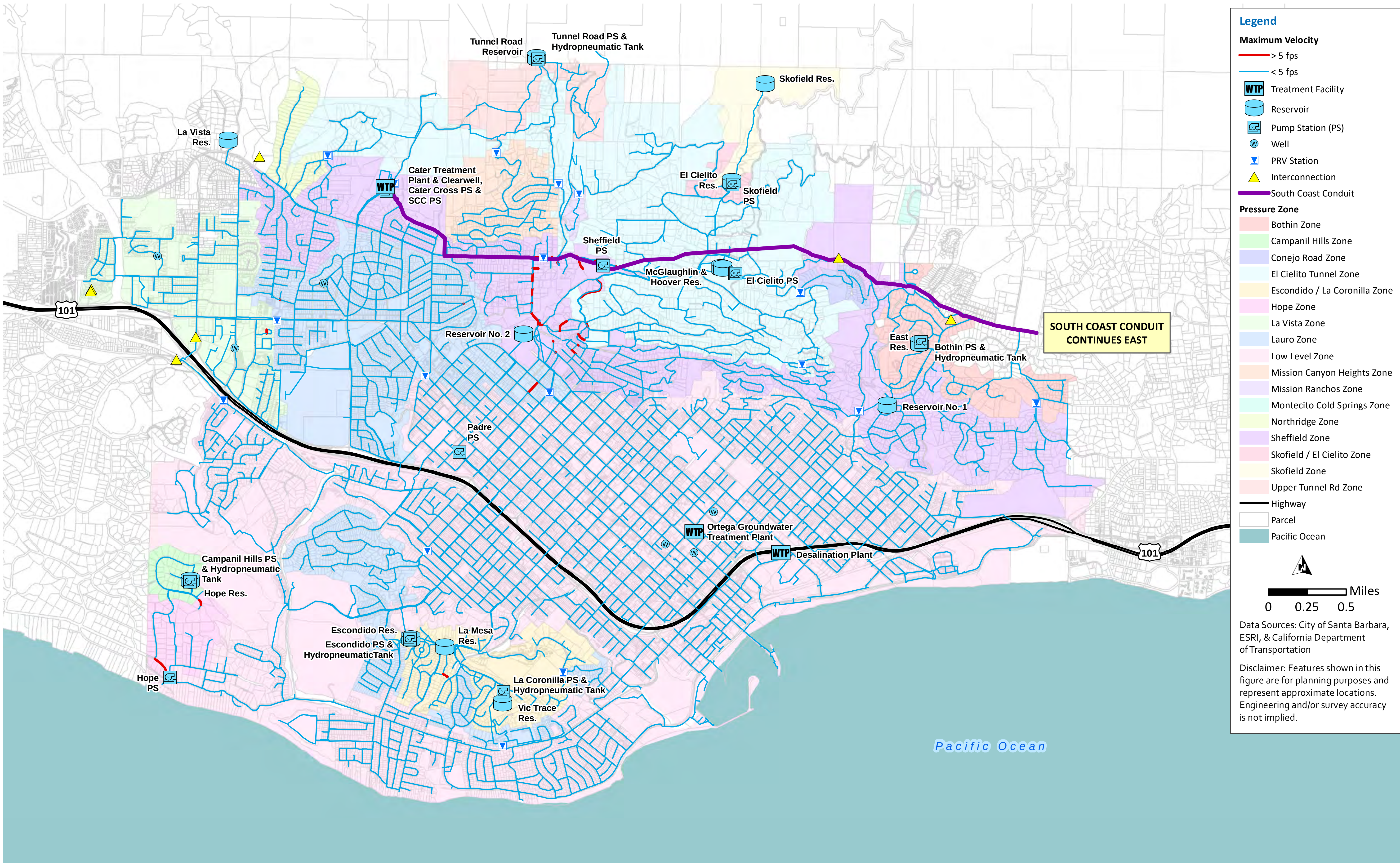


Figure 3.7 Maximum Velocity Analysis Benchmark - 2019 ADD

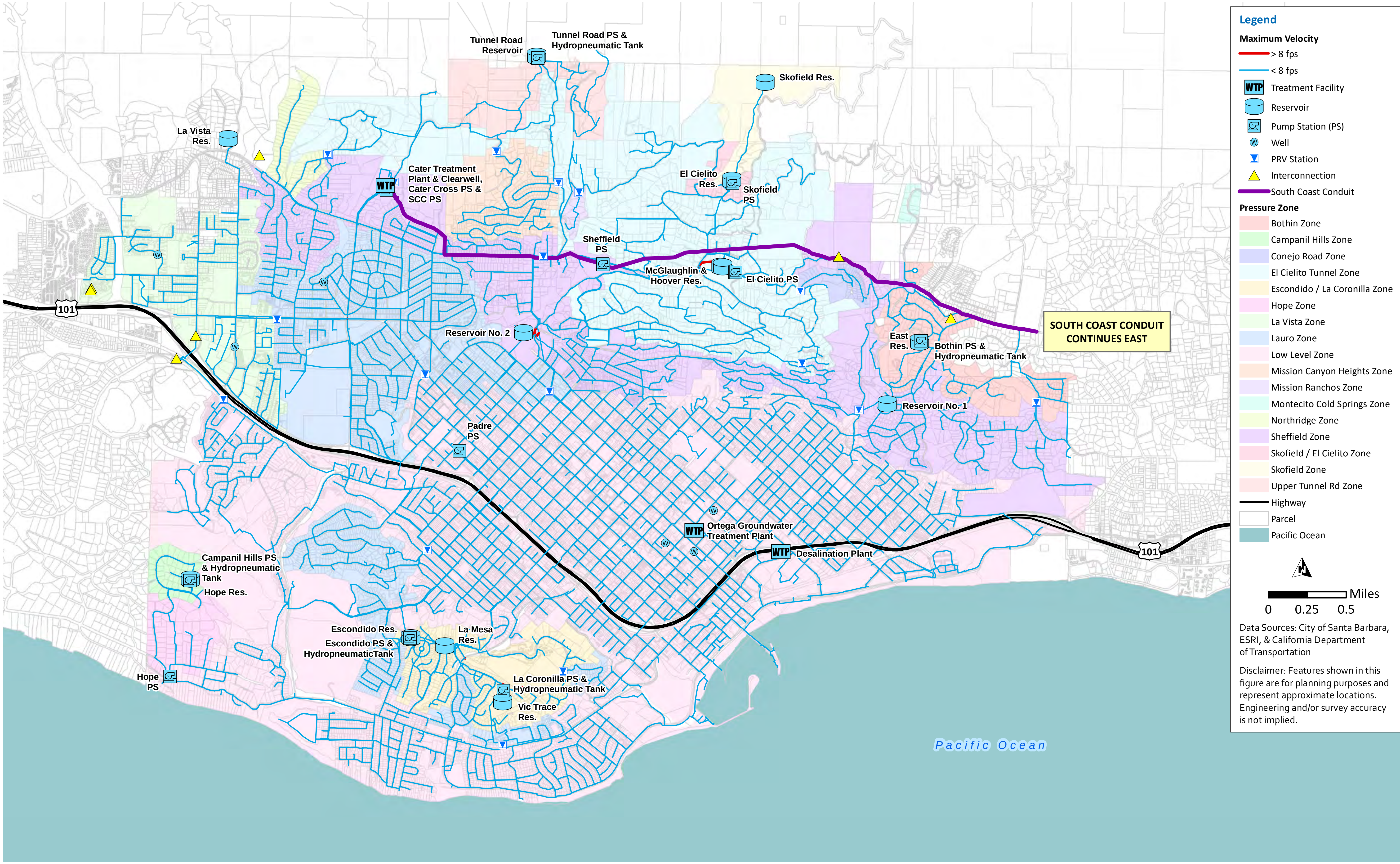


Figure 3.8 Maximum Velocity Analysis Benchmark - 2019 MDD

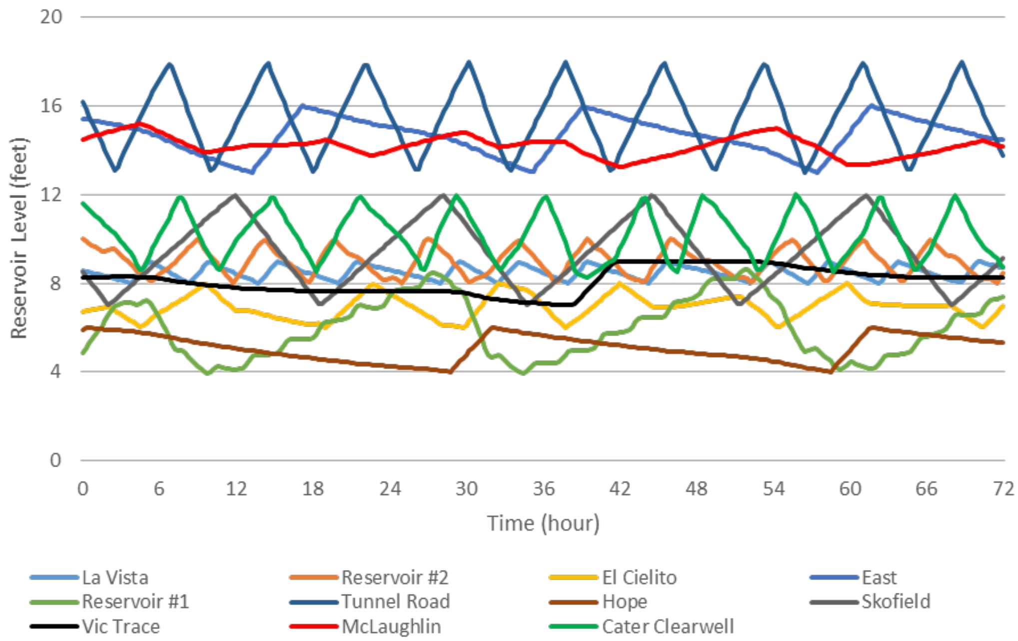


Figure 3.9 Reservoir Level Analysis Benchmark – 2019 ADD

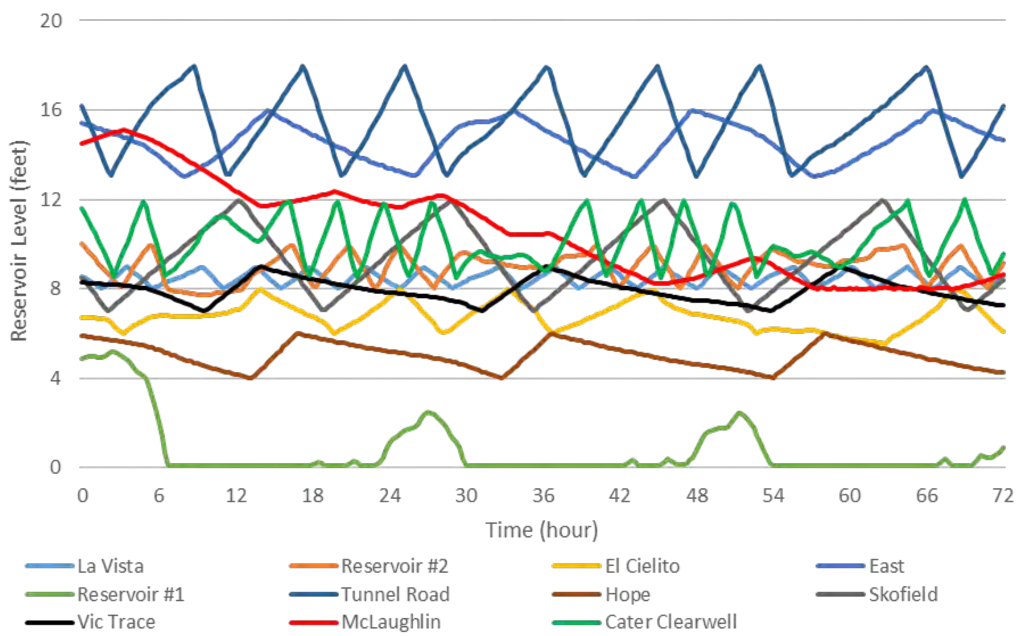


Figure 3.10 Reservoir Level Analysis Benchmark – 2019 MDD

3.5 Stress Scenarios

The purpose of the stress analysis is to analyze the existing system performance when key facilities and/or transmission mains are out of service. The City and Carollo Engineers, Inc. (Carollo) developed 10 stress scenarios. The hydraulic model was used to mimic these scenarios and analyze system pressures, velocities, and reservoir levels to determine potential capital improvement projects and/or operational modifications. The hydraulic analysis results include some initial common-sense operational modifications (e.g., both Hoover and McLaughlin Reservoirs were assumed to be operational when Vic Trace is taken out of service for maintenance). Additional solutions were developed to accomplish hydraulically desired performance (e.g., avoid over-pressurizing the Low Zone by adjusting PRV settings and the installation of pressure relief valves at locations that will allow discharge of excess water to a storm drain, open channel, or open space, if needed).

Some stress scenarios include the planned 24-inch diameter dedicated Desalination Conveyance Transmission Main (also referred to as the Desal TM), as shown on Figure 3.11. The proposed dedicated Desalination Conveyance Transmission Main would convey desalinated water from the Desalination Plant to higher zones. The Desalination Conveyance Transmission Main consists of the construction of approximately 13,000 feet 24-inch diameter transmission main between the Desalination Plant and the intersection of Mission and Garden Streets (Project TM-1A). From there, existing 24-inch and 30-inch diameter transmission mains are isolated via valves to convey the water between the intersection of Mission and Garden Streets and Cater WTP. In addition, new field piping at the Cater WTP that connect the Desalination Conveyance Transmission Main with the Cater Clearwell would be required (Project TM-1B).
The Desalination Pump Station (PS) will also require upgrades so it can pump the additional head required to reach the Cater Clearwell (Project PS-1).

A new PRV Station at Yanonali Street will be constructed at the Desalination Plant so that Cater WTP can deliver water to the Low Level Zone directly. This PRV is also part of the Desal TM project (Project TM-1A).

In addition, the supply from the Ortega WTP will connect to the planned Desalination Conveyance Transmission Main with via approximately 1,300 feet of 16-inch diameter water main (Project TM-6). This includes upgrading the Ortega PS so that it can pump the additional 140-feet of head required to reach the Cater Clearwell (Project PS-2).

Table 3.4 summarizes the 10 stress scenarios.

Table 3.4 Stress Scenarios Summary

Scenario No.	Description	Type	With or Without Desal TM?
1	Main break along a 24-inch diameter pipeline (E9-4) near Robbin Street	Operations	Without
2	Main break along a 36-inch diameter pipeline (D3-50) at the intersection of San Roque Road and Foothill Road.	Operations	With
3	Cater WTP has lost connection to Gibraltar Reservoir and Lake Cachuma so is not producing water, but the Cater Clearwell can receive/distribute water from other sources.	Supply	With

Scenario No.	Description	Type	With or Without Desal TM?
4	Cater WTP has lost connection to Gibraltar Reservoir and Lake Cachuma, but the Cater Clearwell can receive/distribute water from other sources.	Supply	Without
5	Vic Trace Reservoir is out of service, due to rehabilitation. Evaluated for 7-days EPS.	Operations	Without
6	La Vista Reservoir out of service, and all the division gates between La Vista Zone and Lauro Zone are opened eliminating the La Vista Zone increasing the Lauro Zone. Downsize existing 22-inch to a 12 –inch diameter pipeline down Hope Avenue, and add a 12 inch diameter pipeline from San Roque and Foothill to La Vista Reservoir.	Operations	Without
7	Reservoirs 1 and 2 and La Mesa Reservoir are out of service, to show how the Low Level Zone functions without an open reservoir.	Operations	With
8	Reservoirs 1 and 2 and La Mesa Reservoir are out of service to show how the Low Level Zone functions without an open reservoir.	Operations	Without
9	Desalination Plant is out of service. This scenario will evaluate the reverse flow in the proposed dedicated 24-inch diameter pipeline using the new Yanonali PRV station.	Operations	With
10	Evaluates how the City wants to operate their system by 2050. Scenario 10 involves taking many reservoirs out of service in order to allocate resources to less facilities. See Section 3.4.10 for detailed description.	Operations /Supply	With

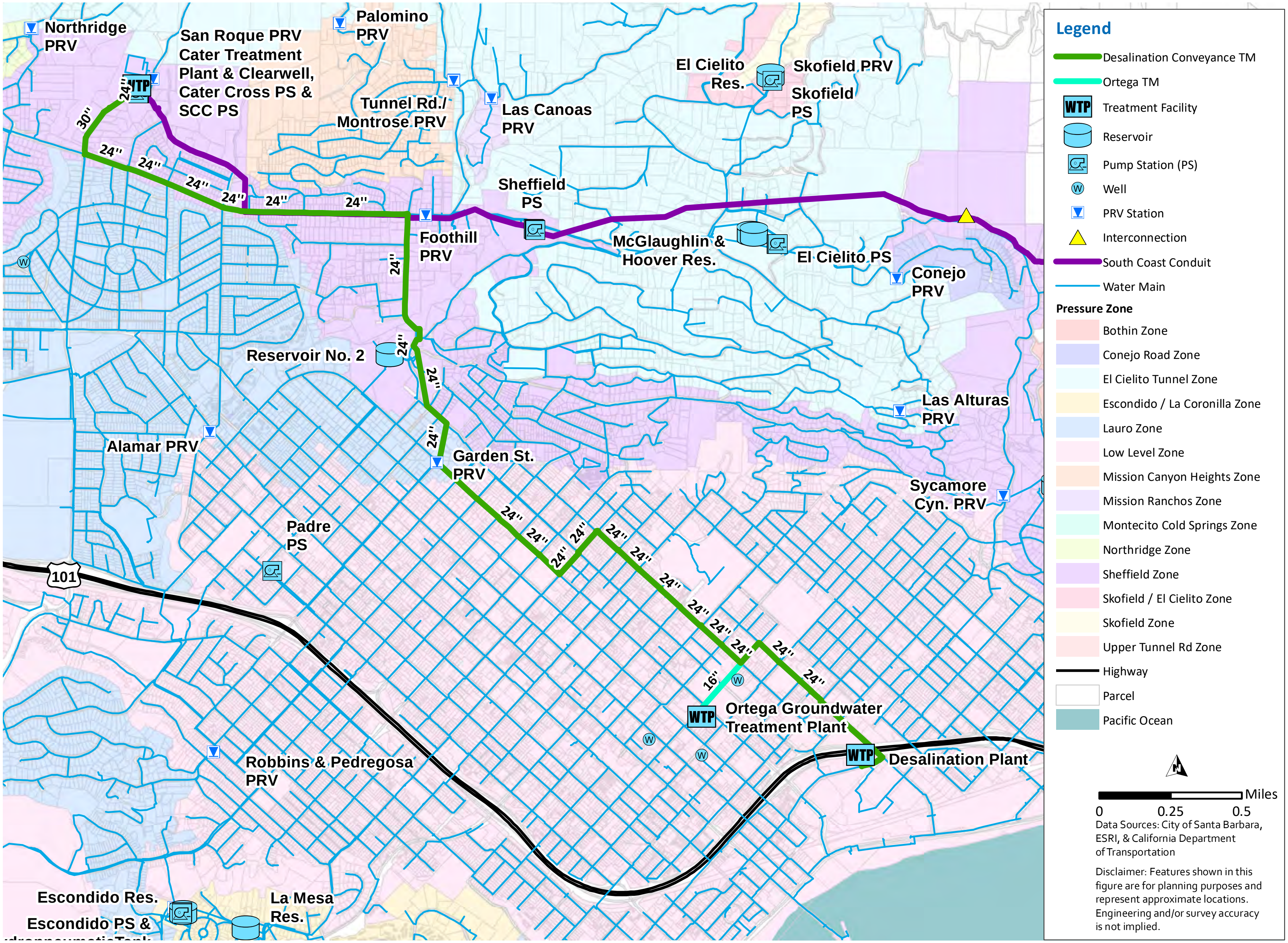


Figure 3.11 Desalination Conveyance Transmission Main

The results of each stress scenario are discussed in the following sections. The pressure and velocity results from each stress analyses were compared to the benchmark analysis to identify additional pressure and velocity deficiencies. Figures depicting new areas of pressure and velocity deficiencies for each scenario under MDD conditions can be found in Appendix 3A.

In addition to pressure and velocity deficiencies, reservoir levels within a 72-hour period were also evaluated to determine the existing reservoir's ability to cycle for each scenario under ADD and MDD conditions. Graphs of the reservoir levels are shown under their respective scenario.

