Exhibit 1

2017 WATER
MASTER PLAN
City of Santa Ana

TETRA TECH

2017 Santa Ana Water Master Plan

for the:

City of Santa Ana

January 2018

Prepared by:

TETRA TECH

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SECTION 1 ••OVERVIEW

The 2017 Santa Ana Water Master Plan (Master Plan) was prepared to document a multi-year capital improvement program to maintain the City's Water utility infrastructure systems in sound operable condition and to meet the level of service expectations of the City over the proposed planning period. The Master Plan covers the planning period from fiscal year 2017/18 to 2039/40.

The City's water enterprise provides water to all of Santa Ana's residents and businesses, and it is vital that the water system management activities incorporate industry best practices to maintain the water system's reliability, overall hydraulic operations as well as any future system improvement needs. The 2017 Master Plan was developed to identify needed system improvements, define typical refurbishment and replacement requirements, recommend the prioritization of these improvements/replacements, and establish an overall general implementation schedule and budget for these future capital improvement projects.

The ultimate goal of the 2017 Master Plan was to establish a Capital Improvement Program (CIP) schedule and budget for the planning period of fiscal year 2017/18 to fiscal year 2039/40. This CIP schedule/budget will assist the City in making decisions on future improvements and rehabilitation/replacements of existing facilities as necessary to maintain the City's Water utility infrastructure systems in sound operable condition and to meet the level of service expectations of the City over the proposed planning period.

SECTION 2 ••WATER SYSTEM COMPUTER MODELING RESULTS

The City of Santa Ana previously had IDModeling, Inc. develop and calibrate a computerized water system model of the City's existing water system. This water model allows for the evaluation and analysis of the City's water system for reliability, system hydraulic operations, and future needs. Technical Memorandum #7, prepared by IDModeling and dated July 2015, summarized the major tasks of the Water System Computer Modeling project. The tasks of the modeling project included: model build; demand allocation; diurnal pattern development; steady state and extended period simulation calibrations; and subsequent hydraulic analyses of the existing City water system using the calibrated models. This section of the Master Plan provides an overall summary of these findings.

SECTION 3 ••NEAR-TERM AND BUILDOUT MODEL EVALUATION

As part of the Master Plan Project, IDModeling performed additional near-term and buildout hydraulic analysis using the calibrated water model. These additional analysis are documented in the Master Plan Hydraulic Analysis Final Technical Memorandum. The tasks documented within the memorandum include: summary of future demands for near-term and buildout analysis; analysis of the existing, near-term, and future system deficiencies; analysis of ability to meet fire flow requirements under future demand conditions; and analysis evaluating the ability of the City to serve the future system without imported water. This section of the Master Plan provides an overall summary of these analyses. In summary, the results of the system analysis are a good indication of the overall robustness of the City's distribution system.

During the existing and near-term demand analysis, the only deficiencies identified were low pressures along the border of the Low and High Zones south of the Interstate 5 Freeway. These low pressure deficiencies will be resolved once the proposed future well located in the vicinity of the Elevated Tank is constructed.

In addition, the results of the water supply analysis indicated that the City's water system has adequate capacity and distribution capabilities to supply the entire water system demands using only groundwater wells.

SECTION 4 ••SOURCE EVALUATION

The City obtains water from two primary sources: local well water from the Lower Santa Ana River Groundwater Basin, also known as the Orange County Groundwater Basin (OC Basin), which is managed by OCWD; and imported water from Metropolitan. Groundwater production accounts for roughly 70 to 75 percent of the water supply and Metropolitan imported water supplies provide the remaining 25 to 30 percent. The City's water system has a total of 21 groundwater wells, and seven import water connections.

This section summarizes the following: existing well data; existing well assessment; proposed new wells; major well rehabilitation; typical well refurbishment and construction costs; well maintenance history; well back-up power; MWD connections; and existing interconnections with surrounding water agencies.

The following are the new wells recommended within the Master Plan: new well in High Zone to replace Well 22; one or two new wells in the vicinity of the Elevated Tank to resolve the low pressures identified in the water system analysis; and new replacement wells for Well 16, Well 18, and Well 24 due to their age and decrease in performance of the well. The City is planning to perform a casing evaluation of these three wells to determine the condition of the existing well casings. Based on the results of this evaluation, the City may need to accelerate or delay the proposed replacement of Well 16, Well 18 and Well 24.

The City is planning to perform major well rehabilitation at Well 32 due to elevated nitrate levels and at Well 29, due to recent car accident damaging/destroying most of the existing above ground facilities.

The City's existing wells play a critical role in providing water service cost effectively to the City. Therefore, maintaining the existing wells is of upmost importance if the City wants to maintain the sound operable condition of the water system and meet the current level of service and water operating budget expectations (MWD water is more expensive than groundwater). Due their critical role, a typical well refurbishment plan was developed with the corresponding refurbishment costs.

To give the City an opportunity to continue to use groundwater and not use imported water even during extended power outages, the City is planning to construct emergency generators at five of the key wells that pump directly into the distribution system (Well 31, Well 35, Well 37, Well 40 and Well 41). At a future date, the City is planning to construct emergency generators at the remaining wells that pump directly into the distribution system (Well 28 and Well 38) and at the John Garthe Station at Well 32 and Well 36. By adding these facilities, the City will increase its reliability during a long, extended power outage.

SECTION 5 ••RESERVOIR AND PUMP STATION EVALUATION

The City's water system consists of two pressure zones (High Zone and Low Zone). Each of these pressure zones have groundwater wells, reservoirs and booster pump stations which supplies potable water to the City's customers. In general, the facilities are consolidated into several stations consisting of multiple groundwater wells, a storage reservoir, and a booster pump station. At each station, the wells pump groundwater into the storage reservoir and the booster pump station pumps water from the storage reservoir to the distribution system.

This section summarizes the following: the existing reservoirs and pump stations; existing reservoir and pump station assessments; major pump station rehabilitation; typical reservoir and pump station refurbishment and construction costs; reservoir and pump station refurbishment history; and pump station back-up power.

The City is under construction on the Walnut Pump Station Rehabilitation. The City is planning to design and construct major rehabilitation projects at Cambridge and East Pump Station Facilities.

In order to maintain the condition of the existing reservoirs and pump stations, a typical refurbishment plan was developed with the corresponding refurbishment costs.

In addition, the City is planning to construct emergency generators at the Crooke and Cambridge Pump Station facilities due the criticalness of these facilities in the High Zone. By adding emergency power at these facilities, the reliability of the High Zone during extended power outages will be improved.

SECTION 6 ••DISTRIBUTION SYSTEM EVALUATION

The City's water system is comprised of approximately 480 miles of transmission and distribution mains. Overall, the water distribution system is robust and hydraulically sound with almost no hydraulic concerns.