During the hydraulic analysis some of the scenarios show that some of the reservoirs are unable to avoid complete draining during the 72-hour model simulation. Where applicable, operational recommendations were made to isolate main breaks, change the status of facilities, and other initial operational changes to avoid that parts of the system become isolated during the 72-hour model runs. It should be noted that the sequence to open and close facilities is highly dependent on the initial model settings and actual field conditions. During an outage scenario, it is recommended that the City balance system demands/storage in upper and lower zones (i.e. opening a PRV to move stored water from a higher zone to a lower zone where the reservoir is nearly empty) to avoid complete drainage of any reservoir.

3.5.1 Scenario 1

Scenario 1 evaluates the system's response to a main break in the 24-inch diameter transmission main (E9-4) that is located near Robbin Street, as shown on Figure 3.12. This evaluation was completed without the planned dedicated Desalination Conveyance Transmission Main, which means that the Ortega WTP is pumping directly into the Low Level Zone.

A portion of Lauro Zone and Escondido La Coronilla Zone become isolated from the rest of the distribution system during Scenario 1. This analysis evaluates the operational recommendations needed to mitigate system deficiencies caused by this main break until it is fixed.

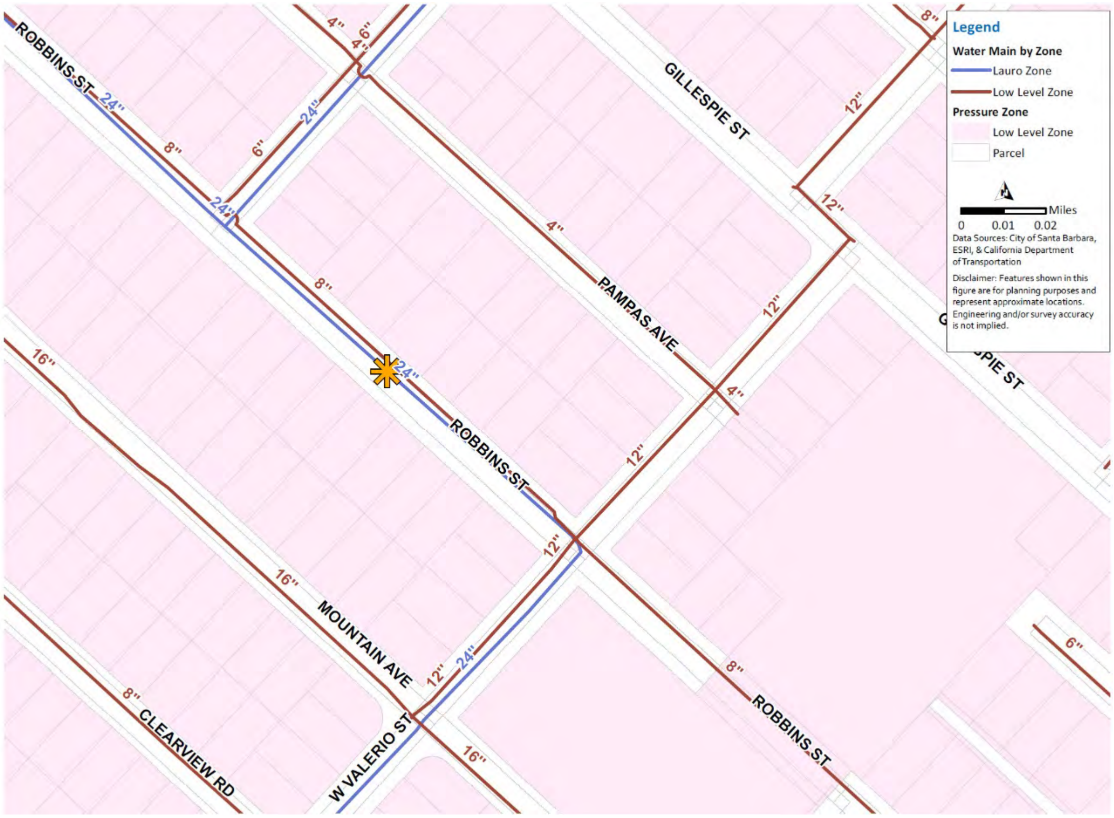


Figure 3.12 Stress Analysis Detail - Scenario 1

The following three valves must be closed to isolate the broken water main (E9-4):

- Close valve WV-D09-048 at the intersection of Robbins Street and West Islay Street.
- Close valve WV-E09-016 along West Islay Street between Gillespie Street and Pampas Avenue.
- Close valve WV-E09-013 at the intersection of Robbins Street and West Valerio Street.

The following operational changes are recommended in the event water main (E9-4) breaks:

- Open Sycamore Canyon PRV Station to enable Sheffield Zone to supply Low Level Zone. This extends the time it takes Vic Trace Reservoir to empty.
- Close La Vista del Oceano PRV Station to extend the time it takes Vic Trace Reservoir to empty.

The hydraulic model was used to predict reservoir levels over a 72-hour period under Scenario 1 ADD and MDD conditions and shown on in Figure 3.13 and Figure 3.14, respectively. The hydraulic analysis demonstrates the reservoirs are able to cycle for 72-hours using Scenario 1 with the initial operational modifications under existing ADD and MDD conditions.

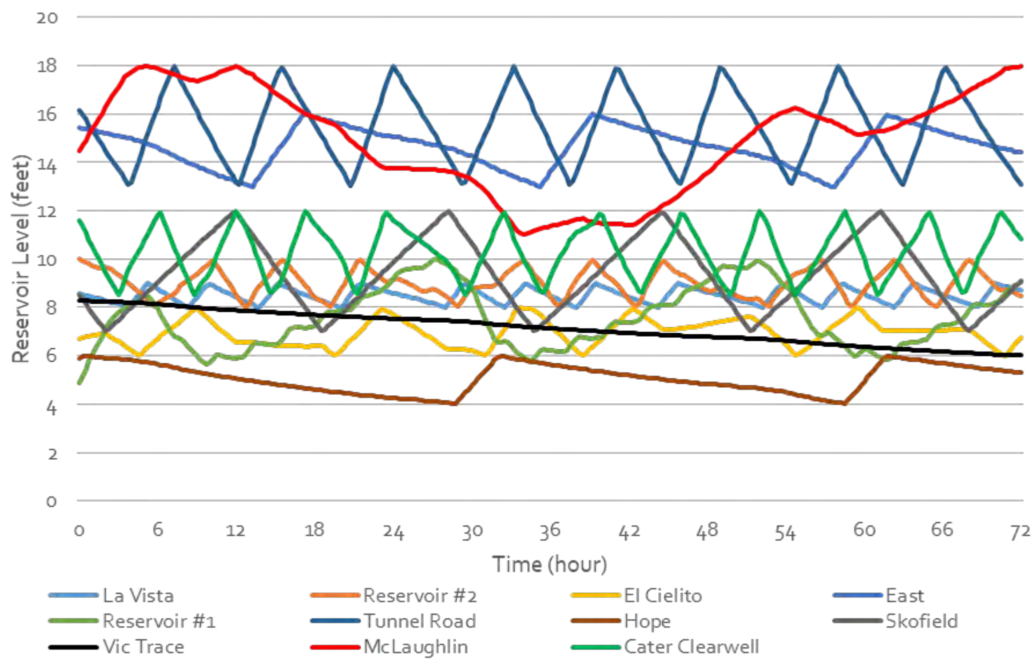


Figure 3.13 Reservoir Level Analysis Scenario 1 – 2019 ADD

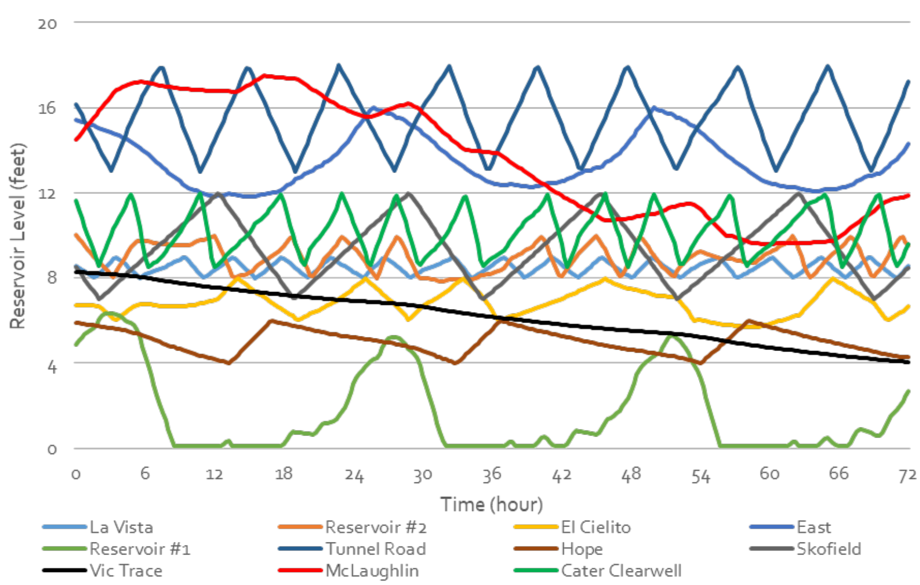


Figure 3.14 Reservoir Level Analysis Scenario 1 – 2019 MDD

A comparison between Scenario 1 deficiencies and benchmark deficiencies under existing MDD conditions is provided in Appendix 3A. The new Scenario 1 system deficiencies are minor and no capacity improvements are recommended.

A main break like this would take typically approximately 24-hours to repair, assuming that City staff has the necessary parts and materials on hand. The recommended operational changes are considered adequate because the reservoirs are able to cycle for 72-hours. However, some additional recommendations are described below:

- Have the necessary parts and materials ready on hand in case of a 24-inch diameter transmission main break.
- Implement water restrictions in the Lauro Zone and Escondido La Coronilla Zone if there is an unexpected delay with the repair.

3.5.2 Scenario 2

Scenario 2 evaluates the system's response to a main break in the 36-inch diameter pipeline (D3-50) located at the intersection of San Roque Road and Foothill Road, as shown on Figure 3.15. This evaluation was completed with the planned 24-inch diameter dedicated Desalination Conveyance Transmission Main, which conveys desalinated water from the Desalination plant directly to the Cater Clearwell, as well as water from the Ortega WTP.

During Scenario 2, the Lauro Zone, La Vista Zone, and Escondido La Coronilla Zone become hydraulically isolated from the rest of the distribution system, with the exception of Padre PS. . This hydraulic analysis was performed to help determine the operational changes needed to route water to this now isolated area.

Figure 3.15 Stress Analysis Detail - Scenario 2

The following six valves must be closed to isolate the broken water main (D3-50):

- Close valve WV-D03-028 at the intersection of Foothill Road and San Roque Road.
- Close valve WV-C05-071 at the intersection of San Roque Road and Calle Noguera.
- Close valve WV-C05-013 at the intersection of State Street and Las Positas Road.
- Close valve WV-C05-010 at the intersection of State Street and Las Positas Road.

- Close valve WV-C05-083 along Las Positas Road south of the intersection of Las Positas Road and McCaw Avenue.
- Close valve WV-C05-062 within Mackenzie Park, along Las Positas Road south of the intersection of Las Positas Road and State Street.

It should be noted that these six valves are different from, and extend beyond, the view of Figure 3.15. In addition, the following operational changes are recommended in the event water main (D3-50) breaks:

- Reverse flow through proposed dedicated Desalination Conveyance Transmission at the Cater Clearwell site.

The hydraulic model was used to predict reservoir levels over a 72-hour period under Scenario 2 ADD and MDD conditions and shown on in Figure 3.16 and Figure 3.17, respectively. The reservoir level analysis demonstrated the reservoirs are able to cycle for 72-hours using Scenario 2 initial operation modifications under existing ADD and MDD conditions, with the exception of Reservoir 1 which drains completely in 3-6 hours. Reservoir 2 cycles even though Reservoir 1 and Reservoir 2 are in the Low Level Zone. Reservoir 2 is supplied directly by the Lauro Zone and Reservoir 1 floats on the Low Level Zone. The difference in reservoir operations is caused by the system head losses between supply sources and Reservoir 1. The initial operational recommendations demonstrate that the City can route water supply from Cater WTP to the isolated Lauro Zone.

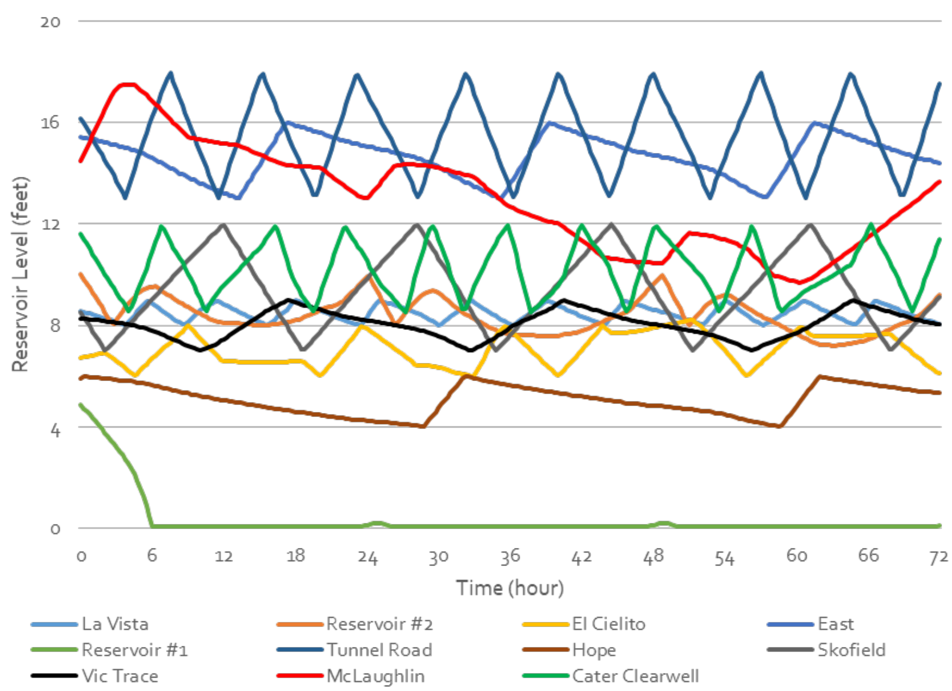


Figure 3.16 Reservoir Level Analysis Scenario 2 – 2019 ADD

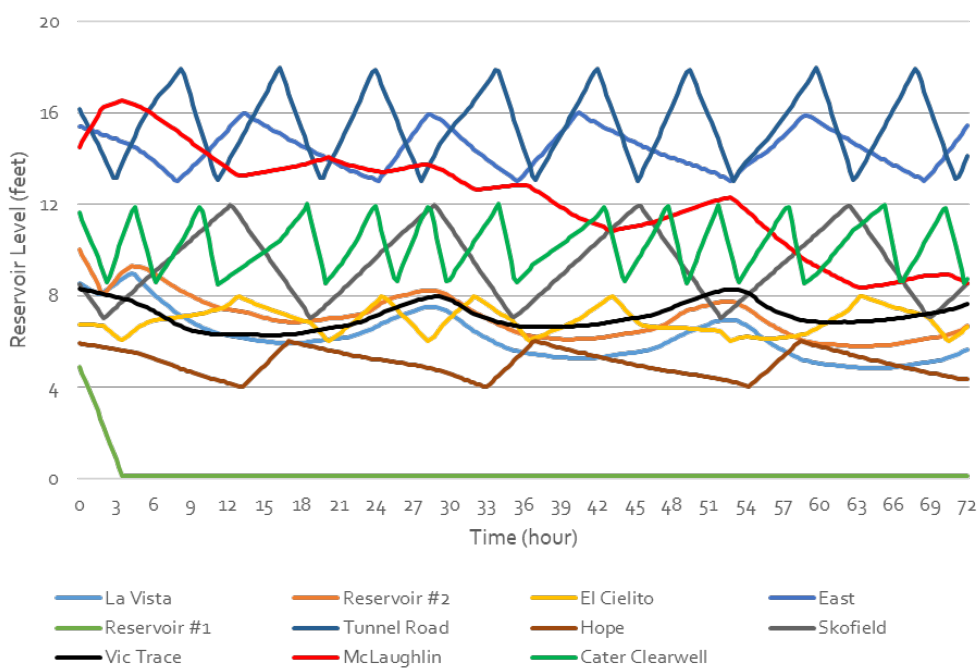


Figure 3.17 Reservoir Level Analysis Scenario 2 – 2019 MDD

A comparison between Scenario 2 deficiencies and benchmark deficiencies under existing MDD conditions is shown in Appendix 3A. The Scenario 2 system deficiencies are minor and no capacity improvements are recommended.

A main break like this would take typically approximately 24-hours to repair, assuming City staff has the necessary parts and materials on hand. The recommended operational changes are considered adequate because the reservoirs are able to cycle for 72-hours. However, an additional recommendation are described below:

- Have the necessary parts and materials ready on hand in case of a 36-inch diameter transmission main break.

3.5.3 Scenario 3

Scenario 3 evaluates the system's response to the Cater WTP losing connection to Gibraltar Reservoir and Lake Cachuma. At the beginning of this outage, the City has sufficient storage in Lauro Reservoir for several days, but for the purpose of analysis starts when Lauro Reservoir has drained completely. This evaluation was completed with the planned 24-inch diameter dedicated Desalination Conveyance Transmission Main, which conveys desalinated water from the Desalination plant directly to the Cater Clearwell, as well as water from the Ortega WTP.

The Cater WTP is the City's major water supply and having it out of service for an extended period will require changing operations to maintain water to all parts of the City. This hydraulic analysis helps identify operational changes to mitigate system deficiencies in the short term as well as recommendations to mitigate Cater WTP not producing water for an extended period of time. However, the City would maximize the use of desalination and groundwater production in this Scenario.

The following operational changes are recommended in the event Cater WTP not producing water for an extended period of time:

- Allow Cater Clearwell to empty if needed, because the outage is an emergency.
- Raise La Vista del Oceano PRV setting by 15 psi to 78 psi. This will allow for water to be conveyed to the Low Level Zone and provide water service to City customers for a longer duration.

Based on the hydraulic model results, the system reservoirs are predicted to maintain sufficient reservoir levels for 72-hours using the Scenario 3 initial operation modifications under existing ADD conditions as shown on Figure 3.18. However, Vic Trace Reservoir is predicted to empty in approximately 16-hours under MDD conditions as shown in Figure 3.19, at which point the model becomes unbalanced due to insufficient supply to the system. For this reason, Figure 3.19 is only shown for 16-hours. Figure 3.18 shows Tunnel Reservoir filling even though Cater Clearwell is empty. This is possible because the flow in from the planned Desalination Conveyance Transmission Main is equal to the outflow via Cater Cross PS, SCC PS, and the Lauro Zone.

To maintain water service for more than 16 hours during summer demand conditions, the City will need to reduce system demand should the Cater WTP be out of service during a MDD condition. The estimated required demand reduction amount is shown in Table 3.5.

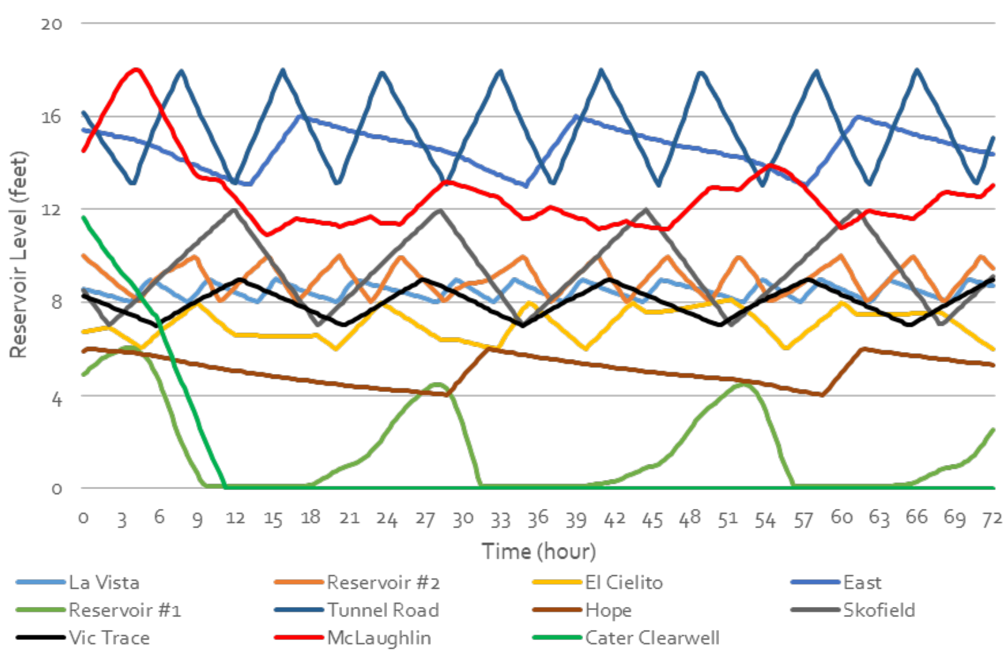


Figure 3.18 Reservoir Level Analysis Scenario 3 – 2019 ADD

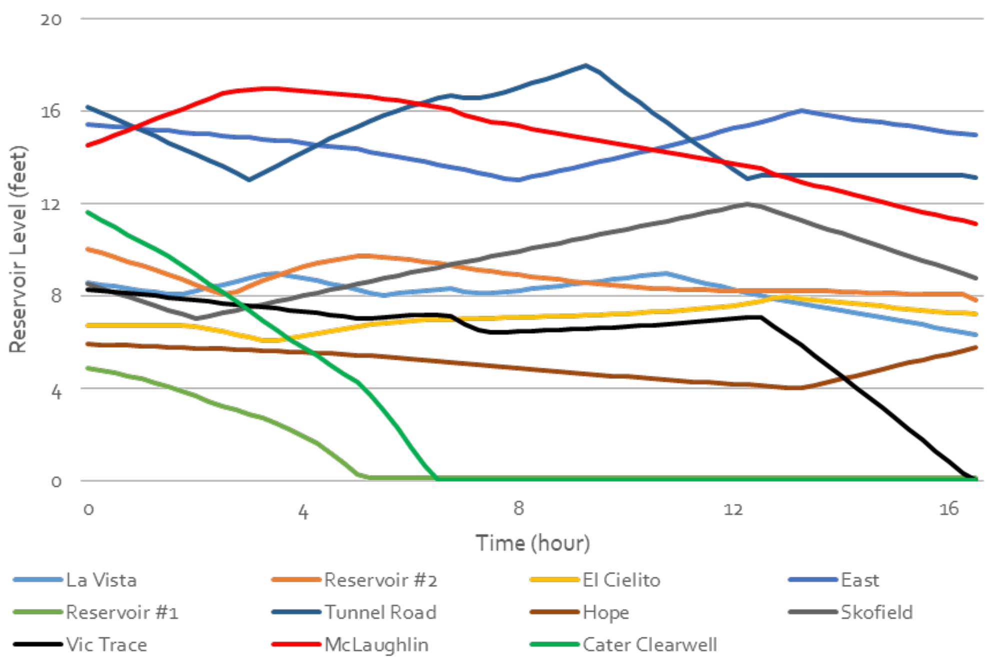


Figure 3.19 Reservoir Level Analysis Scenario 3 – 2019 MDD

A comparison between Scenario 3 deficiencies and benchmark deficiencies under existing MDD conditions is shown in Appendix 3A.

If the Cater WTP is not producing water for an extended amount of time, it is recommended that the City implement system wide water use restrictions such that consumption does not exceed production. As shown in Table 3.5, the City's water supply deficit in this scenario is about 3.2 million gallons per day (mgd). To offset this supply shortfall, the City's customer demand would need to be reduced by an additional 36 percent below the 2019 ADD of 8.9 mgd. Hence, it is recommended that the City implements aggressive system-wide water restrictions when the Cater WTP cannot produce water. To achieve the City's water use efficiency goals, it is recommended that the City upgrade all customer's meters with Advance Metering Infrastructure (AMI) with remote advanced reading technology to have real time consumption data (Project SU-3).

Table 3.5 Water Conservation Needs During Cater WTP Outage – Scenario 3

Supply Facility	Flow (mgd)
Desal Plant	3.02
Ortega WTP[(1)]	1.67
Hope Well	0.36
Los Robles Well	0.10
San Roque Well	0.56
Total Supply	**5.71**

Supply Facility	Flow (mgd)
2019 ADD(2)(3)	8.93
Supply Deficit	-3.22
Water Conservation Needs	36%

Notes:
(1) Assumes Firm Pumping Capacity as defined in TM 2.
(2) Includes Wholesale Customers: Goleta Water District (GWD) and La Cumbra Mutual Water Company (LCMWC)..
(3) Includes water consumption with 8 percent water loss.

3.5.4 Scenario 4

Scenario 4 evaluates the system's response to the Cater WTP losing connection to Gibraltar Reservoir and Lake Cachuma. During this outage the City has several days of storage on average Lauro Reservoir, but for the purpose of the analysis starts when Lauro Reservoir is empty This evaluation was completed without the planned dedicated Desalination Conveyance Transmission Main. This means that the Ortega WTP is pumping directly into the Low Level Zone.

As the Cater WTP is the City's major water supply, having it not produce water for an extended period of time will disrupt system performance. This hydraulic analysis helps identify operational changes to help mitigate system deficiencies in the short term as well as recommendations to mitigate Cater WTP being out of service for an extended period of time. The following operational changes are recommended in the event Cater WTP is not producing water for an extended period of time:

- Cater Clearwell is allowed to empty because this outage is an emergency.
- Raise La Vista del Oceano PRV setting by 5 psi at 68 psi. This will allow for water to be conveyed to the Low Level Zone and provide water service to City customers for a longer duration.
- Close valve WV-E05-008 to isolate Reservoir 2 from the Lauro Zone.

Based on the hydraulic model results, the system reservoirs are predicted to maintain sufficient reservoir levels for 72-hours under ADD conditions as shown in Figure 3.20. As shown in Figure 3.20, Tunnel Reservoir is filling even though Cater Clearwell has completely drained. This is possible because the flow inflow comes from the Vic Trace Reservoir, which is emptying while Padre PS moves water from the Low Level Zone to the Lauro Zone. The outflow comes from the Cater Cross PS and SCC PS. In addition, Vic Trace Reservoir is predicted to empty in approximately 14-hours under MDD conditions as shown in Figure 3.21, at which point the model becomes unbalanced due to insufficient supply to the system. For this reason, Figure 3.21 is only shown for 14-hours. Therefore, the City will need to reduce system demand should the Cater WTP be out of service during a MDD condition. See Table 3.5 for the required demand reduction amount.

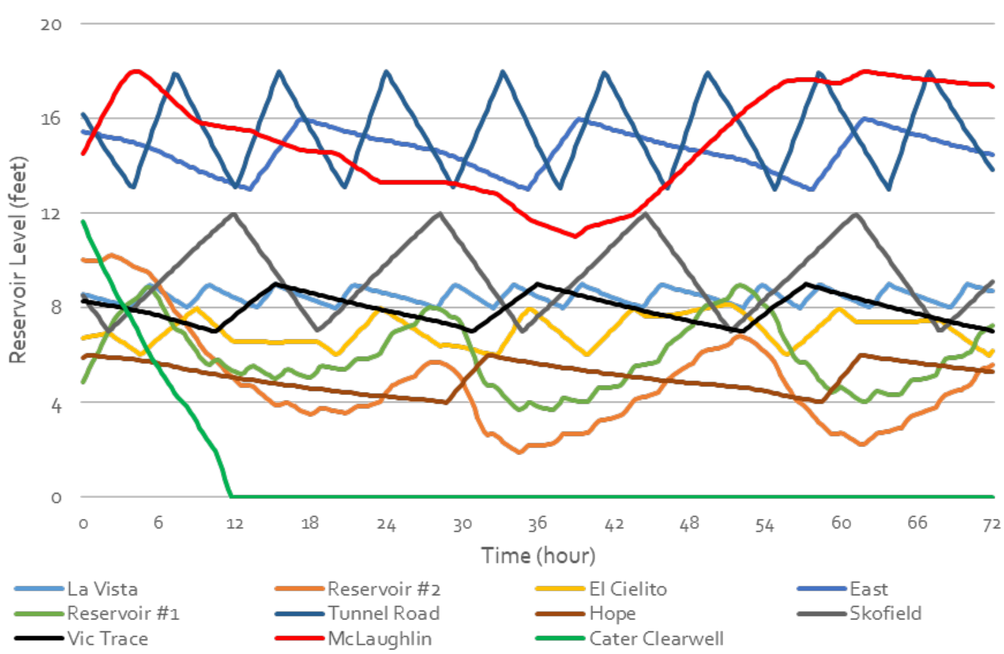


Figure 3.20 Reservoir Level Analysis Scenario 4 – 2019 ADD

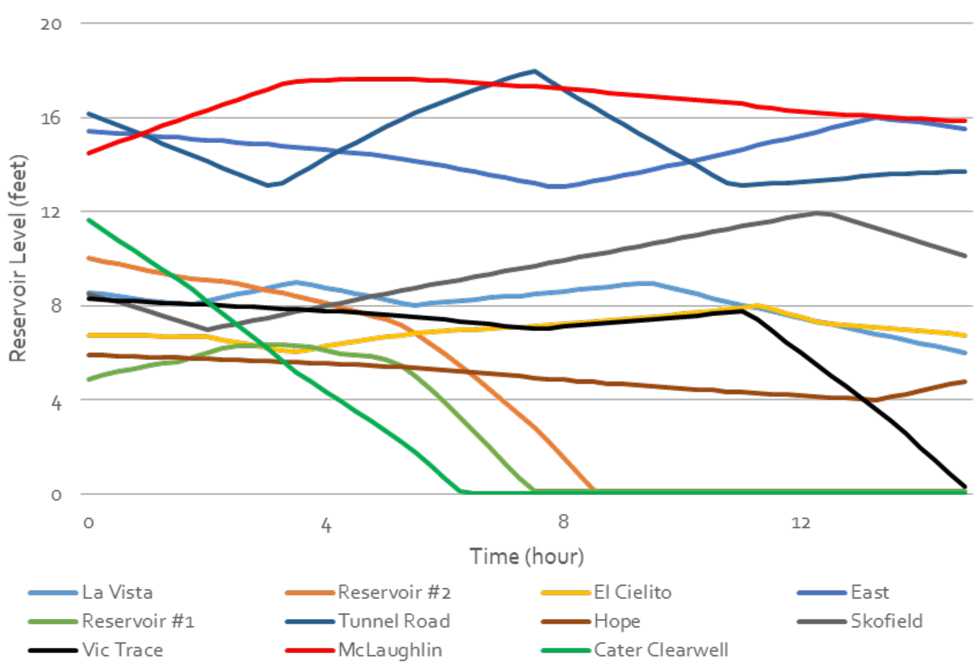


Figure 3.21 Reservoir Level Analysis Scenario 4 – 2019 MDD

A comparison between Scenario 4 deficiencies and benchmark deficiencies under existing MDD condition is included in Appendix 3A. It is anticipated that the proposed operational recommendations extend the time it takes for system reservoirs to empty and reduce the risk of the City's system running out of water during higher demands.

Similar to Scenario 3, if the Cater WTP is not producing water for an extended amount of time, it is recommended that the City implement system wide water use restrictions such that consumption does not exceed production. As shown in Table 3.5, the City's water supply deficit in this scenario is about 3.2 mgd. To offset this supply shortfall, the City's customer demand would need to be reduced by an additional 36 percent below the 2019 ADD of 8.9 mgd. Hence, it is recommended that the City implements aggressive system-wide water use restrictions when the Cater WTP cannot produce water.

3.5.5 Scenario 5

Scenario 5 evaluates the system's response to having Vic Trace Reservoir out of service for 7 days. Vic Trace Reservoir location is shown on Figure 3.1. This evaluation was completed without the planned Desalination Conveyance Transmission Main. This means that the Ortega WTP is pumping directly into the Low Level Zone in this scenario.

Vic Trace Reservoir was constructed in the mid-1950s and needs to be taken out of service for either rehabilitation or replacement. The City wants to know if Vic Trace Reservoir can be taken out of service for months and what operational changes are needed to maintain system performance when it is out of service.

The following two valves must be closed to take Vic Trace Reservoir out of service:

- Close valve WV-E11-087 at the Vic Trace Reservoir site.
- Close valve WV-E11-004 at the Vic Trace Reservoir site.

The following operational changes are recommended in the event Vic Trace Reservoir is out of service:

- Open valve WV-E11-005 to bypass the Vic Trace Reservoir. This prevents users between Vic Trace Reservoir and La Vista del Oceano PRV Station from becoming isolated.
- McLaughlin and Hoover Reservoirs are both in service. The storage analysis described in TM 2 shows that McLaughlin and Hoover Reservoirs should be online to prevent a storage deficit when Vic Trace Reservoirs is out of service.
- Open Sycamore Canyon PRV Station. Vic Trace Reservoir currently helps mitigate the Low Level Zone's storage deficit as described in TM 2. Opening Sycamore Canyon PRV Station allows surplus storage within the Sheffield Zone to mitigate the storage deficit in the Low Zone.

Based on the hydraulic model results, the system reservoirs are predicted to maintain sufficient reservoir levels for 168-hours (7 days) under existing ADD and MDD conditions as shown in Figure 3.22 and Figure 3.23, respectively.

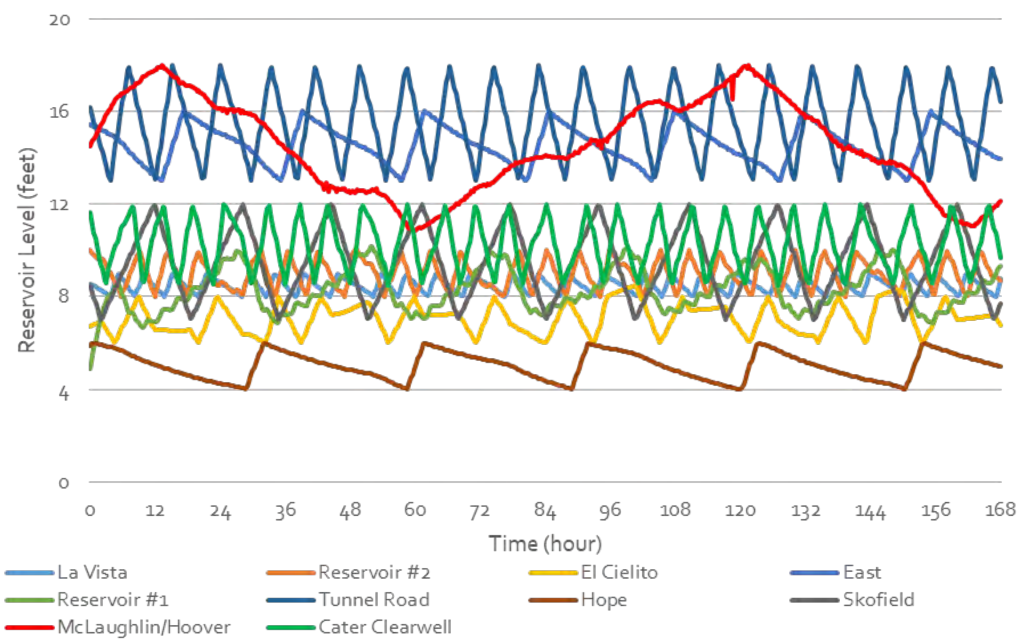


Figure 3.22 Reservoir Level Analysis Scenario 5 – 2019 ADD

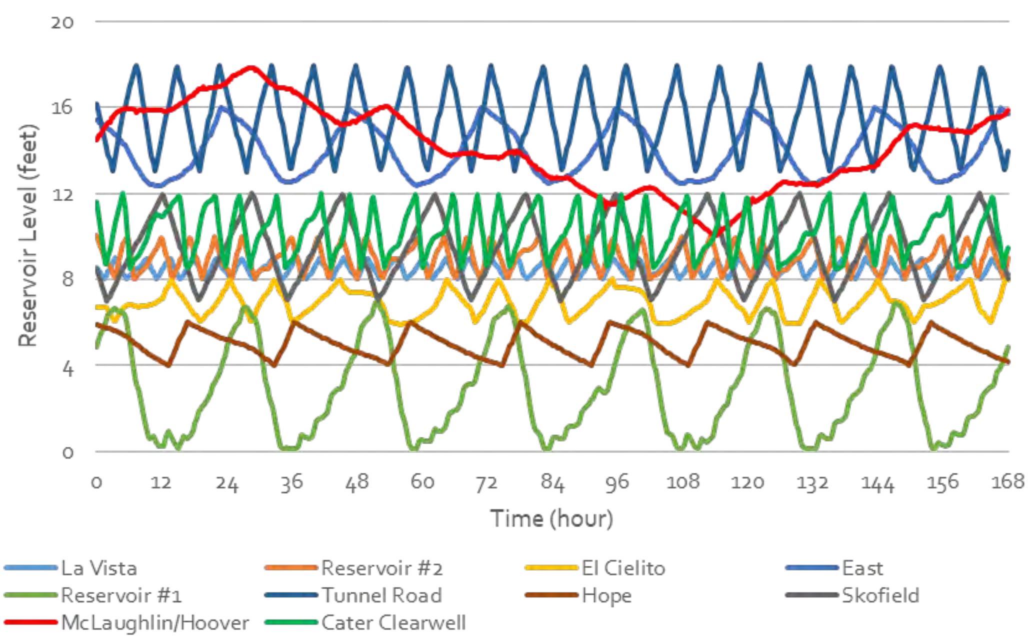


Figure 3.23 Reservoir Level Analysis Scenario 5 – 2019 MDD

A comparison between Scenario 5 deficiencies and benchmark deficiencies under existing MDD conditions in included in Appendix 3A.

3.5.6 Scenario 6

Scenario 6 evaluates the system's response to having La Vista Reservoir out of service and the potential of downsizing the existing 22-inch diameter water main along Hope Avenue that feeds to lower part of the La Vista Zone from La Vista Reservoir. The existing 22-inch diameter pipeline is reaching the end of its useful life and downsizing would help improve water quality. As shown on Figure 3.24, this 9,000 foot water main runs from Highway 101 to La Vista Reservoir. The service connections along this downsized main would be replaced with a new 12-inch diameter pipeline that would run from San Roque and Foothill to La Vista Reservoir. Moreover, all the division gates between La Vista Zone and Lauro Zone would be opened, eliminating the need for a separate La Vista Zone and increasing the size of the Lauro Zone.

This evaluation was completed without the planned 24-inch diameter dedicated Desalination Conveyance Transmission Main that connects to the Cater Clearwell. This means that the Ortega WTP is pumping directly into the Low Level Zone in this scenario.

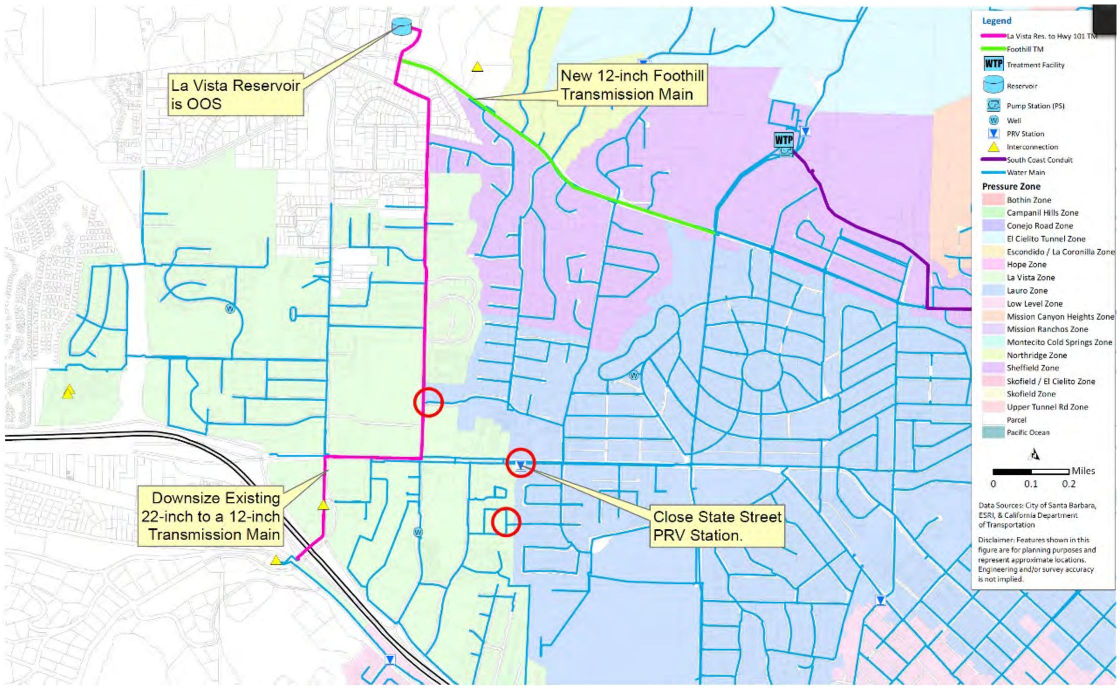


Figure 3.24 Scenario 6 Detail

The following valve must be closed to take La Vista Reservoir out of service:

- Close valve WV-B02-019 along the La Vista Reservoir inlet pipeline.