This section summarizes the following: water main install date and pipe material; assessment of the distribution system; cast iron replacement; pipeline replacement construction costs; and the recommended pipeline replacement program.

As of 2017, based on the age of the existing pipe, 20% (about 560,000 feet of pipe) of the City's distribution system has already past the pipe materials typical useful life. By the end of the proposed planning period (fiscal year 2039/40), 70% (about 1,870,000 feet of pipe) will have past the pipe materials typical useful life. Figure ES-1 provides a summary of the age of the existing pipes within the City's distribution system.

In summary, the distribution system is old and needs to be systematically replaced.

The City has been slowly working on the replacement of the existing cast iron pipelines. Most of the past projects have been focused on replacing cast iron and older asbestos cement pipelines within a selected City Neighborhood prior to proposed City Public Works paving projects. Figure ES-2 shows a summary of the cast iron pipe remaining within the City's distribution system. The ball park construction cost to replace all of the remaining cast iron pipe is about $250M.

To replace the other pipe materials that as of 2017 have already past the pipe material's typical useful life is another $20M. If the goal is to replace all of the pipe material (including cast iron) that has a useful life that is past by the end of the proposed planning period of 2039/40, the ball park construction cost is about $500M.

The City does not have a CIP budget within this proposed planning period to cover the replacement of just the cast iron pipe ($250M) and for sure not all of the pipe that will pass its expected useful life ($500M). Therefore, it is important for the City to establish a pipeline replacement program focused on limiting risks of failure. Since neither of the two previous assessment analysis that were performed identified a common factor for failure, it is recommended that the City move forward with a plan to replace the oldest pipes first. However, for public relations and to minimize impacts to a community and its water service, the replacement program will continue to proceed by neighborhoods.

The estimated construction cost for the recommended pipeline replacement projects within the planning period is about $110M.

SECTION 7 ••MISCELLANEOUS IMPROVEMENTS

The City's water system includes wellhead treatment facilities, four pressure regulating stations, valves, facility security, telemetry/controls and communication facilities. These items play a key role in the overall water system.

This section summarizes the following improvements/upgrades to these miscellaneous facilities: wellhead treatment; pressure regulating stations; valve replacement; service meters; SCADA, Communications and Instrumentation; sustainable energy; security assessment; and operations and maintenance programs.

The new wellhead treatment facilities have been installed or will be installed by the end of 2018. The expected useful life for these treatment facilities is typically assumed to be 12 to 15 years.

For the four pressure reducing/pressure sustaining valve stations, the City is planning in the future to add power and remote control to these stations so that the City will be able to control flow from the High Zone to the Low Zone as part of its normal daily operation.

At this time, the City is not planning to establish a valve replacement program as it currently does not have sufficient budget to perform the required pipeline replacement projects. The City will continue to replace the valves as it systematically replaces the aged water mains.

The City is planning to upgrade its existing meters with an Automated Meter Infrastructure which will allow the City personnel and customers access to real-time water consumption data. This will be very helpful if the drought regulations are reinstated in the future.

The City is planning to upgrade its SCADA, communications and instrumentation at various facilities throughout the water system. In addition, the City is planning to install a fiber-optic backbone facility from each key facility to the City Yard hub. This will improve the SCADA capabilities of operating and maintaining the various City facilities.

The City is considering the installation of solar panels at the John Garthe and West Reservoir Facilities which will provide the City with sustainable energy.

It is recommended that the City restrict access to the reservoir sites by constructing perimeter walls, installing intrusion alarms as well security cameras. The goal is ensure no intruder can contaminate the City's water system at the reservoir sites. For sites with wells, pump stations and outdoor piping, the City is planning to improve the perimeter fencing to impede easy access to the site.

SECTION 8 ••CAPITAL IMPROVEMENT PROGRAM

The ultimate goal of the 2017 Water Master Plan for the City of Santa Ana is to establish a Capital Improvement Program (CIP) based on the recommended improvements/projects summarized in the previous sections. The planning period for the CIP is from fiscal year 2017/18 to fiscal year 2039/40. This CIP schedule/budget will assist the City in establishing priorities and help make decisions on future improvements and refurbishment/replacement of existing facilities.

The projects were prioritized based on discussions with the City, importance of the facilities to the overall water system, and key to maintaining reliable water service to the City's customers.