The following three valves must be opened to merge the La Vista Zone with the Lauro Zone:

- Open valve WV-C05-023 along State Street between Ontare Road and Hitchcock Way.
- Open valve WV-C05-018 along Santa Maria Lane East of South Ontare Road.
- Open valve WV-C04-050 at the intersection of North Hope Avenue and Brenner Drive.
- Close State Street PRV Station because it is no longer needed to break the pressure to the La Vista Zone.

In this scenario, the system reservoirs are predicted to maintain sufficient levels for 72-hours under existing ADD and MDD conditions as shown in Figure 3.25 and Figure 3.26, respectively.

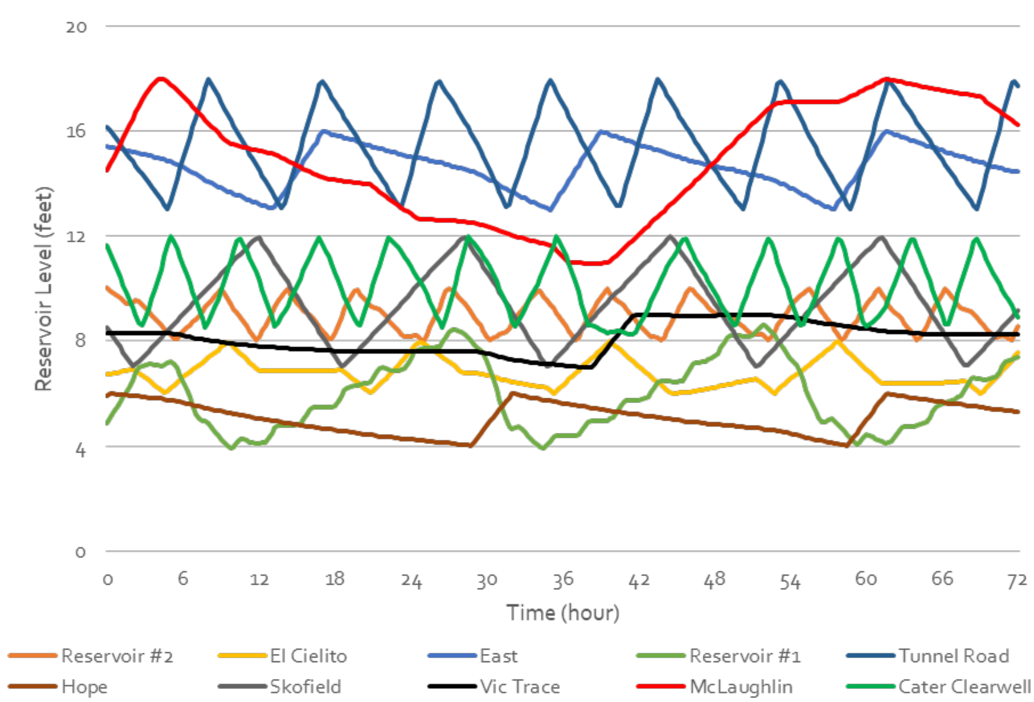


Figure 3.25 Reservoir Level Analysis Scenario 6 – 2019 ADD

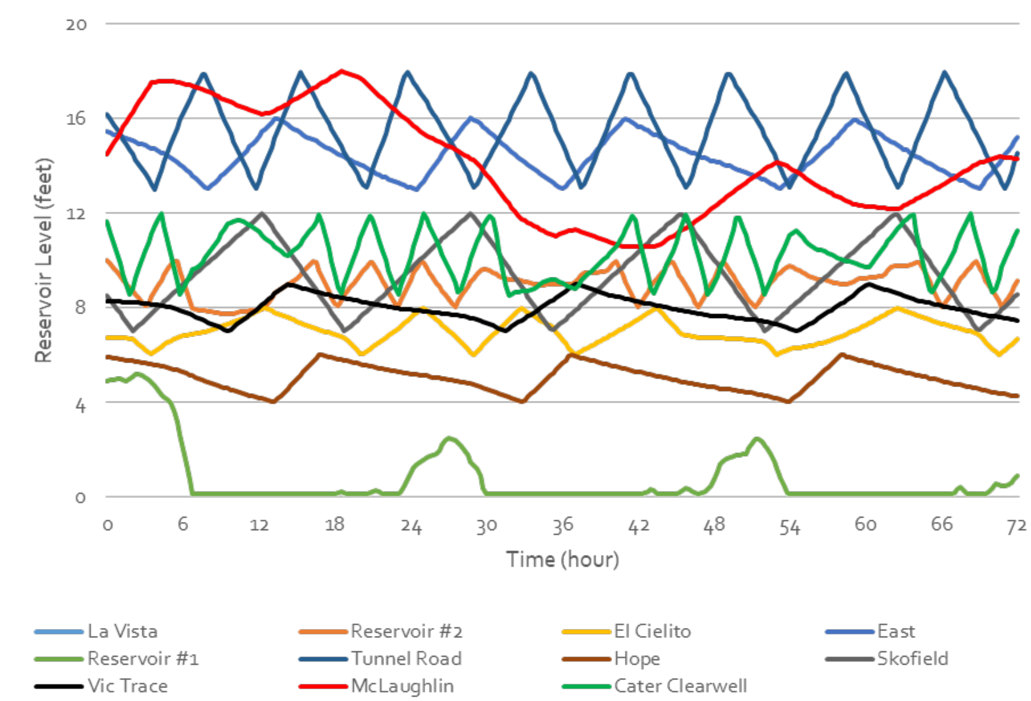


Figure 3.26 Reservoir Level Analysis Scenario 6 – 2019 MDD

A comparison between Scenario 6 deficiencies and benchmark deficiencies under existing MDD conditions is included in Appendix 3A. In addition, the hydraulic model results showed that the 22-inch diameter water main can be downsized to a 12-inch diameter water main while maintaining adequate pressure and meeting the velocity requirements. It should be noted that the proposed downsized water main is sized for existing and future City users (Projects TM-2A and TM-2B). It was not sized to deliver additional future water to Goleta Water District (GWD) and La Cumbra Mutual Water Company (LCMWC). Therefore, if GWD or LCMWC were to increase their demands in the future, an additional study is recommended to determine if the proposed 12-inch main is appropriately sized.

The La Vista Zone still relies on one transmission main to serve its customers. It is recommended that approximately 5,200 feet (or nearly 1 mile) of new 12-inch diameter water main would be constructed along Foothill Road between San Roque Road and Barger Canyon Road (Project TM-3). The proposed project is shown on Figure 3.24. The purpose of this project is to improve quality in the La Vista Zone.

3.5.7 Scenario 7

Scenario 7 evaluates the system's response to all of the Low Level Zone reservoirs (Reservoir 1, Reservoir 2, and La Mesa Reservoir) being out of service. The locations of these reservoirs are shown on Figure 3.1. This evaluation was completed with the planned dedicated Desalination Conveyance Transmission Main that conveys desalinated water from the Desalination plant directly to the Cater Clearwell, as well as water from the Ortega WTP.

Currently, Reservoir 1 and Reservoir 2 provide gravity storage, as well as, surge protection for the Low Level Zone by storing excess water during lower demand periods. Taking the reservoirs out of service will eliminate gravity reservoir storage and would change the functionality of Padre PS to a back-up facility in case water would need to be pumped out of the Low Level Zone. The Padre PS is currently used to pump either groundwater or desalinated water out of the Low Zone if supply exceeds demands. However, when both the planned dedicated Desalination Conveyance Transmission Main is constructed with a tie-in from the Ortega WTP, these supplies are already conveyed to the Cater Clearwell via the planned dedicated Desalination Conveyance Transmission Main.

The following six valves must be closed to take Reservoir 1, Reservoir 2, and La Mesa Reservoir out of service. As stated earlier, La Mesa Reservoir is assumed to be out of service for all stress scenarios.

- Close valve WV-K06-050 to isolate Reservoir 1 from the Sheffield Zone.
- Close valve WV-K06-057 to isolate Reservoir 1 from the Low Level Zone.
- Close valve WV-E05-008 to isolate Reservoir 2 from the Lauro Zone.
- Close valve WV-E05-003 to isolate Reservoir 2 from the Low Level Zone.
- Close valve WV-E10-035 to isolate La Mesa Reservoir from the Low Level Zone.
- Close valve to isolate La Mesa Reservoir from the Lauro Zone.
- Open Sycamore Canyon PRV Station (this valve is not in the current water GIS).

Based on the hydraulic model results, the system reservoirs are predicted to maintain sufficient reservoir levels 72-hours under existing ADD and MDD conditions as shown on Figure 3.27 and Figure 3.28, respectively.

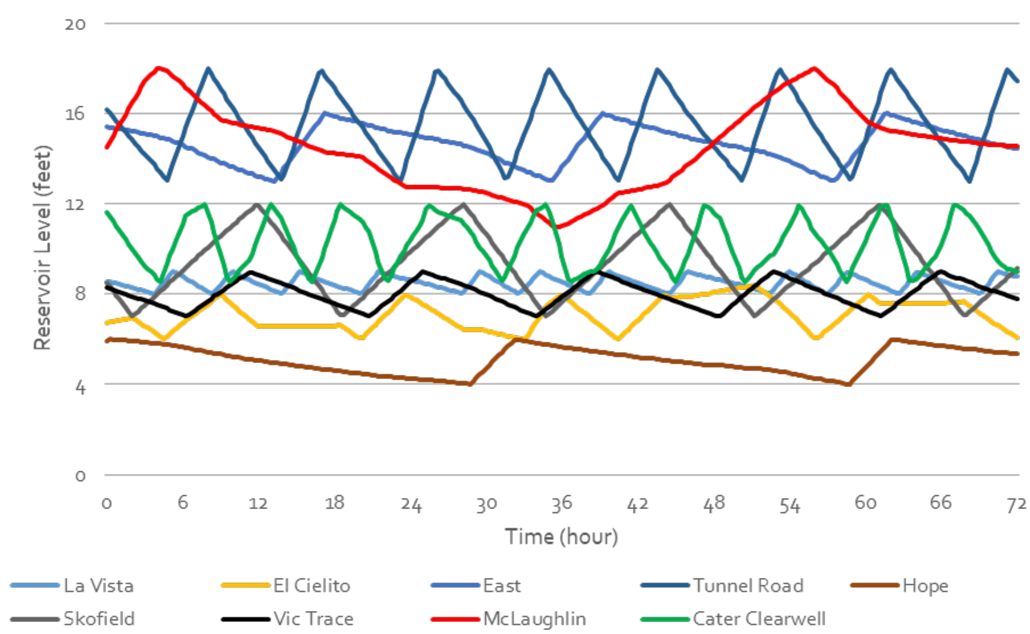


Figure 3.27 Reservoir Level Analysis Scenario 7 – 2019 ADD

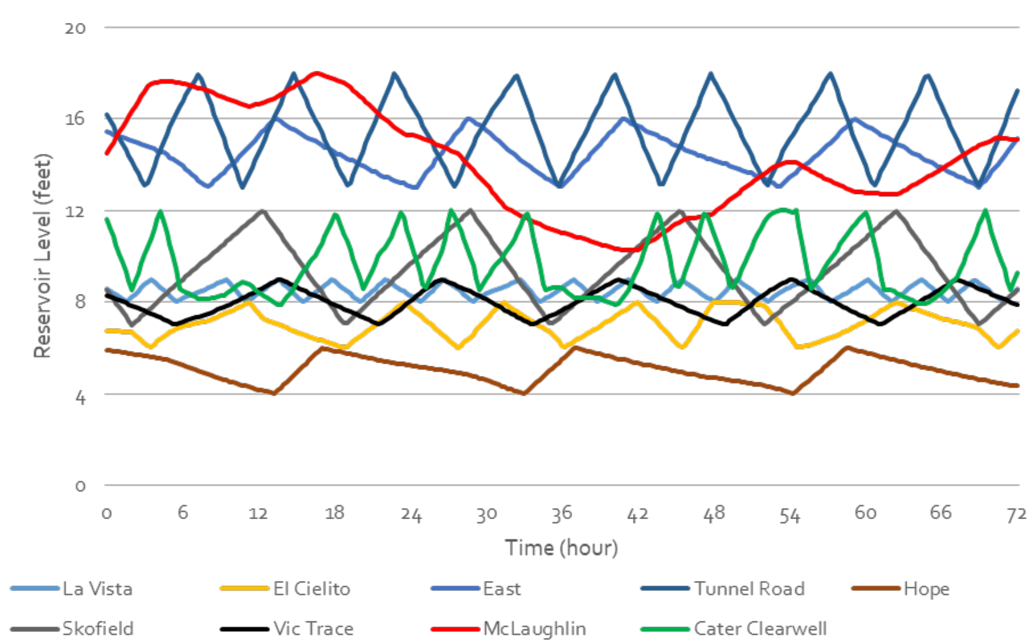


Figure 3.28 Reservoir Level Analysis Scenario 7 – 2019 MDD

Figure 3.29 shows the maximum pressures under 2019 ADD conditions. Most of the high system pressures are located within the El Cielito Tunnel Zone and the Sheffield Zone and occur in areas with high static head due to relatively low ground elevations. The higher Sheffield Zone pressures can be explained by the Sheffield Zone reaching a higher HGL because McLaughlin Reservoir reaches a higher level in Scenario 7 compared to the Benchmark Scenario. It is not recommended to change pressure zone boundaries unless an unusual amount of water main breaks and/or leaks would start occurring in these areas. A comparison between Scenario 7 deficiencies and benchmark deficiencies under existing MDD conditions in included in Appendix 3A.

Based on the hydraulic model results, it can be concluded that the system experiences a minimum number of new pressure deficiencies under MDD conditions (see details are included in Appendix 3A). Table 3.6 summarizes the average flow for PRV Stations that feed the Low Level Zone. As shown, the majority of the Low Level Zone demand is supplied through the Garden Street PRV under ADD conditions, while the La Vista del Oceano PRV Station delivers about an equal flow under ADD conditions. While the La Vista del Oceano PRV Station delivers a smaller proportion flow under MDD conditions supplemented with the Robbins & Pedregosa PRV and Alamar PRV.

Table 3.6 Average Flow through PRVs feeding the Low Level Zone – Scenario 7

PRV Station	Average Flow (gpm) - ADD	ADD Average Flow (%)	Average Flow (gpm) - MDD	MDD Average Flow (%)
Garden Street	1,803	49	3,002	47
Robbins & Pedregosa	76	2	1,097	17
La Vista del Oceano	1,752	47	2,082	33
Alamar	70	2	208	3
Sycamore Canyon	0	0	0	0
Total	**3,700**	**100**	**6,390**	**100**

The flow distribution shown in Table 3.6 is a result of system hydraulics like headloss and PRV settings. Overall, the model mimics system conditions finding the path of least resistance to meet all demands. Although there are benefits to distributing flows between the PRV stations more evenly, adjusting a PRV settings could also impact facilities operations (i.e. longer duration for a reservoir to cycle). Having real time control will help the City to monitor PRV flows and make pressure setting adjustments as needed to change the distribution of flows. Additional discussion and how this improvement relates to Scenario 9 is included in Section 3.5.9.

3.5.8 Scenario 8

Similar to Scenario 7, Scenario 8 evaluates the system's response to all of the Low Level Zone reservoirs (namely Reservoir 1, Reservoir 2, and La Mesa Reservoir) being out of service. The location of these reservoirs is shown on Figure 3.1.

Contrary to Scenario 7, this evaluation was completed without the planned dedicated Desalination Conveyance Transmission Main that conveys desalinated water from the Desalination plant directly to the Cater Clearwell. In this scenario, the Desal Plant delivers 2,000 gpm to the Low Level Zone. This scenario evaluates the Low Level Zone's ability to operate without Low Level Zone reservoirs.

The following six valves must be closed to take Reservoir 1, Reservoir 2, and La Mesa Reservoir out of service. As stated earlier La Mesa Reservoir is assumed to be out of service for all stress scenarios.

- Close valve WV-K06-050 to isolate Reservoir 1 from the Sheffield Zone.
- Close valve WV-K06-057 to isolate Reservoir 1 from the Low Level Zone.
- Close valve WV-E05-008 to isolate Reservoir 2 from the Lauro Zone.
- Close valve WV-E05-003 to isolate Reservoir 2 from the Low Level Zone.
- Close valve WV-E10-035 to isolate La Mesa Reservoir from the Low Level Zone.
- Close valve (missing ID) to isolate La Mesa Reservoir from the Lauro Zone.
- Close Garden Street PRV Station under existing ADD conditions.
- Close Robbins & Pedregosa PRV Station under existing ADD conditions.
- Padre Pump Station Pump operating based on Low Level Zone pressures.
- Operate the Ortega WTP at 1/3 capacity under existing ADD conditions and at full capacity at existing MDD conditions.

In this scenario, the system reservoirs are predicted to maintain sufficient reservoir levels 72 hours under existing ADD and MDD conditions as shown on Figure 3.30 and Figure 3.31, respectively.

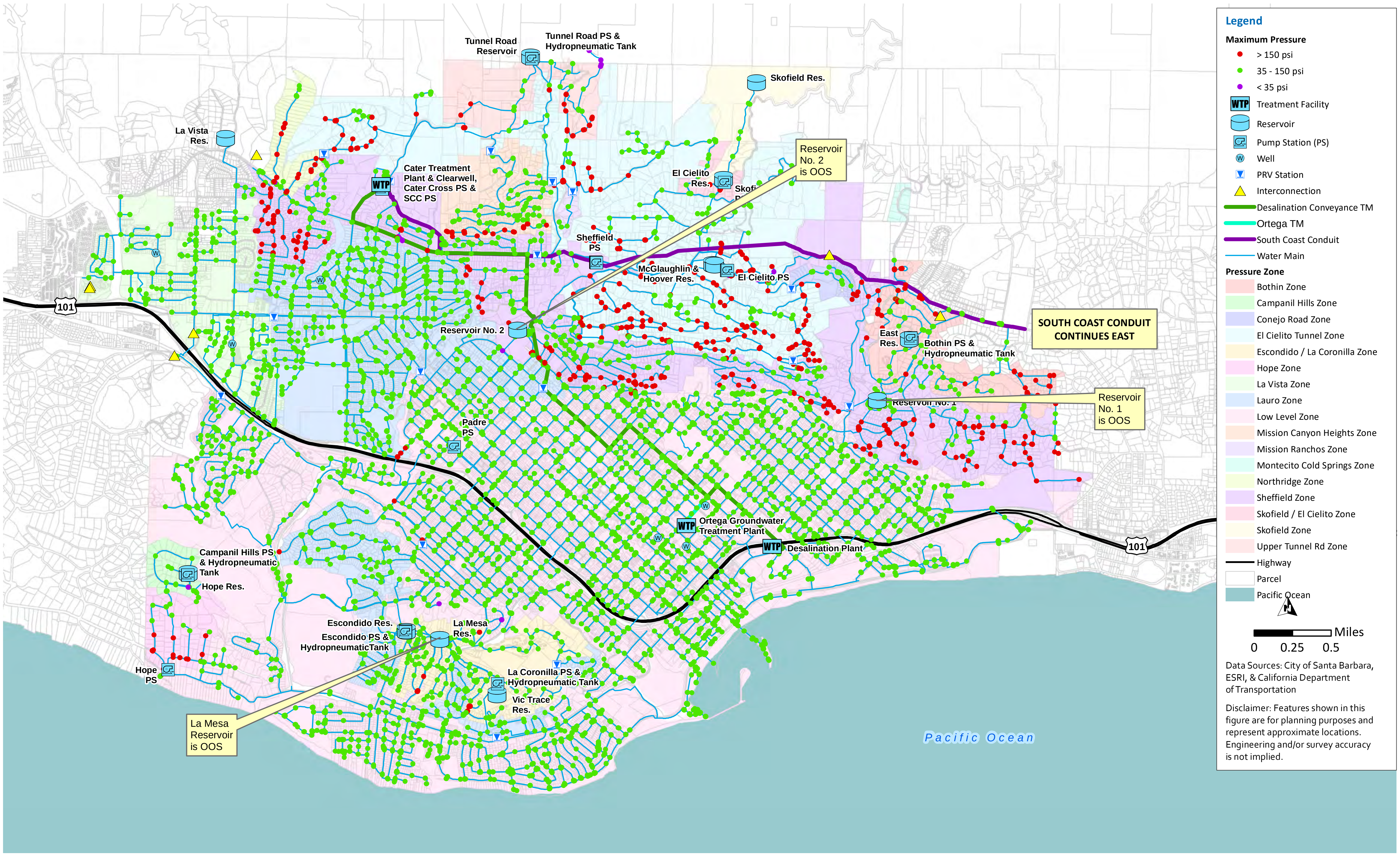


Figure 3.29 Maximum Pressure Analysis Scenario 7 - 2019 ADD

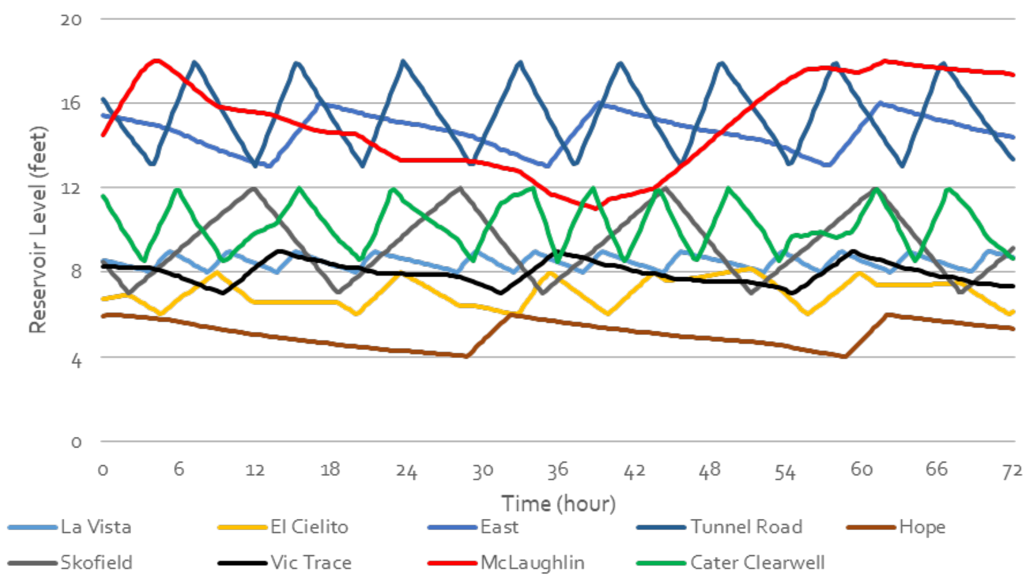


Figure 3.30 Reservoir Level Analysis Scenario 8 – 2019 ADD

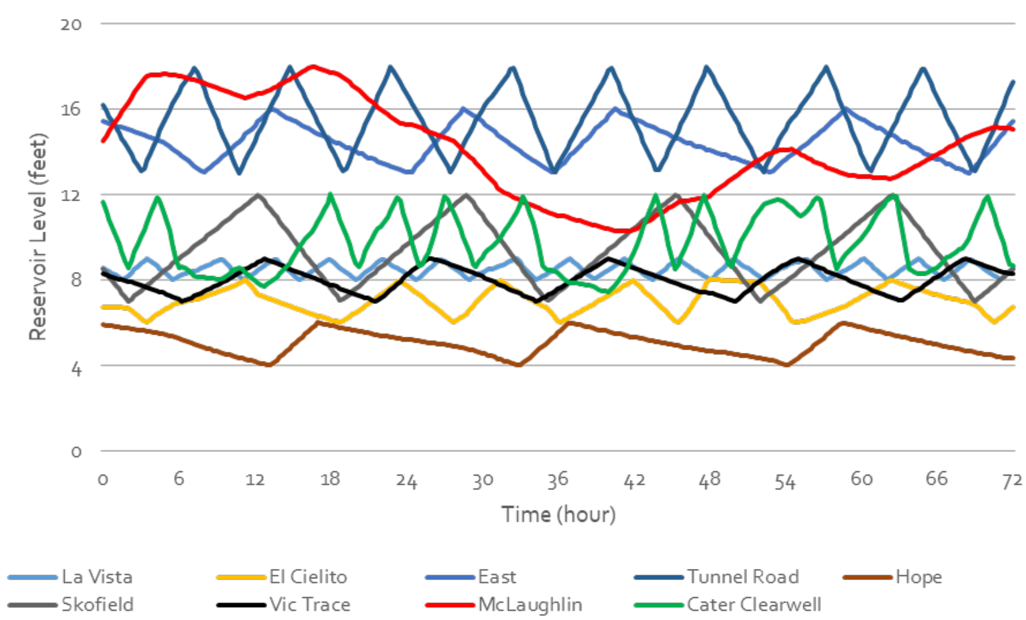


Figure 3.31 Reservoir Level Analysis Scenario 8 – 2019 MDD

Figure 3.32 shows the maximum pressures under 2019 ADD conditions. Most of the high system pressures are located in areas with high static head due to relatively low ground elevations. The higher pressures in the Sheffield Zone can be explained by the Sheffield Zone reaching a higher HGL because McLaughlin Reservoir reaches a higher level in Scenario 8 compared to the Benchmark. It is not recommended to change pressure zone boundaries unless an unusual amount of water main breaks and/or leaks would start occurring in these areas. A comparison between Scenario 8 deficiencies and benchmark deficiencies under existing MDD conditions is included in Appendix 3A.

To summarize the flow distribution between the five existing PRV stations that feed the Low Level Zone, the average daily flow for each PRV Station over a 24-hour model simulation under ADD and MDD conditions is shown in Table 3.7. As shown, majority of the Low Level Zone demand is supplied through the La Vista del Oceano PRV under ADD conditions, while the Garden Street PRV delivers about an equal flow under MDD conditions supplemented with the Robbins & Pedregosa PRV and Alamar PRV.

Table 3.7 Average Flow through PRVs Feeding the Low Level Zone – Scenario 8

PRV Station	ADD Average Flow (gpm)	ADD Average Flow (%)	MDD Average Flow (gpm)	MDD Average Flow (%)
Garden Street	298	20	1,698	44
Robbins & Pedregosa	0	0	297	8
La Vista del Oceano	1,222	80	1,796	46
Alamar	4	0	96	2
Sycamore Canyon	0	0	0	0
Total	**1,524**	**100**	**3,888**	**100**

As discussed in Scenario 7, the flow distribution is a result of system hydraulics like headloss and PRV settings. Overall, the model mimics system conditions finding the path of least resistance to meet all demands. However, it could be beneficial to distribute flows between the PRV stations more evenly because would distribute flows to the Low Level Zone more evenly. The City must consider the impacts that adjusting settings have on how facilities operate. It is recommended that PRV Settings are optimized to spread flow more evenly that allows reservoirs to adequately cycle.

3.5.9 Scenario 9

Scenario 9 evaluates the system's response to having the Desalination Plant is out of service. The City has operated without Desalination plant until 2017 when the plant was reactivated in response to severe state-wide drought. The location of the Desalination Plant is shown on Figure 3.1. This evaluation was completed with the planned Desalination Conveyance Transmission Main that conveys desalinated water from the Desalination plant that directly connects to the Cater Clearwell, as well as water from the Ortega WTP.

Unlike previous scenarios, the planned dedicated Desalination Conveyance Transmission Main was evaluated to understand its ability to convey water in reverse direction, from the Cater WTP to the Low Level Zone via the proposed Yanonali PRV Station when the Desal Plant is out of service. The following operational changes are recommended in the event the Desal Plant is out of service:

- Reverse flow through proposed dedicated Desalination Conveyance Transmission at the Cater Clearwell site.
- Open the new Yanonali PRV Station.

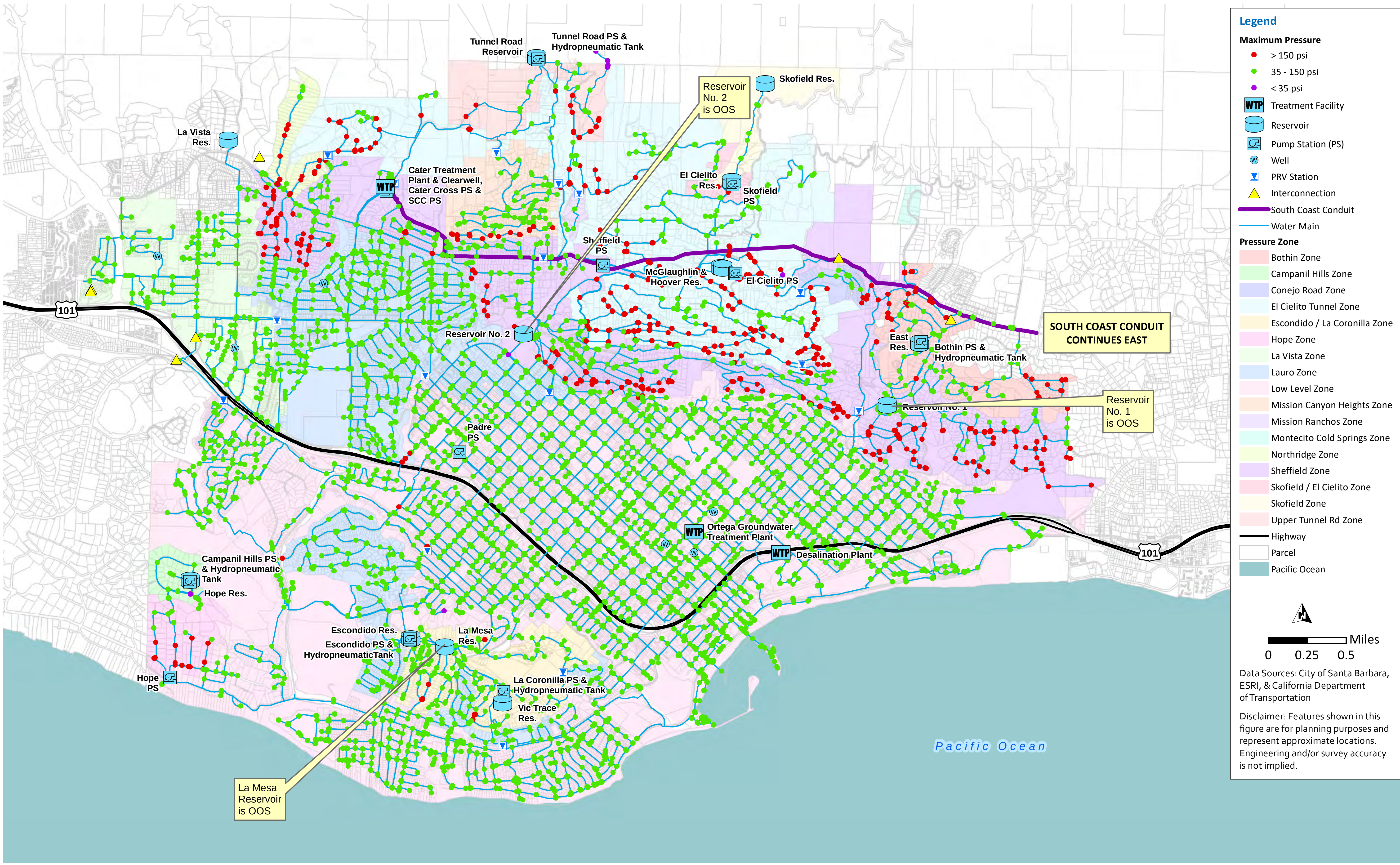


Figure 3.32 Maximum Pressure Analysis Scenario 8 - 2019 ADD

To understand the impact that the proposed Yanonali PRV Station has on delivering water to the Low Level Zone, the Yanonali PRV Station was simulated with varying pressure settings. These results are summarized in Table 3.8.

Based on the results shown in Table 3.8, it can be concluded that the overall impact to the delivering water to the Low Level Zone is that a higher pressure setting at Yanonali will increase the overall flow through Yanonali PRV Station and will reduce the amount of flow conveyed through the remaining PRV stations. For the purpose of the remaining hydraulic analysis, it was assumed that the Yanonali PRV Station had a setting of 145 psi and Sycamore PRV Station is offline (since it is typically offline). It is recommended that the City optimize the setting of the Yanonali PRV station to balance flows, possibly on a seasonal basis as demand and system pressures change.

Table 3.8 Average PRV Station Flows Feeding the Low Level Zone – Scenario 9

PRV Station	Average PRV Flow Under 2019 MDD Conditions (gpm)			
	Yanonali PRV at 130 psi(1)	Yanonali PRV at 140 psi(1)	Yanonali PRV at 145 psi(1)	Yanonali PRV at 150 psi(1)
Garden Street PRV	705	0	0	0
Robbins & Pedregosa PRV	0	0	0	0
La Vista del Oceano PRV	1,590	978	604	364
Alamar PRV	0	0	0	0
Sycamore Canyon PRV	0	0	0	0
Yanonali PRV (new)	1,138	2,782	4,296	5,531
Total	**3,433**	**3,760**	**4,900**	**5,895**

Notes:
(1) Sycamore Canyon PRV Station is closed.

Based on the hydraulic model results, the distribution system is predicted to meet pressure and velocity requirements under both ADD and MDD conditions. In addition, the system reservoirs are predicted to maintain sufficient reservoir levels 72-hours under existing ADD and MDD conditions as shown on Figure 3.33 and Figure 3.34, respectively. The hydraulic analysis shows Vic Trace Reservoir is not cycling as well under ADD conditions as compared to MDD conditions. This raises concerns about water age within Vic Trace Reservoir under ADD conditions. A solution to this would be to vary the Yanonali PRV settings depending on the flow conditions. For instance, during low to average flow conditions the City could lower the Yanonali PRV settings to promote Vic Trace Reservoir cycling.

As discussed in Scenario 7, it is recommended that PRV stations that undergo rehabilitation would be upgraded with SCADA Controls and flow meters and that this is a standard practice for any future PRV stations not identified in this WDIP (part of project RRV-3).

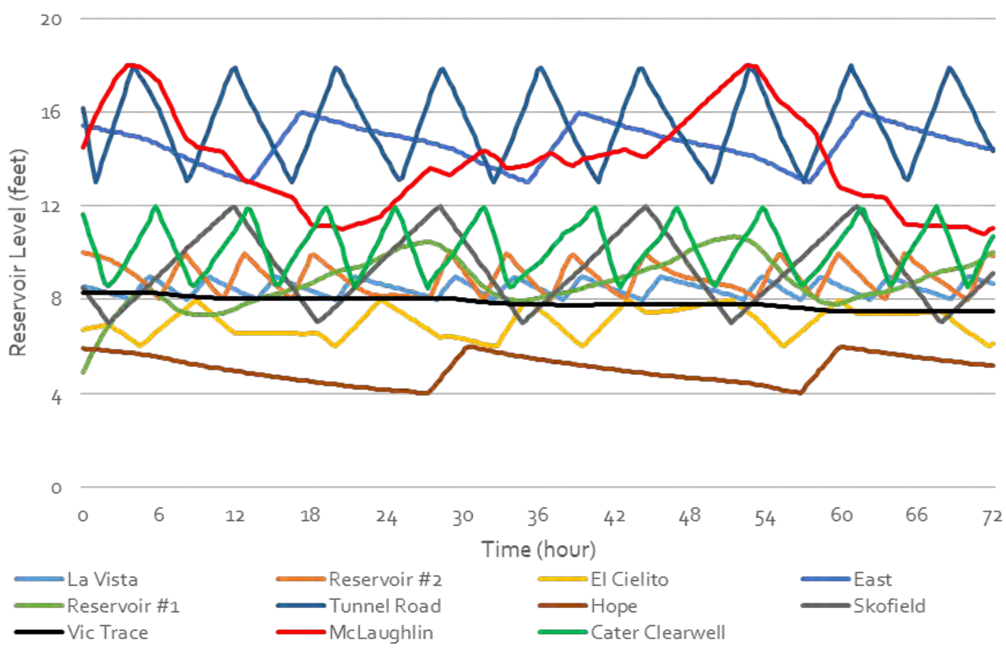


Figure 3.33 Reservoir Level Analysis Scenario 9 – 2019 ADD

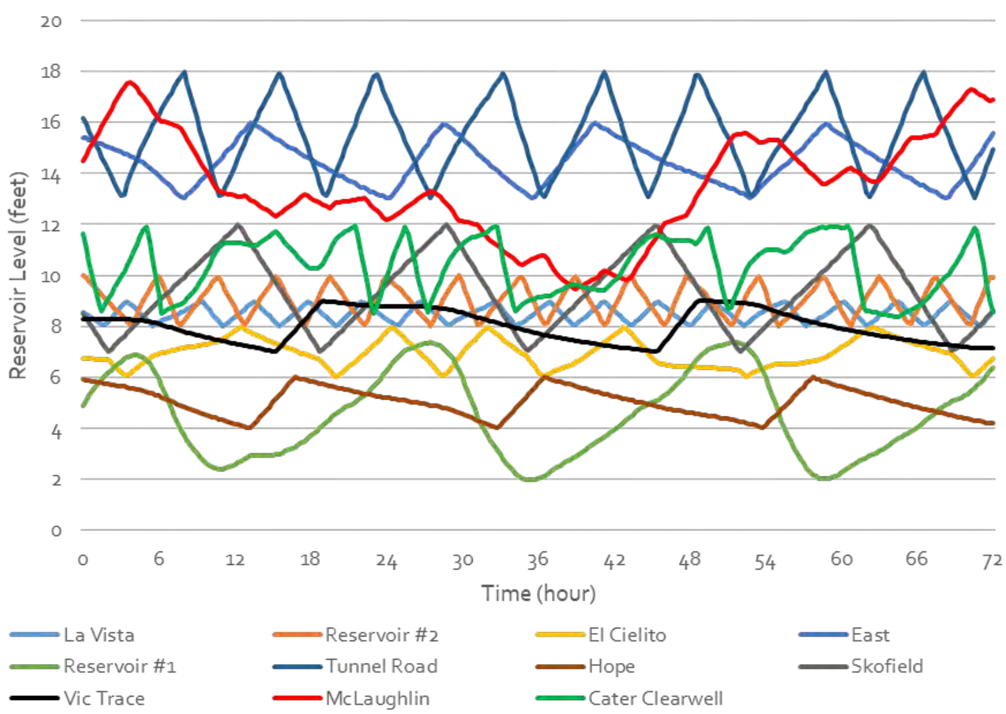


Figure 3.34 Reservoir Level Analysis Scenario 9 – 2019 MDD

A comparison between Scenario 9 deficiencies and benchmark deficiencies under existing MDD conditions is included in Appendix 3A.

3.5.10 Scenario 10

Scenario 10 evaluates all the changes the City wants to make to their distribution system based on the information gathered from the analysis conducted for Scenarios 1 through 9. For analysis purposes, it is assumed that these changes would be implemented by year 2050. The proposed changes generally focus on reducing operational and maintenance cost by removing some of the excess storage capacity and aging infrastructure. The proposed Scenario 10 distribution system changes are shown on Figure 3.35 and can be summarized as follows:

- The model was run using the projected 2050 demands.
- The planned 24-inch diameter dedicated Desalination Conveyance Transmission Main would connect the Desal Plant and Ortega WTP to the Cater Clearwell (Projects TM-1A, TM-1B, and PS-1).
- The Ortega WTP is connected to the planned Desalination Conveyance Transmission Main with via approximately 1,300 feet of 16-inch diameter water main. This includes upgrading the Ortega Pump Station so that it can pump the additional 140-feet of head required to reach the Cater Clearwell (Projects TM-6 and PS-2).
- Reservoir 1, Reservoir 2, East Reservoir, La Mesa Reservoir, and La Vista Reservoir are all assumed to be out of service in this Scenario (Projects RRSR-4 through RRSR-9).
- The Vic Trace Zone is isolated via 24-inch diameter automated plug valve near intersection of Robbins Street & Pedregosa Street, which controls flow to fill Vic Trace Reservoir from Lauro Zone based on Vic Trace water levels (Project V-2).
- El Cielito Reservoir is rebuilt to match the hydraulic grade line of Tunnel Reservoir and has a usable storage volume of 1.5 MG. The minimum storage volume calculation is included in TM 2 (Project SR-3).
- Approximately 5,200 feet (1 mile) of new 12-inch diameter water main is constructed along Foothill Road between San Roque Road and Barger Canyon Road (Project: TM-3).
- Approximately 9,000 feet (or 1.7 miles) of existing 22-inch diameter water main is replaced with a 12-inch diameter water main within the existing La Vista Zone (Scenario 6, Projects TM-2A & TM-2B).
- Various diameter water mains that are not within the City's ROW are replaced with approximately 2,300 feet (or 0.4 miles) of 12-inch diameter water main along Stanwood Drive between El Cielito Pump Station and East of Orizaba Lane (Project TM-4).