This section summarizes the following: well, pump station, reservoir, distribution, emergency power and miscellaneous improvement priorities; recommended Capital Improvement Program; and limited Capital Improvement Program.
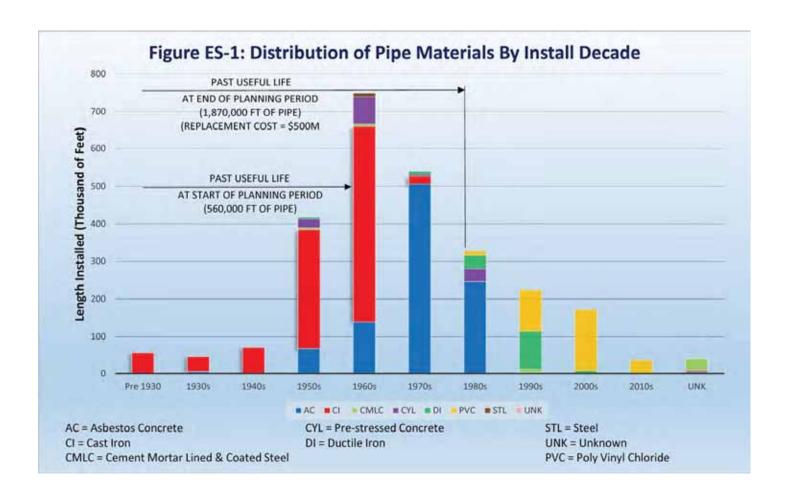
The total projected CIP budget, including the 2% inflation, over the planning period of 23 fiscal years is **$327M**, or an average of **$14.2M** per year.
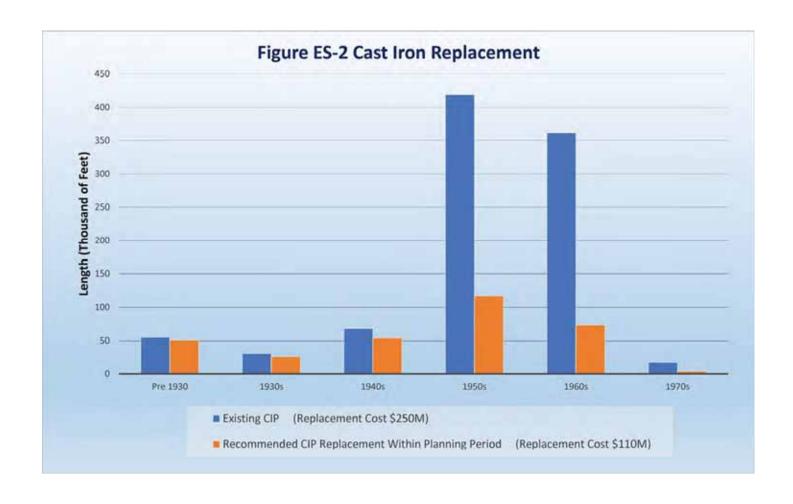
Per the 2014 Water Rate Study prepared for the City, the total budget for the planning period is **$240M**, or an average of **$10.4M** per year. Therefore, in order to maintain CIP expenditure levels per the 2014 water Rate Study, a significant number of the recommended projects identified in the Master Plan will have to be deleted or delayed in order to reduce the CIP budget in an amount of $90M over the planning period.
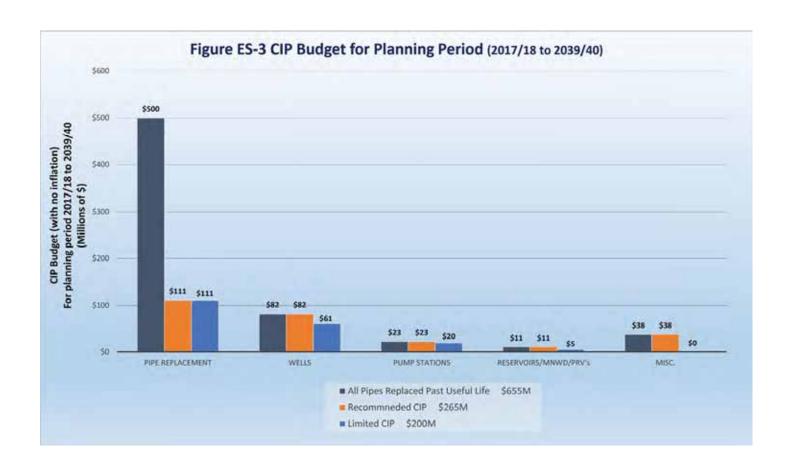
None of the recommended capital improvement projects that are needed to maintain the level of service and/or operation of the water system should be deleted or delayed. Only recommended improvement projects that enhance or improve the existing water system or its operation should be considered to be deleted or delayed. Based on the project deletions identified, a Limited Capital Improvement Program was prepared and presented within this section.
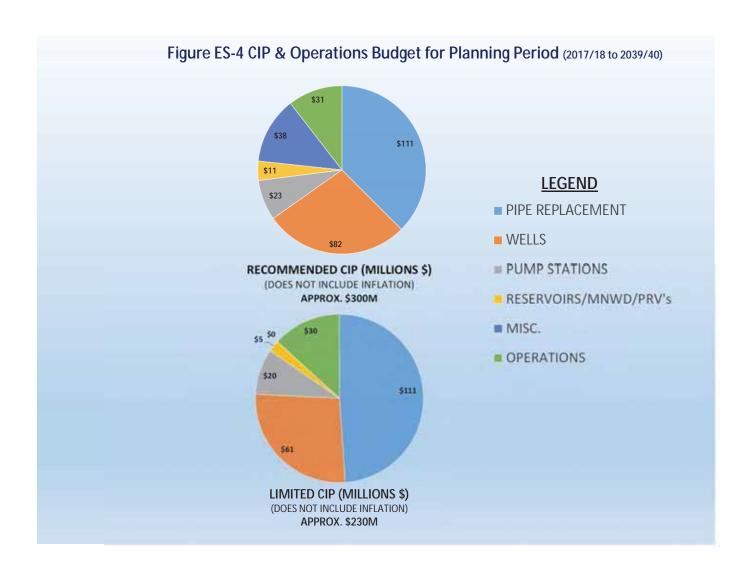
Figure ES-3 shows the CIP Budget for the planning period for the three alternative scenarios: recommended CIP budget plus the replacement of all pipes past their useful life; the recommended CIP budget; and the limited CIP budget. Figure ES-4 summaries the CIP and Operations Budget for the planning period of both the Recommended CIP and the Limited CIP Programs.

It is recommended that the City perform a new Water Rate Study using the recommended CIP budget, as a minimum, to ensure the City meets its goal of providing safe and reliable drinking water for future generations.

Figure ES-1: Distribution of Pipe Materials By Install Decade

Figure ES-2 Cast Iron Replacement

Figure ES-3 CIP Budget for Planning Period (2017/18 to 2039/40)

Figure ES-4 CIP & Operations Budget for Planning Period (2017/18 to 2039/40)

$31
$38
$111
$11
$23
$82

RECOMMENDED CIP (MILLIONS $)
(DOES NOT INCLUDE INFLATION)
APPROX. $300M

$5 $0 $30
$20
$111
$61

LIMITED CIP (MILLIONS $)
(DOES NOT INCLUDE INFLATION)
APPROX. $230M

LEGEND

- PIPE REPLACEMENT
- WELLS
- PUMP STATIONS
- RESERVOIRS/MNWD/PRV's
- MISC.
- OPERATIONS

SECTION 1 ••OVERVIEW

1.0   Introduction

The 2017 Santa Ana Water Master Plan (Master Plan) was prepared to document a multi-year capital improvement program to maintain the City's Water utility infrastructure systems in sound operable condition and to meet the level of service expectations of the City over the proposed planning period. The Master Plan covers the planning period from fiscal year 2017/18 to 2039/40.

The City's water enterprise provides water to all of Santa Ana's residents and businesses, and it is vital that the water system management activities incorporate industry best practices to maintain the water system's reliability, overall hydraulic operations as well as any future system improvement needs. An important industry best practice is to develop a Master Plan that will identify needed system improvements, define typical refurbishment and replacement requirements, recommend the prioritization of these improvements/replacements, and establish an overall general implementation schedule and budget for these future capital improvement projects.

1.1   Background

1.1.1   Overview of City of Santa Ana

The City of Santa Ana is one of the oldest cities in Orange County incorporated in 1886. It encompasses 27.5 square miles and is in the heart of Orange County. It is rated the eleventh largest city in California with a population of roughly 324,500 (2010 US Census). The City owns and operates through the Department of Public Works two self-supporting enterprises: Water and Sewer.

Santa Ana was, for many years, a ranching community with some farming. To serve this growing agricultural and domestic community, a municipal water system was formed in 1886. The original source of water supply for the City was from shallow irrigation wells. As the City continued to grow and change from agriculture to an urban community, the need for additional sources of water was recognized if economic development were to continue.

To tap into water sources from outside the area, the City joined with 12 other southern California cities to form and be an original member agency of the Metropolitan Water District of Southern California (Metropolitan) on February 27, 1931. Metropolitan, as a regional wholesaler, supplies imported water to Southern California from the Colorado River and from the State Water Project from Northern California. Metropolitan's primary purpose is to develop, store and distribute water at wholesale rates to its member public agencies for domestic and municipal uses.