The following six valves must be closed to abandon Reservoir 1, Reservoir 2, La Mesa Reservoir, La Vista Zone, East Reservoir, and Escondido Reservoir (been out of service). As stated earlier, La Mesa Reservoir is assumed to be out of service for all stress scenarios.

- Close valve WV-K06-050 to isolate Reservoir 1 from the Sheffield Zone.
- Close valve WV-K06-057 to isolate Reservoir 1 from the Low Level Zone.
- Close valve WV-E05-008 to isolate Reservoir 2 from the Lauro Zone.
- Close valve WV-E05-003 to isolate Reservoir 2 from the Low Level Zone.
- Close valve WV-E10-035 to isolate La Mesa Reservoir from the Low Level Zone.
- Close valve (missing ID) to isolate La Mesa Reservoir from the Lauro Zone.
- Close valve WV-B02-019 to isolate La Vista Reservoir from the La Vista Zone.
- Close valve WV-K05-076 to isolate East Reservoir from Sheffield Zone.

- Close valve WV-K05-036 to isolate East Reservoir from Bothin Pump Station.
- Close valve WV-D10-080 to isolate Escondido Reservoir from the Low Level Zone.
- Close valve WV-D10-018 to isolate Escondido Reservoir from the Lauro Zone.

The following three valves must be opened to merge the La Vista Zone with the Lauro Zone:

- Open valve (WV-C05-023) along State Street between Ontare Road and Hitchcock Way.
- Open valve (WV-C05-018) along Santa Maria Lane East of South Ontare Road.
- Open valve (WV-C04-050) at the intersection of North Hope Avenue and Brenner Drive.

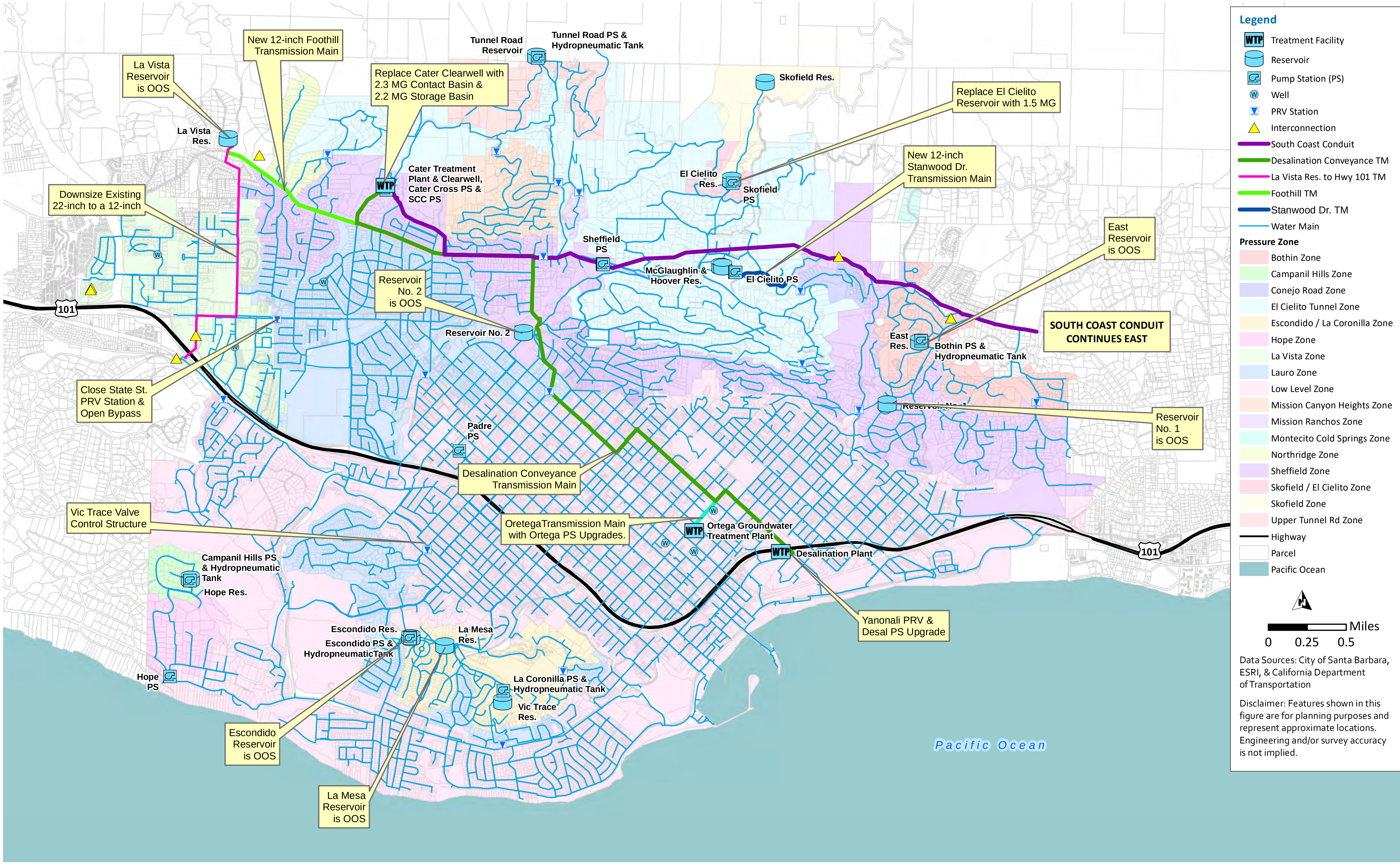


Figure 3.35 Distribution System Overview Scenario 10 - 2050

In this scenario, the system's reservoirs are able to cycle under future ADD and MDD conditions as shown in Figure 3.36 and Figure 3.37, respectively.

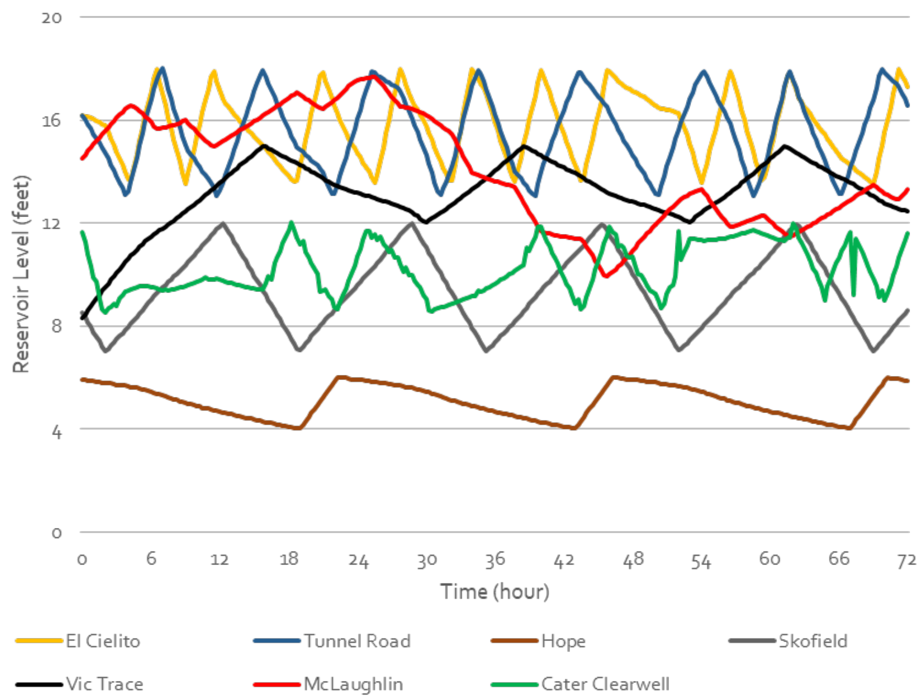


Figure 3.36 Reservoir Level Analysis Scenario 10 – 2050 ADD

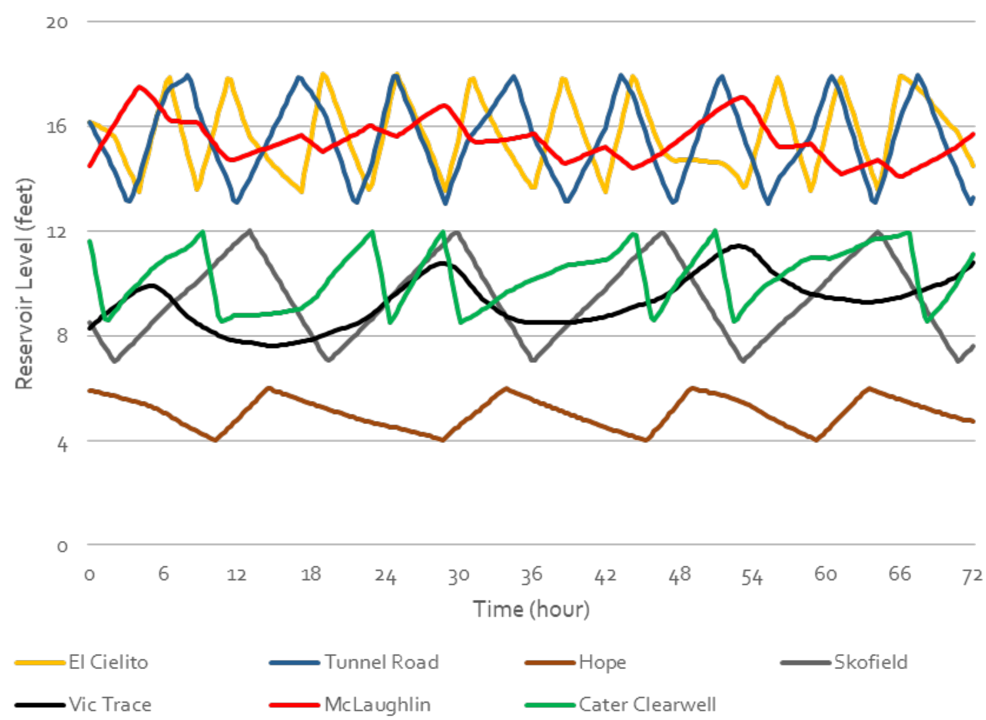


Figure 3.37 Reservoir Level Analysis Scenario 10 – 2050 MDD

In this scenario, approximately 1,200 feet of pipelines exceeded the maximum allowable velocity of 8 fps under 2050 MDD conditions. A comparison between Scenario 10 deficiencies and benchmark deficiencies under future MDD conditions is included in Appendix 3A.

To mitigate the high velocity deficiency, it is recommended that approximately 1,000 feet of 8-inch diameter water main along Mountain Drive between Las Canoas Road and Rockwood Drive is upsized to a 12-inch diameter water main (Project TM-7)

3.6 Recommendations and Conclusions

The distribution system recommendations identified in this TM are summarized in this section and are shown on Figure 3.38, with the exception of fire flow improvements can be found on Figure 3.3. Planning level 5 cost estimates for each of these recommendations are included in the Executive Summary of this WDIP. Based on the distribution system analysis, the following improvements are proposed:

- **Existing Conditions:**
  - Fire Flow Improvements (FF-1 through FF-13). The fire flow analysis identified the need for 13 fire flow improvements projects which are listed in Table 3.2 of TM 3 of this WDIP. The proposed fire flow improvements involve constructing new pipelines, replacing and upsizing existing pipelines, completing pipeline loops, and connecting a few hydrants to higher pressure zones. Approximately 450 feet of new pipeline is proposed. Additionally, 9,800 feet or 1.9 miles of pipeline is proposed to be replaced.
  - Desalination Conveyance Transmission Main (TM-1A, TM-1B, and PS-1). To normalize water quality distributed to all of the City's customers, reduce DBP formation potential, and improve the distribution and supply system's overall reliability, the City has already planned the following projects:
    - Desalination Conveyance Transmission Main (TM-1A). Construct approximately 13,000 feet of 24-inch diameter dedicated Desalination Conveyance Transmission Main. This project includes the construction of Yanonali PRV Station at the Desal Plant that enables Cater WTP to move water to the Low Level Zone.
    - Cater Clearwell Connection (TM-1B). Construct a connection at the Cater Clearwell to enable the dedicated Desalination Conveyance Transmission Main to connect.
    - Desal Pump Station Upgrade (PS-1). Upgrade the Desalination PS so it can pump the additional head required to reach the Cater Clearwell. This project is paired with projects TM-1A and TM-1B.
  - La Vista Zone Transmission Main Downsize (TM-2A and TM-2B). Replace approximately 9,000 feet of 22-inch diameter water main from Highway 101 to La Vista Reservoir with a 12-inch diameter water main. The existing pipeline is reaching the end of its useful life and downsizing would help improve water quality. The recommended diameter was sized for the existing City and wholesale users. It may be necessary to upsize it if La Cumbra wants to purchase more water in the future. This project helps improve water age in the La Vista Zone.

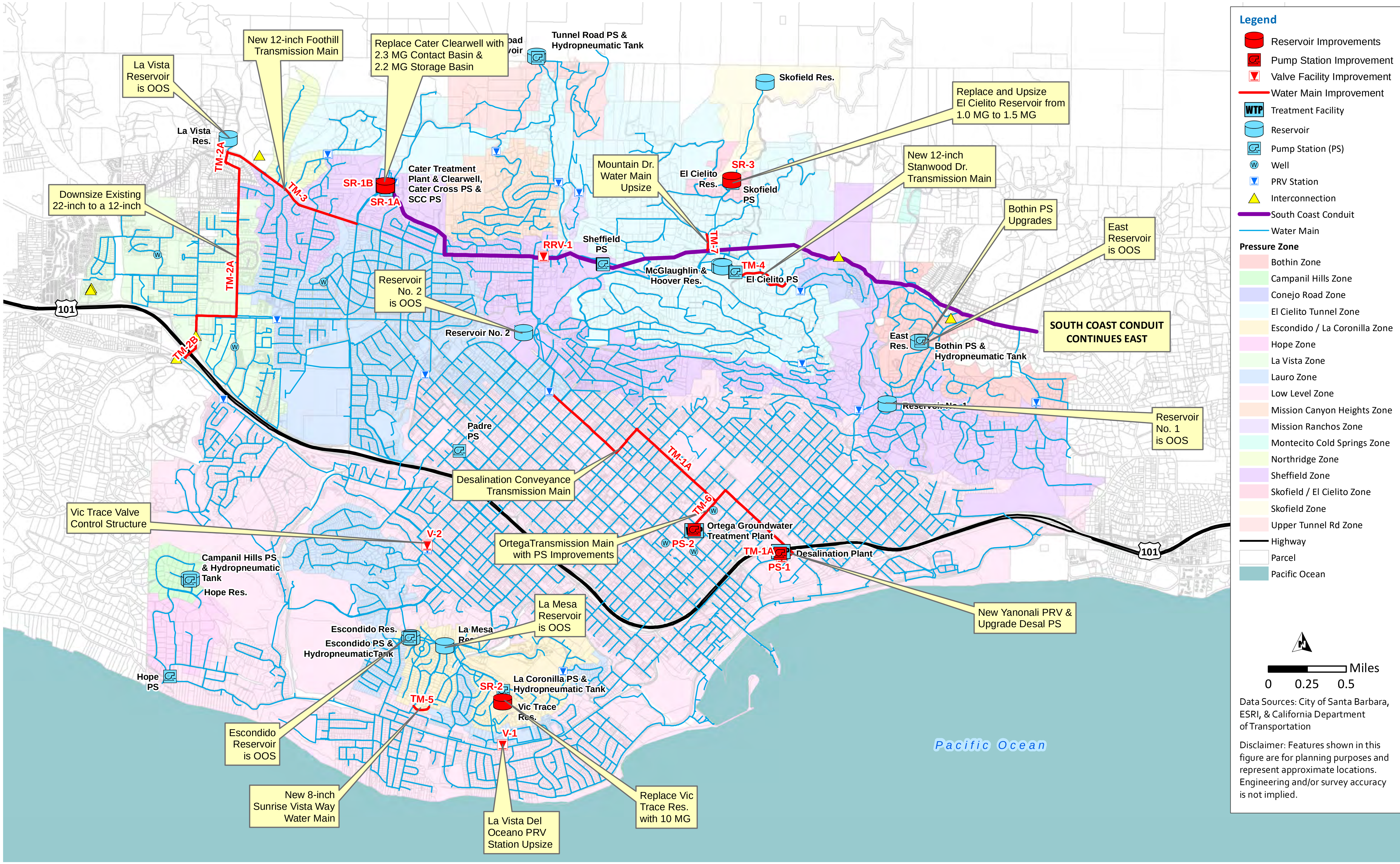


Figure 3.38 Distribution System Improvements

- Foothill Road Transmission Main (TM-3). Construct approximately 5,200 feet (or nearly 1 mile) of new 12-inch diameter water main along Foothill Road between San Roque Road and Barger Canyon Road.
- Stanwood Drive Transmission Main Replacement (TM-4). Construct approximately 2,300 feet of 12-inch diameter pipeline along Stanwood Drive between El Cielito Pump Station and East of Orizaba Lane. This project improves the reliability of Sheffield Zone and Bothin Zone and to get the pipeline out of an easement that is difficult to maintain.
- Sunrise Vista Way (TM-5). To address high velocities in approximately 200 feet of 6-inch diameter pipeline segment along a right-of-way (ROW) between Surf View Drive and Calle Cortita, it is recommended that approximately 600 feet of new 8-inch diameter pipeline be constructed along Sunrise Vista Way to avoid new construction in this ROW.
- Conveyance from Ortega WTP to Desalination Transmission Main Tie-In (TM-6). This project will allow delivery of supply from the Ortega WTP directly into the planned Desalination Conveyance Transmission Main via approximately 1,300 feet of 16-inch diameter water main. This project is paired with project PS-2.
- Ortega Pump Station Replacement (PS-2). This project includes upgrading the Ortega Pump Station so that it can pump the additional 140-feet of head required to reach the Cater Clearwell, as well as the addition of a surge tank at this site. This project is paired with project TM-6.
- La Vista del Oceano PRV Station Upsize (V-1). Replace and upsize the La Vista del Oceano PRV Station will help move water from Lauro Zone to Low Level Zone.
- City-wide AMI Upgrade (SU-3). Replace all customer's meters with remote advanced reading technology.