In 1933, the Orange County Water District (OCWD) was formed by a special act of the State Legislature to manage Orange County's groundwater supply and protection of the County's rights to water in the Santa Ana River. In 1953, the City became a member of OCWD.

The City's Water Enterprise provides water service within its 27.5-square mile service area. The service area includes the City of Santa Ana and a small neighborhood in the City of Orange, near Tustin Avenue and Fairhaven by the northeast corner of Santa Ana.

1.1.2 Santa Ana Water Facilities

The Water Enterprise serves residential, commercial, industrial, institutional and irrigation customers by providing potable and recycled water. To serve its customers, the Water Enterprise obtains water from two primary sources: local well water from the Lower Santa Ana River Groundwater Basin, also known as the Orange County Groundwater Basin (OC Basin), which is managed by OCWD; and imported water from Metropolitan. Groundwater production accounts for roughly 70 to 75 percent of the water supply and Metropolitan imported water supplies provide the remaining 25 to 30 percent.

The City of Santa Ana Public Works Agency – Water Resources Division oversees and maintains the daily operations of the water system. The City's water system has an average demand of about 43 million gallons (MG) with approximately 45,000 services. It is comprised of approximately 480 miles of transmission and distribution mains, ten reservoirs with a storage capacity of 49 MG, seven pumping stations, 21 groundwater wells, four pressure regulating stations and seven import water connections. The City also receives recycled water after advanced treatment from the OCWD facility called Green Acres Project.

Fourteen of the City Wells pump into surface reservoirs with booster stations pumping the water into the distribution system. The remaining seven wells pump directly into the City's distribution system. Water pumped from all of the wells has been naturally filtered as it passes through underlying aquifers of sand, gravel, and soil. This well water only requires disinfectant treatment for system distribution.

The City maintains seven imported water connections to receive water through Metropolitan's Orange County and East Orange County Feeder pipelines. These seven metered connections, with a total capacity of 60,580 gallons per minute (gpm) transfer the imported water into the City's distribution system.

1.2 Purpose

The City of Santa Ana previously developed and calibrated a computerized water system model of the City's existing water system. This water system model allows for the evaluation and analysis of the City's water system for reliability, system hydraulic operations, and future needs. The purpose of the 2017 Water Master Plan was to use the calibrated water system computer model to perform the following tasks:

- Create future demands for near-term and buildout conditions;
- Perform a system-wide analysis to determine the need for piping and facility upgrades to accommodate future growth/redevelopment, as well as, provide fire flows under future demand conditions;
- Analyze the ability to serve the future system without imported water;
- Perform a criticality analysis of the water distribution system valves to assist in prioritization of the City's valve exercise program;
- Conduct a risk assessment on existing distribution system to determine the likelihood of failure and consequence of failure per each pipeline segment;
- Perform Source Evaluation, including existing well assessment;
- Perform Pump Station and Reservoir Evaluation, including existing facility assessment;
- Perform Distribution System Evaluation, including the old cast iron replacement program;

- Summarize the City's water treatment replacement program;

- Perform a cursory vulnerability assessment of the various water facility sites;

- Summarize the City's Telemetry and Communication proposed improvements; and

- Assist the City in development of Operations and Maintenance Programs;

The ultimate goal of the 2017 Master Plan was to establish a Capital Improvement Program (CIP) schedule and budget for the planning period of fiscal year 2017/18 to fiscal year 2039/40. This CIP schedule/budget will assist the City in making decisions on future improvements and rehabilitation/replacements of existing facilities as necessary to maintain the City's Water utility infrastructure systems in sound operable condition and to meet the level of service expectations of the City over the proposed planning period.

SECTION 2 ••WATER SYSTEM COMPUTER MODELING RESULTS

2.0   Introduction

The City of Santa Ana previously had IDModeling, Inc. develop and calibrate a computerized water system model of the City's existing water system. This water model allows for the evaluation and analysis of the City's water system for reliability, system hydraulic operations, and future needs. Technical Memorandum #7, prepared by IDModeling and dated July 2015, summarized the major tasks of the Water System Computer Modeling project. A copy of Technical Memorandum #7 has been included within Appendix A of the Master Plan. The tasks of the modeling project included: model build; demand allocation; diurnal pattern development; steady state and extended period simulation calibrations; and subsequent hydraulic analyses of the existing City water system using the calibrated models. The following subsections provide an overall summary of these findings.

2.1   Facilities Overview

Attached Figure 1 shows the entire Santa Ana water distribution system as it is represented in the water system computer model. The system supplies potable water to two pressure zones (High Zone and Low Zone) and consists of 21 groundwater wells, ten storage reservoirs, seven booster pump stations, and four pressure reducing valve/pressure sustaining valve (PRV/PSV) stations. In general, the facilities are consolidated into several stations consisting of multiple groundwater wells, a storage reservoir, and a booster pump station. At each station, the wells pump groundwater to the storage reservoir and the booster pump station pumps the water from the storage reservoir to the distribution system. The system also includes several wells that pump directly into the distribution system with no storage reservoir or booster pump station. There are four PRV/PSV stations that allow flows from the High Zone to the Low Zone.

2.2   Facility Summary

2.2.1   Low Zone Facilities

Walnut Station: The Walnut Station consists of a 7 MG storage reservoir fed by three groundwater wells (Well 16, Well 29, and Well 33) and a booster pump station that supplies water to the distribution system from the storage reservoir. The booster pump station includes five pumps with a firm capacity of approximately 11,500 gpm. Two pumps are operated with variable frequency drives (VFD) that are controlled by pressure of the discharge header pipe. Walnut Station operates in parallel with other major facilities including the John Garthe Station and Low Zone Well 41. Modeling showed that these facilities are extremely sensitive to very slight changes in the discharge pressure set points. A slight change at one facility could significantly impact the flow balance of other major facilities.

John Garthe Station: The John Garthe Station includes three storage reservoirs with a total storage of 15.8 MG fed by four groundwater wells (Well 18, Well 24, Well 36, and Well 39) and a booster pump station that supplies water to the distribution system from the storage reservoirs. The booster pump station includes five pumps with a firm capacity of approximately 14,800 gpm. Two pumps are operated with VFDs that are controlled by pressure of the discharge header pipe. The John Garthe Station operates in parallel with other major facilities including the Walnut Station and Low Zone Well 41.

As with Walnut Station, modeling showed that these facilities are extremely sensitive to very slight changes in the discharge pressure set points. A slight change at one facility could significantly impact the flow balance of other major facilities.

East Station: The East Station consists of a 6 MG storage reservoir fed by one groundwater well (Well 26) and a booster pump station that supplies water to the distribution system from the storage reservoir. If Well 26 is out of service, the reservoir is filled from the distribution system. The booster pump station includes two pumps with a firm capacity of approximately 2,300 gpm. Both pumps are operated with VFDs that are controlled by pressure of the discharge header pipe.

West Station: The West Station consists of a 6 MG storage reservoir fed by three groundwater wells (Well 20, Well 21, and Well 30) and a booster pump station that supplies water to the distribution system from the storage reservoir. The booster pump station includes five pumps with a firm capacity of approximately 10,500 gpm. Two pumps are operated with VFDs that are controlled by pressure of the discharge header pipe.

South Station: The South Station consists of a 6 MG storage reservoir fed by one groundwater well (Well 34) and a booster pump station that supplies water to the distribution system from the storage reservoir. The booster pump station includes two pumps with a firm capacity of approximately 2,000 gpm. All pumps are operated with VFDs that are controlled by pressure of the discharge header pipe.

Elevated Tank: There is one 1.0 MG elevated storage tank located within the Low Zone. The elevated tank helps maintain a consistent pressure range throughout the Low Zone and is fed primarily by Well 41, John Garthe Station, and Walnut Station.

Low Zone Wells: There are four wells in the Low Zone (Well 31, Well 35, Well 37, and Well 41). These wells utilize VFDs to control the discharge pressure into the distribution system. The Low Zone wells operate in parallel with other major facilities including the Walnut and John Garthe Stations. These facilities are extremely sensitive to very slight changes in the discharge pressure set points; with Well 41 being the most sensitive of all the Low Zone wells.

Low Zone Metropolitan Water District (MWD) Connections: The MWD connections in the Lower Zone include six connections with flow control valves that allow water to be conveyed from the MWD transmission main to the Low Zone distribution system.

2.2.2   High Zone Facilities

Crooke Station: The Crooke Station consists of a 6 MG storage reservoir fed by one groundwater well (Well 27) and a booster pump station that supplies water to the distribution system from the storage reservoir. The booster pump station includes three pumps with a firm capacity of approximately 3,300 gpm. All booster pumps are constant speed that turn on and off based on the pressure of the discharge header pipe. In addition, Well 28 is located at the Crooke Station and consists of one 2,500 gpm capacity VFD pump. Well 28 pumps directly into the High Zone.

Cambridge Station: The Cambridge Station consists of a 1.3 MG storage reservoir fed from the distribution system and a booster pump station that supplies water to the distribution system from the storage reservoir. The booster pump station includes three pumps with a firm capacity of approximately 5,400 gpm. All booster pumps are constant speed that turn on and off based on the pressure of the discharge header pipe.

In addition, Well 38 is located at the Cambridge Station and consists of one 2,500 gpm capacity VFD pump. Well 38 pumps directly into the High Zone.

High Zone Well: Well 40 contains one constant speed pump with a capacity of 2,575 gpm that discharges directly to the High Zone distribution system.

Zone Interconnections: There are four PRV/PSV stations that allow water to flow from the High Zone to the Low Zone and reduces the pressure to acceptable levels in the Low Zone. These valve stations are primarily used for relieving high pressure spikes in the High Zone and can be manually controlled by operations staff.

High Zone Metropolitan Water District (MWD) Connections: There is one MWD connection with a flow control valve that allows water to be conveyed from the MWD transmission main to the High Zone distribution system.

2.3   Demand Summary

Existing system demands were allocated as a component of the Water System Computer Model project. Because the Water System Computer Model Project was started prior to the completion of the City's 2015 Urban Water Management Plan (UWMP), demand data was calculated based upon the City's 2012-13 demand data (the most recent available at the time). In addition, the top 15 usage accounts were identified and their locations within the distribution system were verified to ensure that the largest system demands were allocated to the correct model junctions.

The following is a comparison of existing demands used in the Water System Computer Model Project with the data included in the City's UWMP:

Table 1 – Comparison of Demands by Data Source

Demand Source	2015	Existing
2015 UWMP	36,655 AFY 32.7 mgd	---
Water System Computer Model	----	33.5 mgd

The maximum day demands (MDD) and the peak hour demands (PHD) were developed using production data and hourly SCADA data provided by the City. The peaking factors were calculated as follows:

- The MDD peaking factor, which is the ratio of maximum day production to average daily production, was determined to be 1.32.

- The PHD peaking factor, which is the ratio of peak hour production to average daily production, was determined to be 1.94.

With input from City staff, the following is a summary of the fire flow requirements used in the computer modeling for specific land use categories including residential, commercial, and industrial land uses:

Table 2 – Fire Flow Requirements Based on Land Use

Land Use	Fire Flow Requirements (gpm)	Flow Duration (hours)	Total Volume (gallons)
Residential	1,500	2	180,000
Commercial	3,000	3	540,000
Industrial	4,750	4	1,140,000

Non-revenue water is water that has been produced and is "lost" before it reaches a customer. Losses can be real losses (leaks or flushing events) or apparent losses (theft or metering inaccuracies). Based on production and usage data, the estimated loss was 5.5% of the total water produced.

2.4 Summary of Supplemental Hydraulic Analyses

2.4.1 Model Calibration

The Water System Model was calibrated under steady state and extended period simulation. In general, the model results matched the field data within calibration tolerances and it was determined that it could be used with high confidence for master planning, operational planning, water quality planning, and pumping/energy optimization under varying demand and operating conditions.

2.4.2 Fire Flow Analysis

The calibrated steady state model under the MDD scenario was utilized to perform a system-wide fire flow analysis. This simulation determined the available fire flow at a residual pressure of 20 psi. The simulation results are shown on Figure 2. The results are a good indication of the overall robustness of the City's distribution system and the ability to handle emergency conditions.

2.4.3 Criticality Analysis

Using the calibrated steady state model under MDD conditions, a valve criticality analysis of the City's system was performed. The criticality analysis was performed to determine the water system vulnerability, and pipelines which have the greatest consequence of failure to customers and operations. Figure 3 shows the color-coded Criticality Index for each pipe segment in the water system. Using the figure, the City will be able to identify the vulnerability of a reach of pipeline and have a general understanding of the magnitude of impacts if the pipeline had to be taken out of service.

2.4.4 Water Quality Analysis

The calibrated 48-hour extended period simulation was used as the basis for performing a water age analysis of the City's water system. The results of the water age analysis are shown on Figure 4 and indicate that the distribution system has low water age. Some higher than expected water age was observed in the vicinity of ground water level storage reservoirs that were not being utilized regularly. The following are general recommendations to improve the system water quality:

- Operate the reservoirs at a reduced level during times of water quality concerns;

- Prioritize reservoir turnover by utilizing the booster stations and turn off the system wells, when possible; and

- Attempt to operate each reservoir booster station every day to turn over the water in the reservoir and promote circulation within the distribution system.