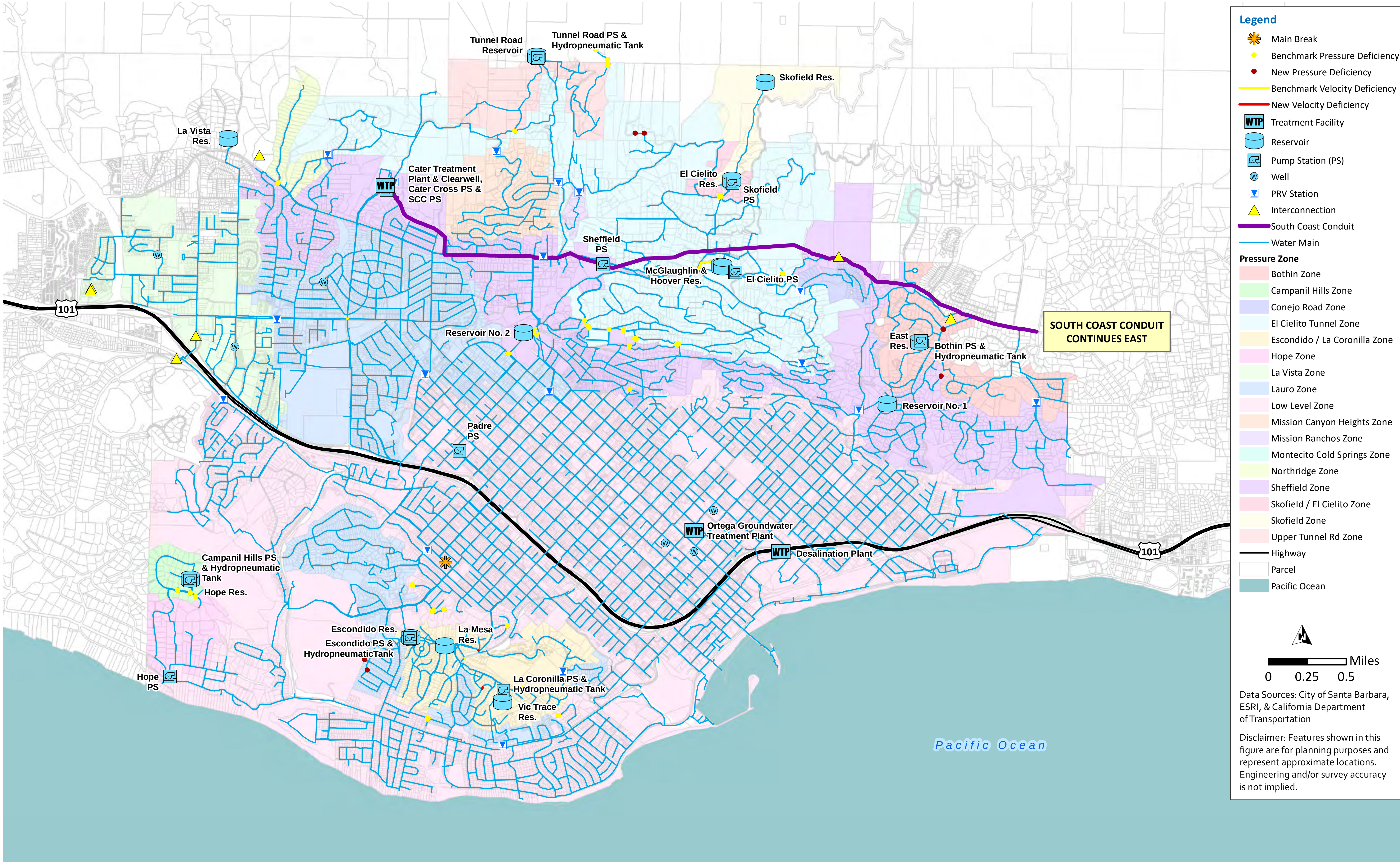
- **Future Conditions:**
  - Mountain Drive Water Main Upsize (TM-7). Replace approximately 1,000 feet of 8-inch diameter water main along Mountain Drive between Las Canoas Road and Rockwood Drive with a 12-inch diameter water main.
  - Reservoir Decommissioning (RRSR-4 through RRSR-9). The reservoirs listed below can be taken out of service, but remain in-place at the current locations, based on the reservoir analysis presented in TM 2 of this WDIP. The sequencing of these reservoirs being taken out of service should consider the condition of each reservoir by minimizing rehabilitation cost for these facilities that are planned to be taken offline in the future. If possible, all these projects should be deferred until Cater Clearwell is replaced (Projects SR-1A and SR-1B), Vic Trace Reservoir is replaced (Project SR-2), El Cielito Reservoir is replaced (Project SR-3) and Foothill PRV station is rehabilitated (Project RRV-1).
    - Escondido Reservoir (RRSR-4). This reservoir is currently out of service and no project is required. The City would close valves WV-D10-080 and WV-D10-018 to take Escondido Reservoir out of service.
    - East Reservoir (RRSR-5). This project requires completion of Projects SR-1A, SR-1B, SR-2, and SR-3 before East Reservoir can be taken out of service. This project includes field piping so Bothin PS can bypass East Reservoir. The City would need to close valves WV-K05-076 and WV-K05-036 to take East Reservoir out of service.

  - Reservoir No. 2 (RRSR-6). This project requires completion of projects SR-2 and V-1 before Reservoir No. 2 is taken out of service. The City must install pressure relief valves to avoid over-pressurization in the Low Level Zone before the last gravity reservoir is taken out of service. The City would need to close valves WV-E05-008 and WV-E05-003 to take Reservoir 2 out of service.
  - La Mesa Reservoir (RRSR-7). This project requires completion of projects SR-2, and V-1 before La Mesa Reservoir is taken out of service. The City must install pressure relief valves to avoid over-pressurization in the Low Level Zone before the last gravity reservoir is being taken out of service. The City would need to close valves WV-E10-035 and (missing ID) to take La Mesa Reservoir out of service.
  - La Vista Reservoir (RRSR-8). This project requires completion of Projects SR-1A, SR-1B, SR-2, TM-3, and RRV-1 before La Vista Reservoir is taken out of service. The City would need to close valve WV-B02-019 to take La Vista Reservoir out of service. It is recommended that the City also consider completing the projects TM-2A and TM-2B before taking La Vista Reservoir is taken out of service to enhance conveyance redundancy to the Low Level Zone.
  - Reservoir No. 1 (RRSR-9): Based on the storage capacity balance, Reservoir No. 1 could also be taken out of service in the future, however, it is recommended that it remain available to be put back in service as needed. This is project requires the completion of projects SR-2 and V-1 before Reservoir No. 1 is out of service. The City must install pressure relief valves to avoid over-pressurization in the Low Level Zone before the last gravity reservoir is decommissioned. The City would need to close valves WV-K06-057 and WV-K06-050 to take Reservoir 1 out of service.

- Valve Automation at Robbins St. & Pedregosa St. (V-2). To improve system operations at Vic Trace, it is recommended that the 24-inch diameter valve at Robbins Street and Pedregosa Street become automated based on Vic Trace Reservoir level.

Appendix 3A

STRESS SCENARIO ANALYSIS PRESSURE AND VELOCITY DEFICIENCIES



carollo
Last Revised: October 08, 2020

Figure 1 Stress Analysis Scenario 1 - 2019 MDD

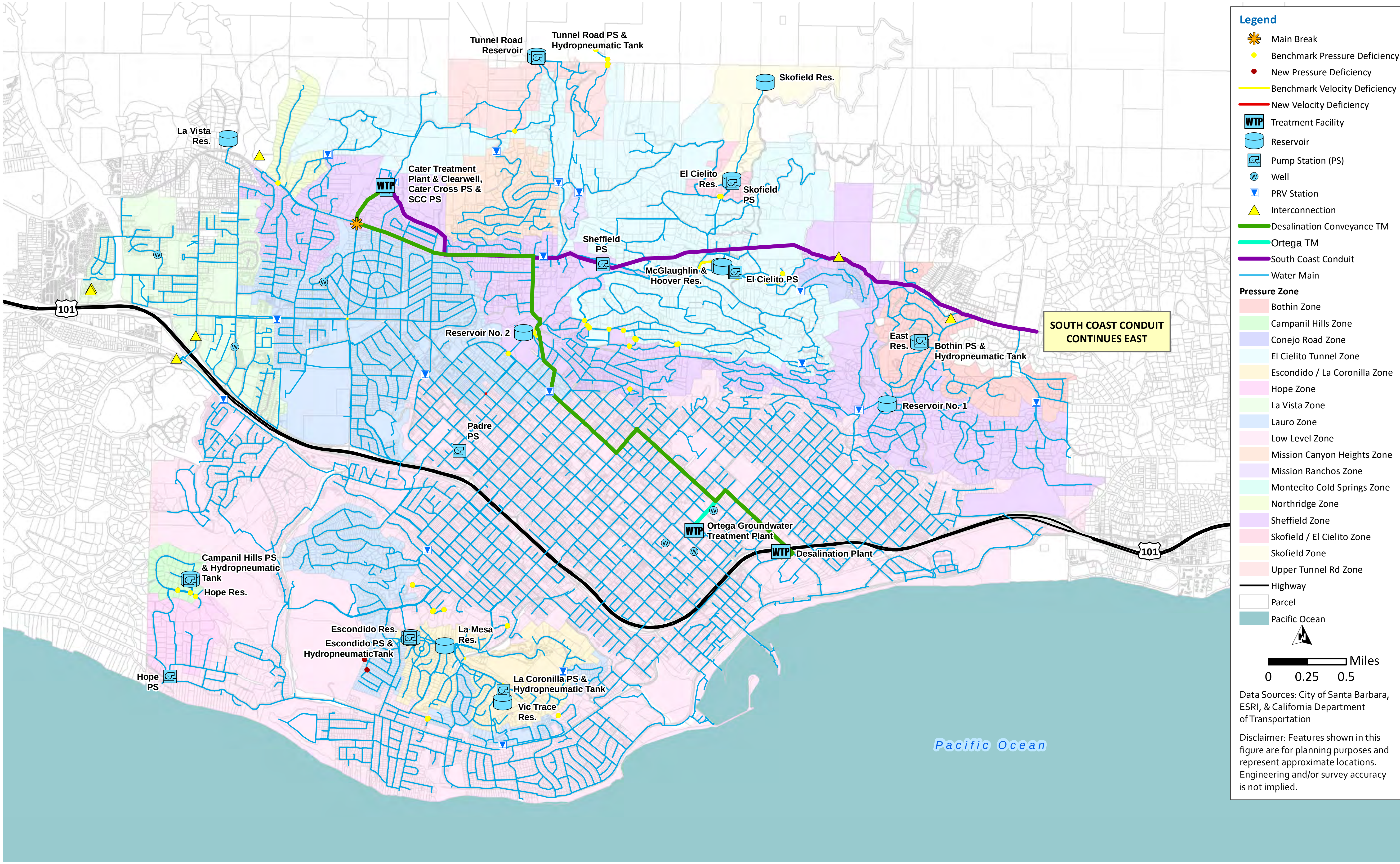


Figure 2 Stress Analysis Scenario 2 - 2019 MDD

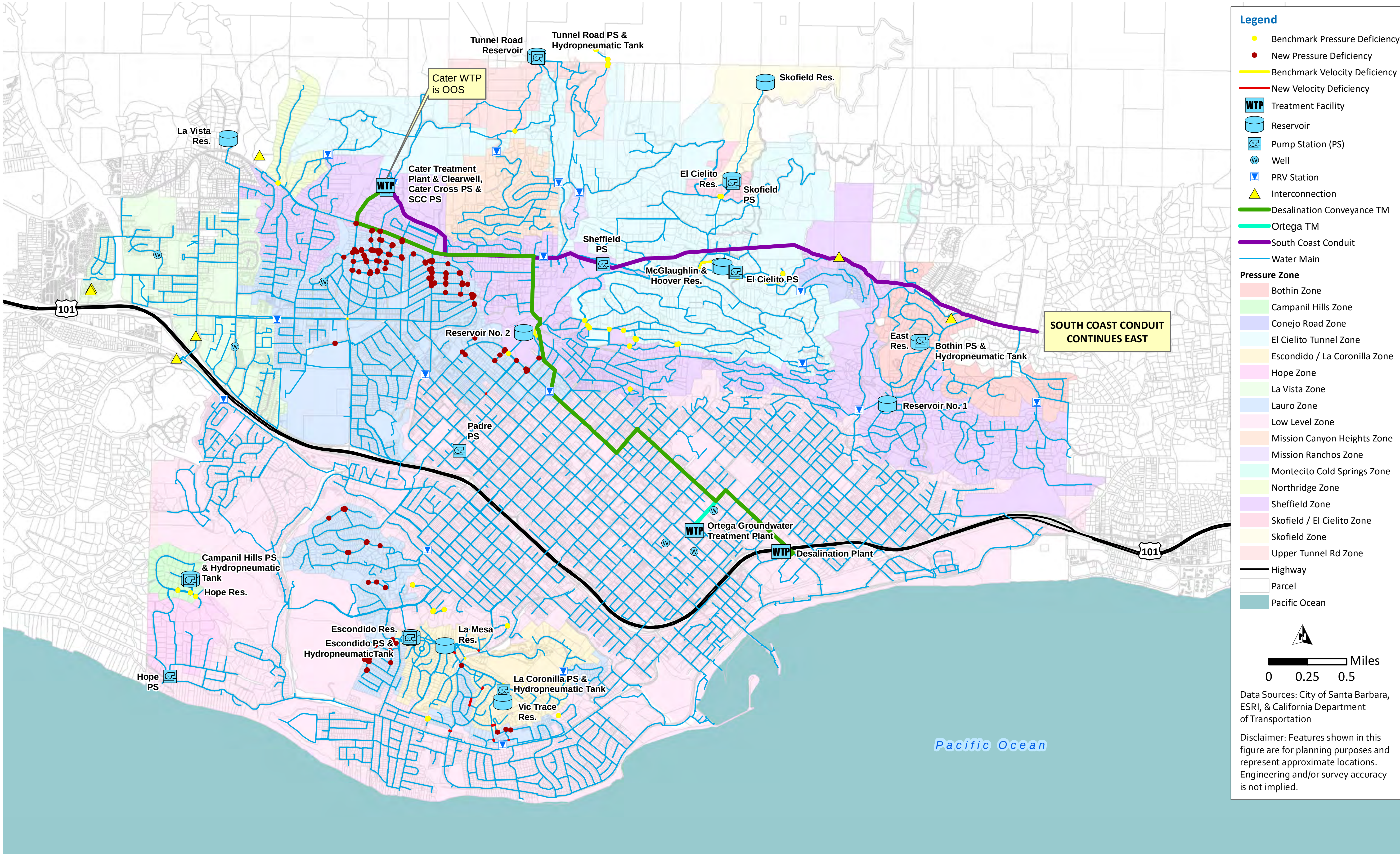


Figure 3 Stress Analysis Scenario 3 - 2019 MDD

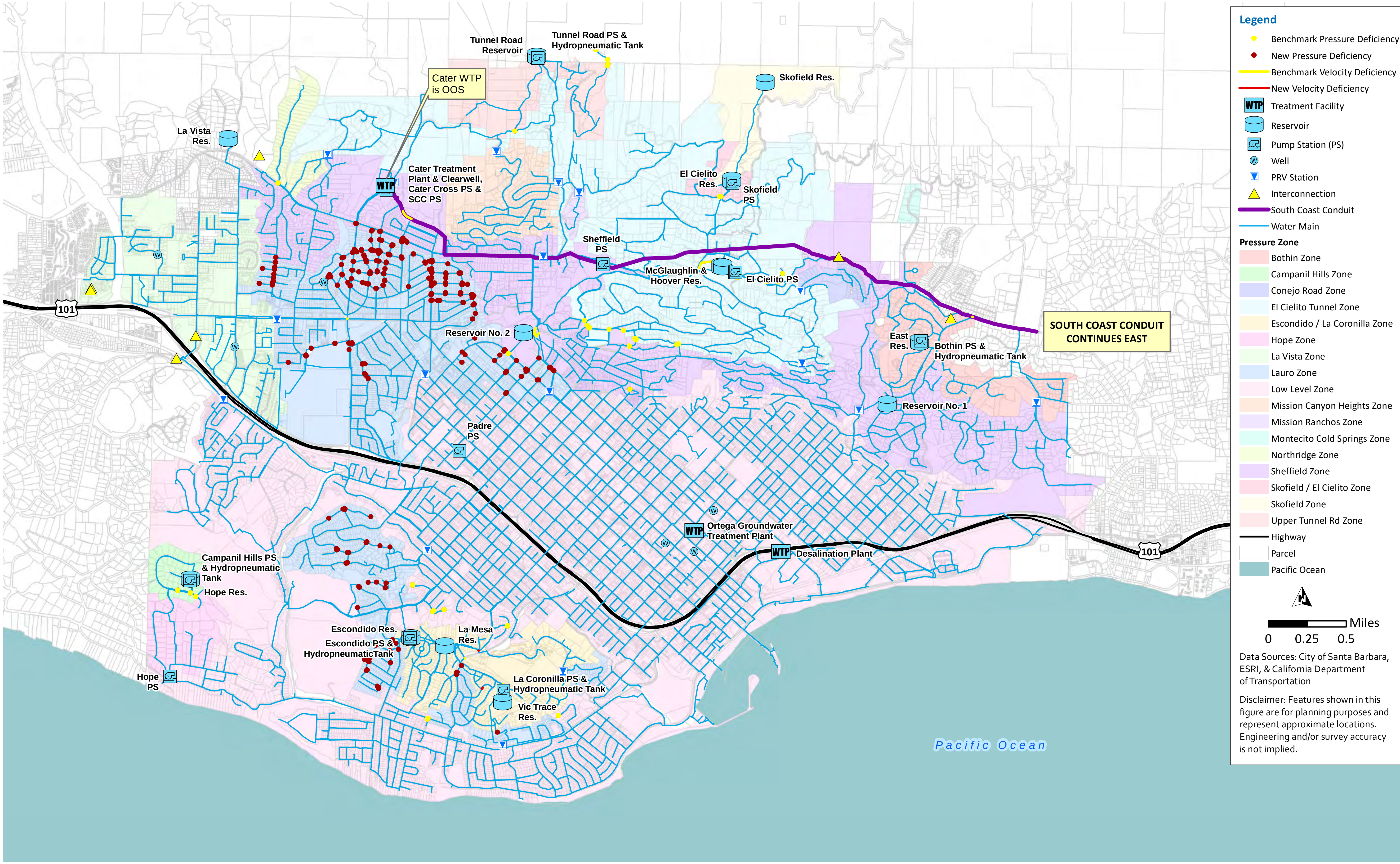


Figure 4 Stress Analysis Scenario 4 - 2019 MDD

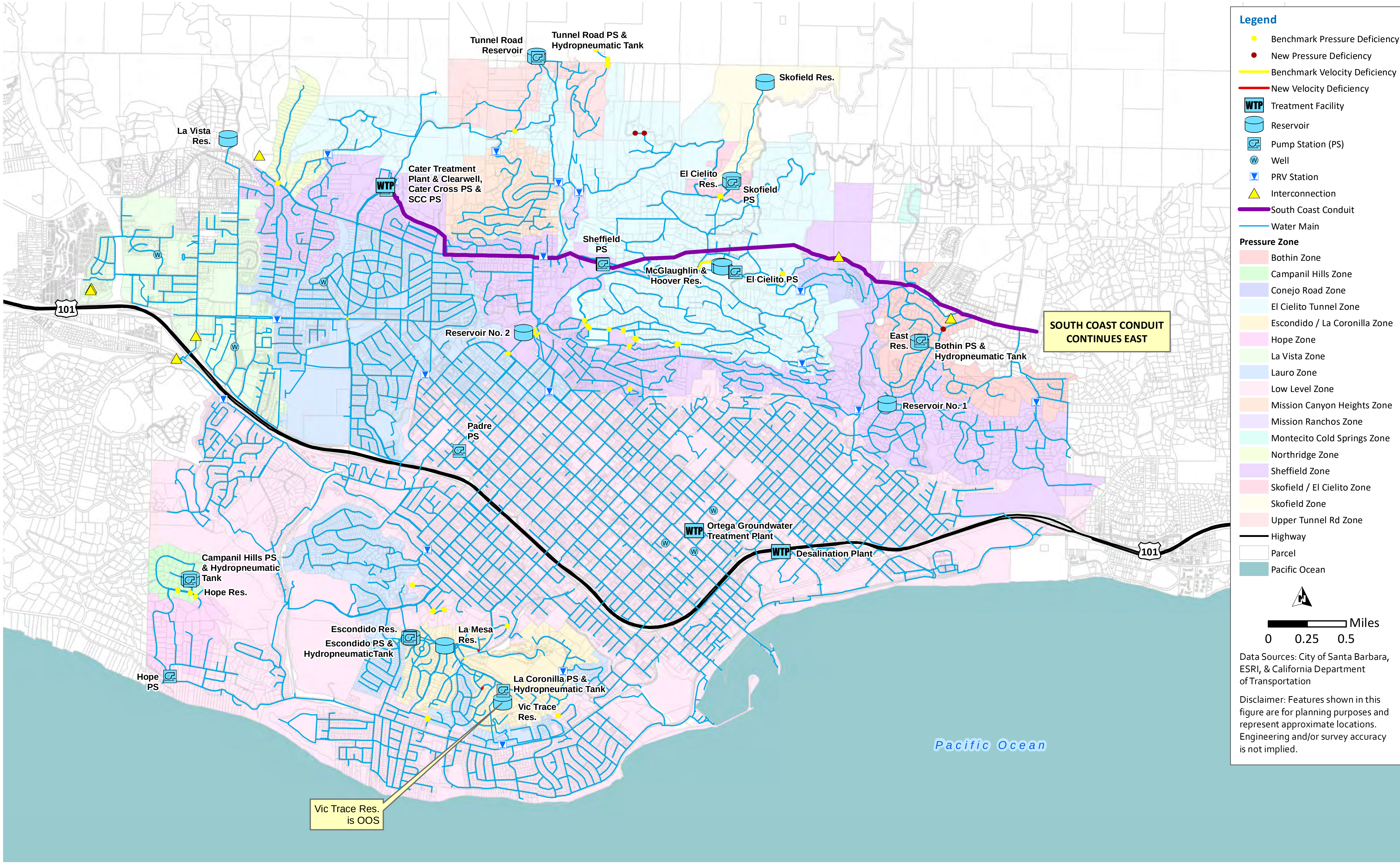


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Figure 5 Stress Analysis Scenario 5 - 2019 MDD