2.4.5 Energy Analysis

The calibrated 48-hour extended period simulation was used as a basis for performing an energy evaluation of the City's water facilities. Using the analysis, the City was provided several recommendations to reduce the overall energy use by the water system. In addition, the analysis summarized the most efficient stations. The following table was provided to the City summarizing the priority of facility operation to conserve energy:

Table 3 – Priority of Facility Operation to Conserve Energy

Zone	Station	Operational Priority
LOW ZONE	John Garthe	1
	Walnut	2
	Well 37	3
	West	4
	Well 41	5
	Well 35	6
	Well 31	7
	South	8
	East	9
HIGH ZONE	Crooke	1
	Well 40	2
	Cambridge	3

2.4.6 Power Outage Analysis

Using the calibrated water model, a power outage analysis was performed. The City determined the need to evaluate the possibility of an area-wide power outage (7 days of outage) which would affect all of the City water facilities. The only source of water during the power outage was assumed to be the MWD source connections. The results of the analysis showed that there is adequate capacity to serve the City under average day demand purely from MWD connections. However, there is some concern of the HGL provided at the MWD connections. The City may need to verify the HGL settings and may need to adjust these settings during an area-wide power outage. A copy of the Power Outage Analysis Technical Memorandum is included within Appendix B of the Master Plan.

SECTION 3 ••NEAR-TERM AND BUILDOUT MODEL EVALUATION

3.0 Introduction

As part of the Master Plan Project, IDModeling performed additional near-term and buildout hydraulic analysis using the calibrated water model. These additional analysis are documented in the Master Plan Hydraulic Analysis Final Technical Memorandum, included within Appendix C of the Master Plan. The tasks documented within the memorandum include: summary of future demands for near-term and buildout analysis; analysis of the existing, near-term, and future system deficiencies; analysis of ability to meet fire flow requirements under future demand conditions; and analysis evaluating the ability of the City to serve the future system without imported water. The following subsections provide an overall summary of these analyses.

3.1 Near-Term and Buildout Demands

Demands were allocated for three time horizons: existing (years 2012-2019); near-term (years 2020-2025); and buildout (years 2040 and beyond). The existing demands were summarized in the Water System Computer Modeling Project.

The near-term demands were developed by scaling upwards the existing demands according to projected population change by geographic area. The geographic areas were delineated by a combination of Traffic Analysis Zones (TAZ) defined by the City's Sewer Master Plan and specific project areas provided by the City's planning department. The additional demand is mainly concentrated in the areas where specific planning processes are already identified with many of these projects affecting the downtown area.

The buildout demands were developed by scaling upwards the existing demands according to projected population change by geographic area to match the year 2040 demand projected included in the 2015 Urban Water Master Plan (UWMP). Like the near-term demands, the additional demand is mainly concentrated in the downtown area.

The following table summarizes the demands and peaking factors for the three time horizons:

Table 4 – Summary of Demands and Peaking Factors

Time Horizon	Average Day Demand (mgd)	Max Day Peaking Factor	Maximum Day Demand (mgd)	Peak Hour Peaking Factor	Peak Hour Demand (mgd)
Existing	33.5	1.35	45.2	1.95	65.3
Near-Term	34.9	1.35	47.1	1.95	68.0
Buildout	35.5	1.35	47.9	1.95	69.1

As stated earlier, the Water System Computer Model Project was started prior to the completion of the City's 2015 Urban Water Management Plan (UWMP). The following is a comparison of the above developed demands in comparison to the demands included in the City's UWMP:

Table 5 – Comparison of Demands by Data Source

Demand Source	2015	Existing	2020	Near-Term	2025	2030	2035	2040 / Buildout
UWMP (AFY)	36,655	--	36,678	--	39,397	39,669	39,658	39,716
UWMP (mgd)	32.7	--	32.7	--	35.2	35.4	35.4	35.5
Master Plan Hydraulic Analysis (mgd)	--	33.5	--	34.9	--	--	--	35.5

3.2 System Analysis

Using the water computer model, the water system was analyzed using the steady-state model for existing, near-term and buildout demands. In general, the system analysis did not identify any peak hour demand deficiencies for the existing, near-term or buildout demands scenarios. Figure 5 presents the results for the peak hour buildout demand condition. In the existing and near-term demand analysis, there were low pressures along the border of the Low and High Zones adjacent to the Interstate 5 Freeway. These low pressures deficiencies were located in the northeastern portion of the Low Zone on the south side of Interstate 5 between East 17th Street and East 1st Street. To resolve these low pressure deficiencies, the Master Plan is proposing a future well located in the vicinity of the Elevated Tank. Without this future well in the vicinity of the Elevated Tank, the water pressure in this area may continue to drop and could reach a level of service that is not adequate in comparison to the rest of the City's water system.

In addition, fire flow modeling was performed for these three time horizon demands as well. There were some locations where the available fire flows did not meet the fire flow requirements (the results of all three demand scenarios were very similar). These fire flow deficiencies typically are located on single-feed pipelines (6-inch in diameter) or 4-inch diameter loops. Figure 6 presents the results for maximum day plus fire flow under buildout demand conditions. The results of the system analysis are a good indication of the overall robustness of the City's distribution system.

3.3 Water Supply Analysis (Wells Only)

Due to persistent drought conditions, IDModeling evaluated the feasibility of serving the entire water system without importing water and using only groundwater wells. This water supply analysis was performed during existing, near-term and buildout maximum day demand scenarios. The results of this water supply analysis indicate that the City's water system has adequate capacity and distribution capabilities to supply the entire water system demands during all three demand scenarios using only groundwater wells.

SECTION 4 ••SOURCE EVALUATION

4.0   Introduction

The City obtains water from two primary sources: local well water from the Lower Santa Ana River Groundwater Basin, also known as the Orange County Groundwater Basin (OC Basin), which is managed by OCWD; and imported water from Metropolitan. Groundwater production accounts for roughly 70 to 75 percent of the water supply and Metropolitan imported water supplies provide the remaining 25 to 30 percent. The City's water system has a total of 21 groundwater wells, and seven import water connections.

4.1   Groundwater Wells

4.1.1   Summary of Existing Wells

Fourteen of the City Wells pump into surface reservoirs with booster stations pumping the water into the distribution system. The remaining seven wells pump directly into the City's distribution system. The following is a summary of the existing groundwater wells:

Table 6 – Groundwater Well Summary

Well Number	Well Pumps To	Power (HP)	Static Depth (ft)	Pumping Depth (ft)	Capacity (mgd)	Design Head (ft)	Design Capacity (gpm)
16	Walnut	150	83	108	2.16	228	2,000
18	John Garthe	150	0	0	3.29	212	2,000
20	West	150	92	115	4.35	161	3,000
21	West	150	93	113	4.16	160	3,000
24	John Garthe	150	127	203	1.85	279	1,800
26	East	125	127	0	3.00	246	2,500
27	Crooke	300	189	298	3.97	370	2,500
28	System	350	180	264	3.62	400	2,500
29	Walnut	200	152	218	3.65	246	2,500
30	John Garthe	150	91	118	4.35	165	3,000
31	System	350	177	246	3.98	408	3,000
32	John Garthe	300	126	0	3.22	315	2,775
33	Walnut	250	148	227	4.10	280	2,800
34	South	125	115	194	2.18	425	2,500
35	System	350	130	165	3.17	305	3,000