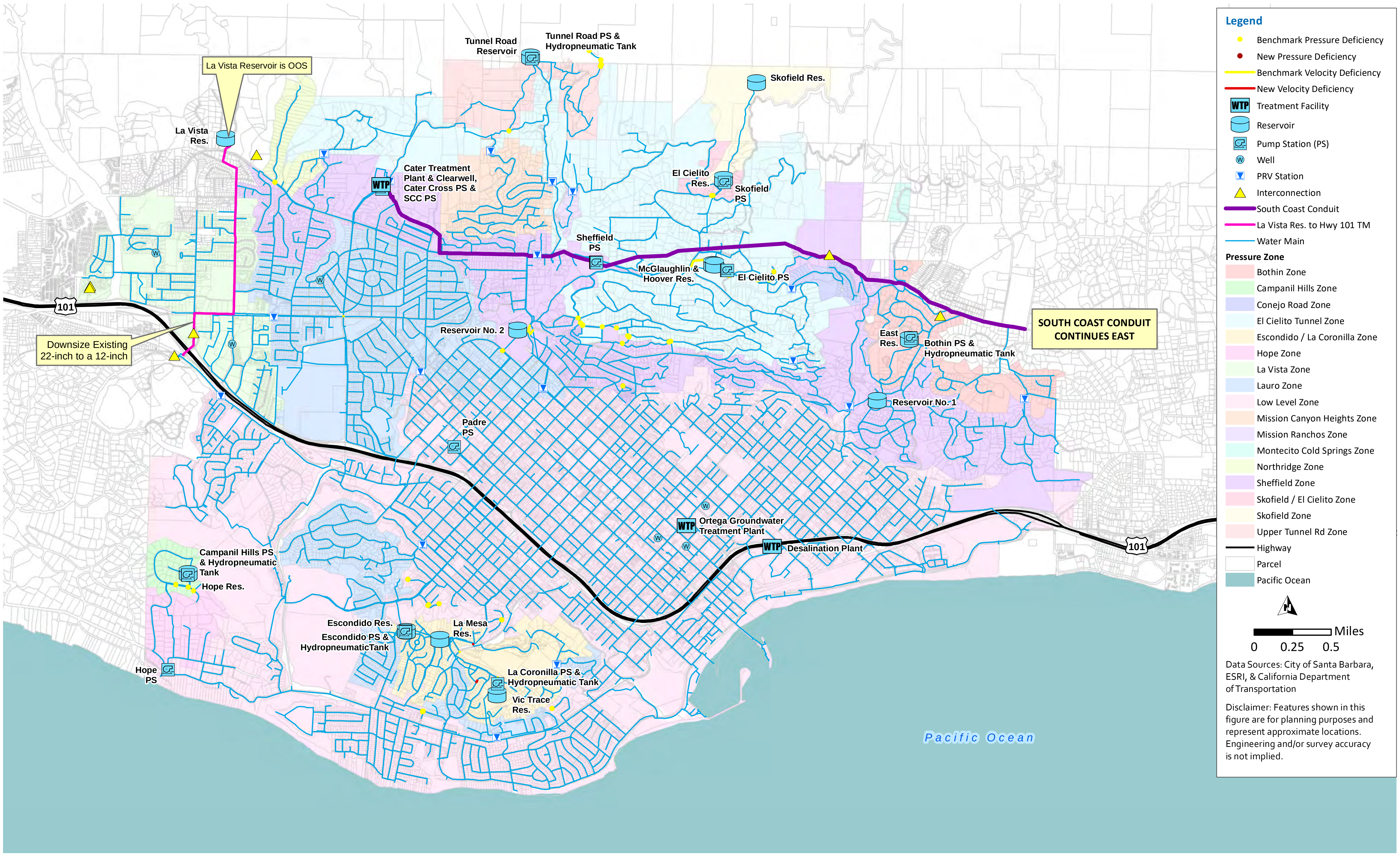

Figure 6 Stress Analysis Scenario 6 - 2019 MDD

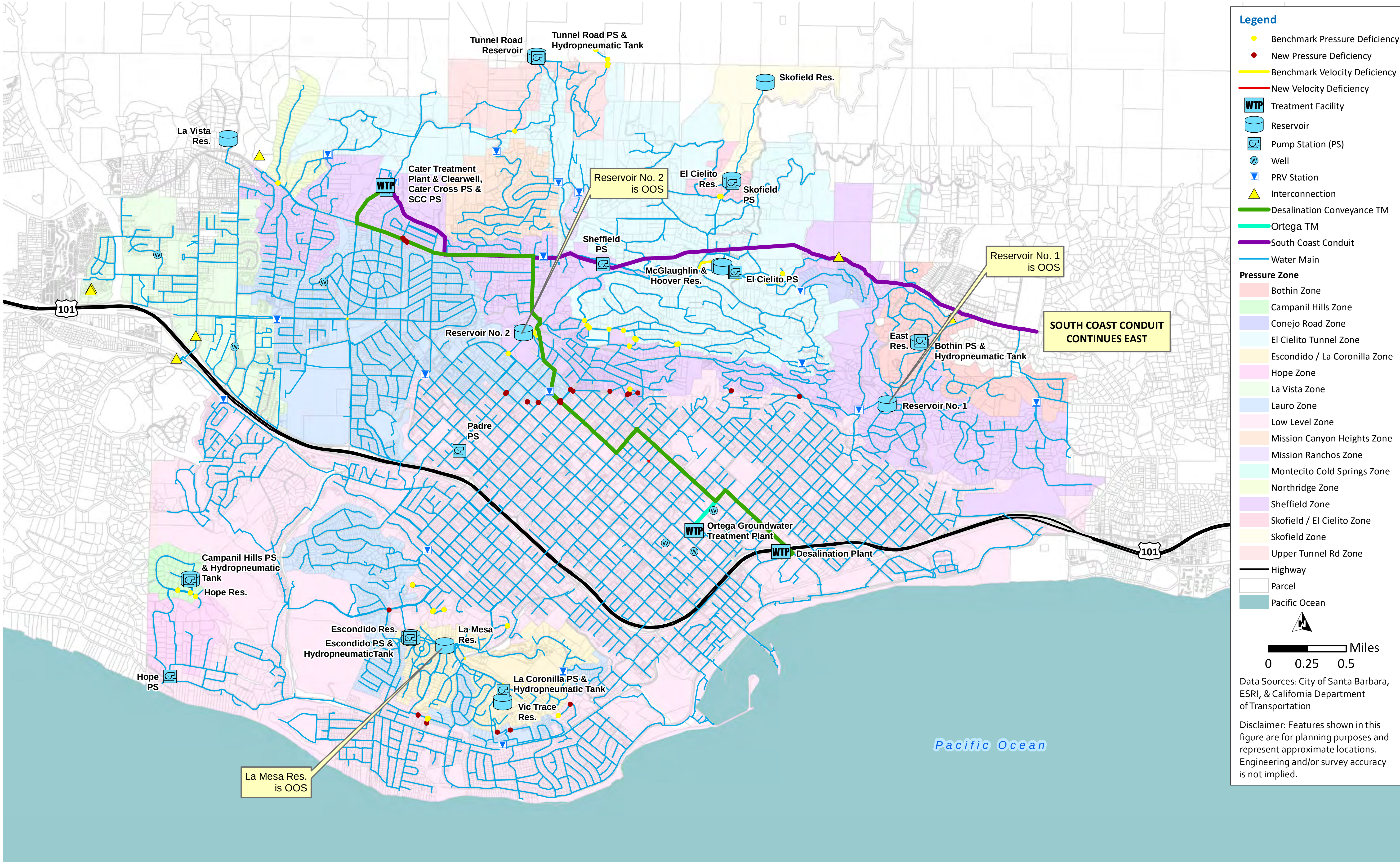

Figure 7 Stress Analysis Scenario 7 - 2019 MDD

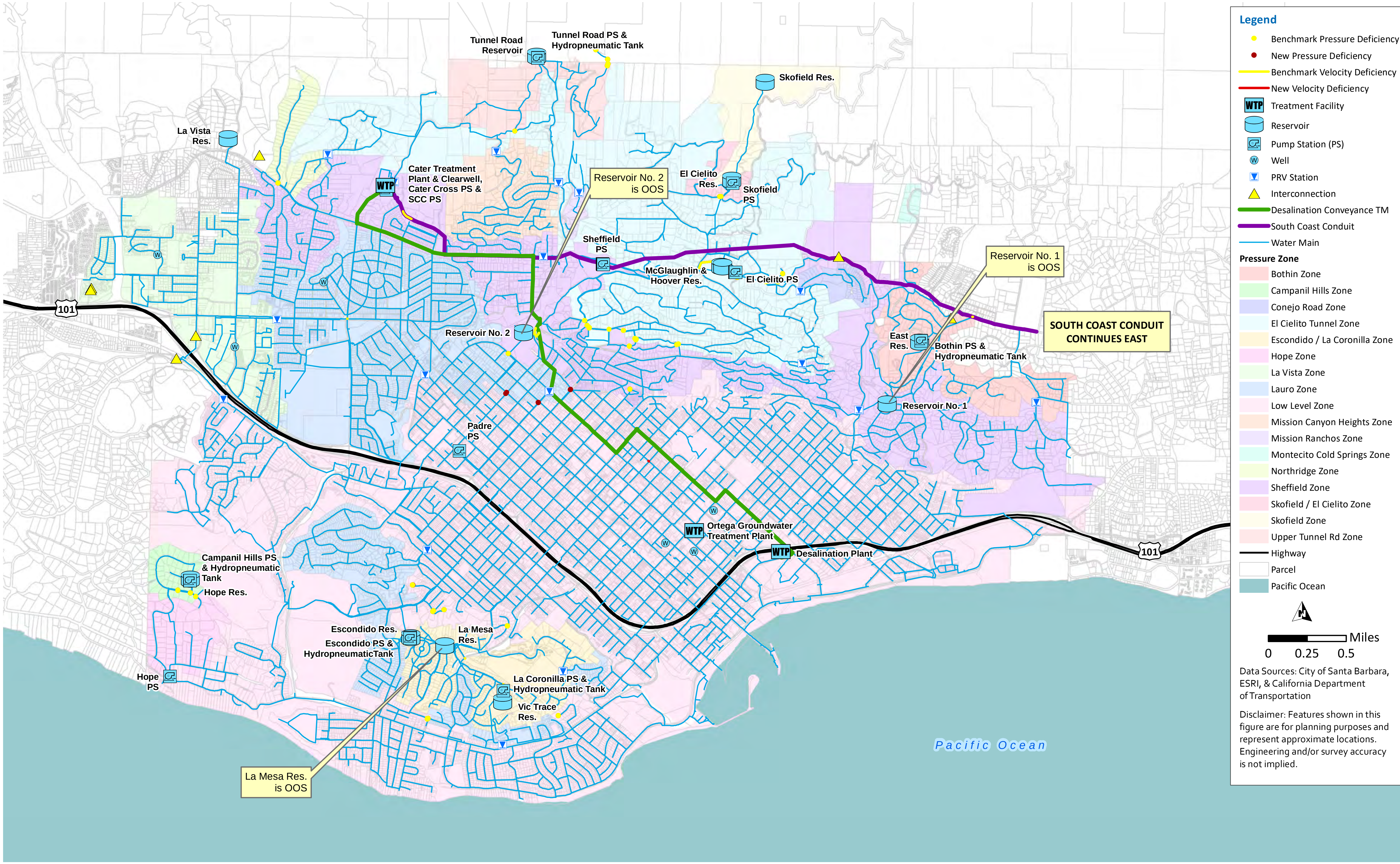

Figure 8 Stress Analysis Scenario 8 - 2019 MDD

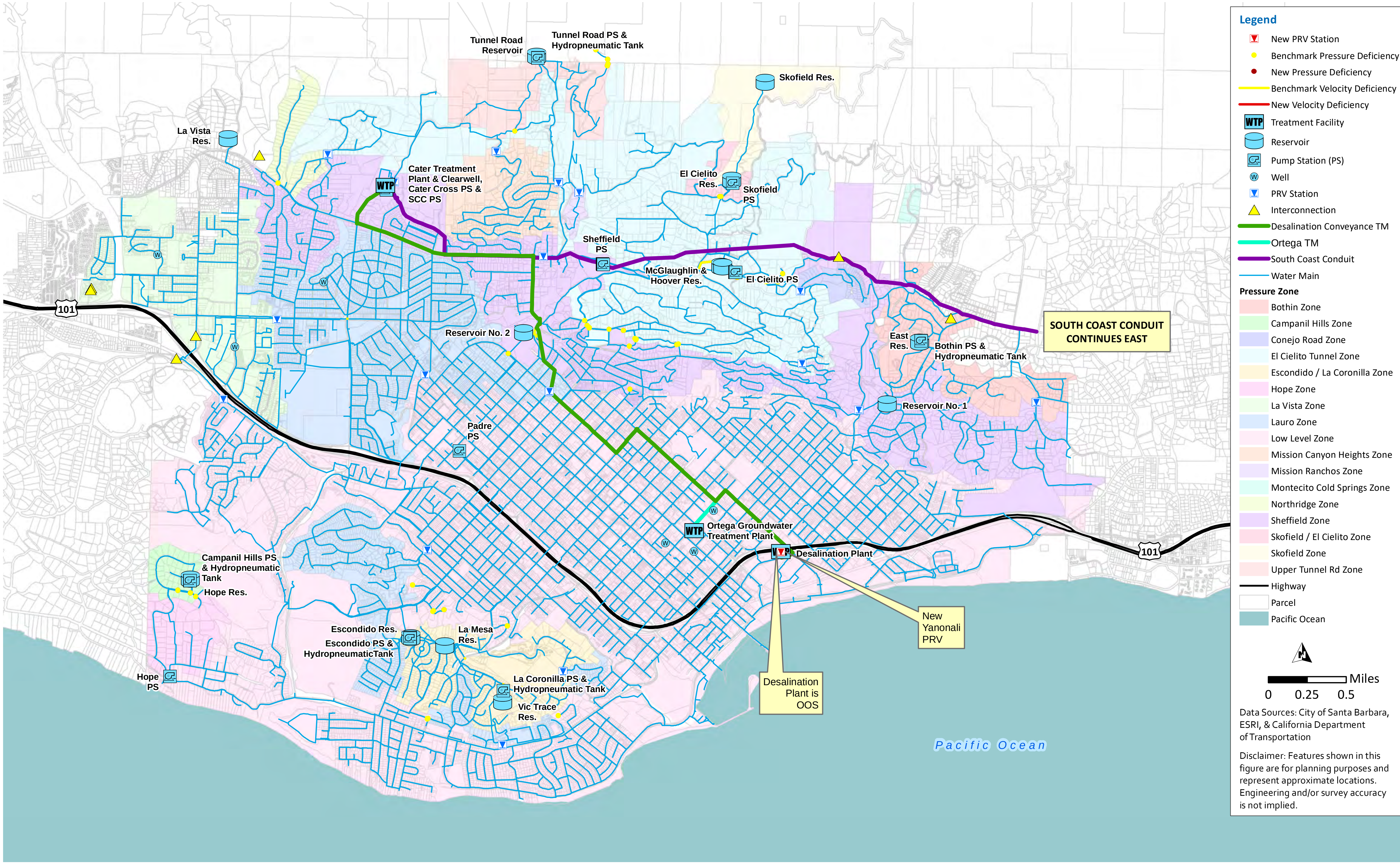

Figure 9 Stress Analysis Scenario 9 - 2019 MDD

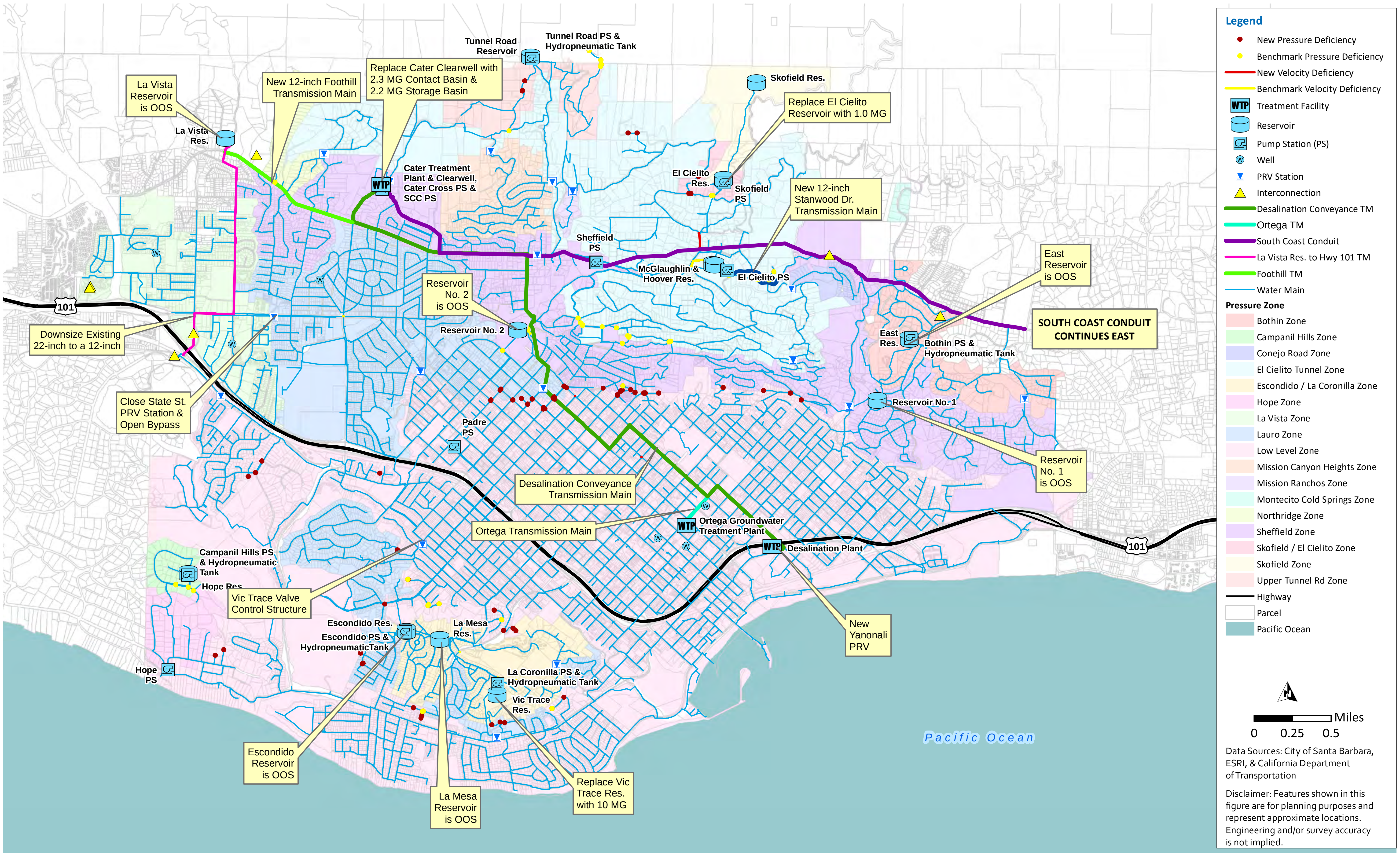

Figure 10 Stress Analysis Scenario 10 - 2050 MDD