Well Number	Well Pumps To	Power (HP)	Static Depth (ft)	Pumping Depth (ft)	Capacity (mgd)	Design Head (ft)	Design Capacity (gpm)
36	John Garthe	250	155	194	5.18	210	3,600
37	System	350	119	137	3.31	330	3,000
38	System	350	221	322	2.16	425	2,500
39	John Garthe	250	153	194	4.32	250	3,000
40	System	400	192	278	3.71	200	2,575
41	System	450	155	201	4.32	350	3,000

4.1.2 Existing Well Assessment

Based on a site visit with the City's maintenance/operation staff, the following is a general summary of the desired upgrades/improvements at each of the wells:

Table 7 – Summary of Well Assessment

Well Number	Well Assessment
16	Install new soft start Relocate electrical controls and SCADA from stadium electrical room Evaluate casing as efficiency is dropping Well is sanding but may be resolved by sealing sounding tube
18	New pump/motor/discharge head and pump concrete base Replace discharge switch, and add power to Cla-valve on flush line
20	Replace discharge switch and add power to Cla-valve on flush line
21	Add well sound enclosure New SCE service, meter and switchboard Replace discharge switch and add power to Cla-valve on flush line
24	Already relined well casing which resulted in reduced capacity Replace MCC
26	Replace discharge switch and add power to Cla-valve on flush line
27	Breaker is at Crooke; Needs separate power and pull new wires New single door frame Replace discharge switch and add power to Cla-valve on flush line
28	New electrical service Upgrade AC for VFDs and replace MOVs New single and double door frames Add chlorine analyzer Coat masonry blocks adjacent to chlorination equipment Add drain at chlorinator or coat concrete and add concrete curb to protect blocks

Well Number	Well Assessment
29	Check condition of casing New building, perimeter wall, pump, motor, above ground piping/valves, etc. New MCC with soft start, SCADA, and move SCE transformer May want ATS
30	Efficiency down, check well redevelopment Sound enclosure for well pump/motor and new pump base Repair v-ditch at channel discharge Needs separate power from West (new SCE service, meter, switchboard, MCC, etc.) Replace discharge switch and add power to Cla-valve on flush line
31	Drawdown is close to pump elevation Add chlorine analyzer Construct drain piping to 1st Street for flushing Replace fans and improve ventilation Replace discharge switch and add power to Cla-valve on flush line
32	Elevated nitrate levels and low operating efficiencies Implement well into Nitrate Blending Plan – pump to John Garthe New building, pump/motor/piping/etc. and chlorination equipment
33	Replace MCC and add soft start Improve flushing discharge (pipe to storm drain if feasible) Repair concrete floor Add fiber optic from well to Walnut Replace discharge switch and add power to Cla-valve on flush line
34	Replace MCC and add soft start Replace building lights Replace discharge switch and add power to Cla-valve on flush line
35	Drawdown is close to pump elevation Pump curve – efficiency drops greatly when not at 100% VFD Add chlorine analyzer Replace discharge switch and add power to Cla-valve on flush line
36	Replace MCC with soft start Add manual ATS Replace discharge switch and add power to Cla-valve on flush line
37	Add chlorine analyzer Repair floor Replace discharge switch and add power to Cla-valve on flush line
38	Drawdown is close to pump elevation Add chlorine analyzer Widen driveway and make gate automatic Specific capacity is degrading – may need to re-develop well Move controls to PLC Sound enclosure for well pump and motor Replace discharge switch and add power to Cla-valve on flush line

Well Number	Well Assessment
39	Poor ventilation (add vent above door by well head) Add solenoid control to Cla-valve and at SA-1 Replace discharge switch and add power to Cla-valve on flush line
40	Repair sounding tube (causing sanding) Add chlorine analyzer Replace PLC program Replace discharge switch and add power to Cla-valve on flush line
41	Change SCE rate schedule as other well sites Add chlorine analyzer Upgrade PLC Replace VFD Replace discharge switch and add power to Cla-valve on flush line

4.1.3 New Wells

The City is planning to drill and equip a new well to replace Well 22 in the High Zone. In addition, the City is planning to drill and equip one or two new wells in the Low Zone in the vicinity of the Elevated Tank at the border of the Low and High Zones adjacent to the 5 Freeway. These new wells will address the low pressures identified in the water system analysis.

Based on the existing condition of the well casing at Well 16 and the desire to relocate the electrical and SCADA controls adjacent to the well, the City is planning to drill and equip a new well to replace Well 16. Due to the degrading specific capacity and dropping efficiency, the City is planning to drill and equip a new well to replace Well 18.

Well 24 is approaching the end of its useful life as it already has a relined well casing which reduced its capacity. Therefore, the City is planning to drill and equip a new well to replace Well 24.

The City is planning to perform a casing evaluation and functional development specification in the coming year to determine the condition of the existing well casings of Well 16, Well 18, Well 22, Well 24, and Well 29. Based on the results of this evaluation, the City may need to accelerate or delay the proposed replacement of Well 16, Well 18 and Well 24. The purpose of evaluating Well 22 steel casing is to determine if Well 22 can be rehabilitated or if the City needs to construct a new well at a different location.

4.1.4 Major Well Rehabilitation

Due to its elevated nitrate levels, the City is planning to perform a major well rehabilitation project at Well 32. The rehabilitation will include new well equipment, new building, new chlorination facilities, and a new pipe to take the well water to John Garthe Reservoir to be blended with low nitrate groundwater.

Due to a car accident, the existing above ground facilities at Well 29 were damaged and/or destroyed. The City is planning to perform a major well rehabilitation project at Well 29 to install new well equipment, building, electrical and chlorination facilities. The existing well casing will be evaluated as part of the upcoming casing evaluation work to confirm that the well casing is still acceptable and a new replacement well is not required.

4.1.5 Typical Well Refurbishment and Construction Costs

The City's existing wells play a critical role in providing water service to the City. Therefore, maintaining the existing wells is of upmost importance to the City if the City wants to maintain the sound operable condition of the water system and meet the current level of service and water operating budget expectations (MWD water is more expensive than groundwater).

For wells, the following are the asset items (equipment or materials) that will require refurbishment: well casing; well pump and motor; VFD; and the MCC, panels and electrical equipment.

The expected useful life (number of years of normal use that can be expected prior to replacement) of a well based on the typical water industry experience is assumed to be between 50 to 75 years. However, the well's useful life depends mainly on the condition of the well casing. Therefore, the refurbishment of the well casing is a key. The expected useful life is an average expected life and will need to be adjusted based on actual condition monitoring of the well.

The following is a summary of the well refurbishment asset items, the general refurbishment description, the refurbishment interval and the estimated refurbishment budget costs:

Table 8 – Well Refurbishment

Asset Item	Refurbishment Description	Refurbishment Interval (years)	Refurbishment Cost (2017 dollars)
Well Casing (building)	Pump removal, downwell video, air-jetting, brush, swab, chemical treatment, and development	7 to 10	$ 400,000
Well Casing (no building)	Pump removal, downwell video, air-jetting, brush, swab, chemical treatment, and development	7 to 10	$ 300,000
Pump/Motor (to system)	Pump removal, new pump and motor	15 to 20	$ 600,000
Pump/Motor (to reservoir)	Pump removal, new pump and motor	15 to 20	$ 500,000
VFD	New VFD and enclosure (stand-alone unit)	10 to 15	$ 400,000
MCC (in building)	Replace MCC, breakers, and panels	20 to 30	$ 100,000
MCC/Elect. (outside)	Replace MCC, breakers, panels and new wiring	15 to 20	$ 400,000
New SCE Service	New SCE service, meter, switchboard, etc.	--	$ 500,000

The following is a summary of the estimated construction costs for the drilling, equipping and major rehabilitation of the new/existing wells:

Table 9 – Well Estimated Construction Costs

Well Number	Estimated Construction Costs (2017 dollars)					
	Drilling	Equipping	Building	Generator	Misc.	Total
16	$ 1,500,000	$ 1,800,000	$ 200,000	--	$ 100,000	$ 3,600,000
18	$ 1,500,000	$ 1,800,000	--	--	$ 100,000	$ 3,400,000
22	$ 1,500,000	$ 1,800,000	--	--	$ 100,000	$ 3,400,000
24	$ 1,500,000	$ 1,800,000	--	--	$ 200,000	$ 3,500,000
29	--	$ 2,000,000	$ 200,000	--	$ 400,000	$ 2,600,000
32	--	$ 2,200,000	$ 400,000	--	$ 1,900,000	$ 4,500,000
Future #1	$ 1,500,000	$ 2,000,000	$ 200,000	$ 400,000	$ 100,000	$ 4,200,000
Future #2	$ 1,500,000	$ 1,800,000	$ 200,000	--	$ 100,000	$ 3,600,000

4.1.6   Well Refurbishment History

Based on discussions with the City's operations/maintenance staff, the following table is a summary of the history maintenance/refurbishment that has occurred in the past at each of the wells. Included within the table will be any of the equipment/facilities that were identified to be in poor condition and recommended to be refurbished/replaced in the near future.

Table 10 – Well Maintenance History

Well Number	Last Well Rehab	Age of Pump/Motor	Age of VFD	Age of MCC	Condition Monitoring
16	2003	2003	--	2004	pump realign 2003; casing issues;
18	2003	2003	--	1992	poor efficiency;
20	2002	2011	--	2020	motor rewind;
21	2002	2011	--	2010	motor rewind;
24	2005	2005	--	1992	new pump assembly; relined casing;
26	2015	2015	--	2015	
27	2000	2003	--	2007	power service issues;
28	2009	2010	2014	2007	electrical upgrades
29	2002	2005	--	2004	damaged by car crash;
30	2002	2002	--	2010	efficiency down; power service issues;

Well Number	Last Well Rehab	Age of Pump/Motor	Age of VFD	Age of MCC	Condition Monitoring
31	2012	2012	2014	2004	
32	2000	2000	--	1992	Motor overhaul/rewind; Rehab well due to nitrates;
33	2001	2010	--	2004	replace MCC (soft start)
34	1996	1996	--	2014	
35	2001	2001	2012	2013	
36	2012	2014	--	1992	replace MCC (soft start);
37	2001	2001	2012	1996	
38	2005	2014	2015	2007	motor rewind;
39	2013	2015	--	1992	motor rewind;
40	2015	2015	--	2005	upgrade PLC program;
41	2011	2013	2013	2013	upgrade PLC program;

4.1.7 Well Back-Up Power

The City's goal is to minimize using imported water (MWD). During power outages of any extended duration, the City is required to take MWD water as the wells will not be able to operate without power. To give the City an opportunity to continue to use groundwater and not use imported water even during extended power outages, the City is planning to construct emergency generators at five of the key wells that pump directly into the distribution system (Well 31, Well 35, Well 37, Well 40 and Well 41). By adding emergency generators at these wells, the City's water system will be even more reliable and will not have to depend on MWD to meet its customer's demands.

At a future date, the City is planning to construct emergency generators at the remaining two wells that pump directly into the distribution system (Well 28 and Well 38). Due to the amount of storage at John Garthe Station and that John Garthe Pump Station has an engine driven pump (and a on-site hydro facility), the City is also planning to construct either an emergency generator or at least an Automatic Transfer Switch (ATS) at Well 32 and Well 36. By adding these facilities, the City will increase its reliability during a long, extended power outage within the City.

4.2 MWD Connections

4.2.1 Summary of MWD Connections

The City maintains seven imported water connections to receive water from MWD. These seven metered connections, with a total capacity of 60,580 gpm, transfer imported water into the City's distribution system. The following table summarizes these seven connections and these connections are typically controlled based on a specified rate of flow requested by the City.

Table 11 – Metropolitan Water District Connections

MWD Connection	Name	Normal Operating Capacity (mgd)	Design Capacity (mgd)	Number of Valves	Valve Type
SA-1	Bristol	5.17	6.46	2	FCV
SA-2	First	5.17	9.69	1	FCV
SA-3	McFadden	5.17	6.46	1	FCV
SA-4	Warner	4.85	6.46	1	FCV
SA-5	Alton	4.85	12.93	1	Out of Service
SA-6	Santa Clara	7.76	12.93	3	FCV
SA-7	Red Hill	4.85	32.31	2	FCV

4.2.2   Connections Refurbishment and Replacement

The City has been slowly upgrading the MWD connections in conjunction with several street widening projects. The design of the SA-5 vault relocation and upgrade has been completed and construction will be scheduled soon. SA-2 connection upgrade is planned as the next facility to be refurbished. SA-7 will be relocated by Caltrans as part of the 55 Freeway widening project and the construction will be paid by Caltrans. In the future, the City desires for SA-1 and the corresponding hydro-generation facilities to be refurbished as it is nearing the end of its useful life.

4.3   Interconnections

The City has several piping connections with the surrounding cities and water agencies. However, most of these connections are not metered and are nothing more than emergency pipeline connections that are isolated by valves. At this time, the City is not planning to upgrade these emergency connections as the City has sufficient reliable sources of water with its wells and MWD connections. It could be beneficial to the surrounding cities and water agencies to upgrade these connections to improve their reliability. Since these potential upgrades would be for their benefit, the City has assumed that they will pay for the majority of the required upgrades and have not been included within CIP program.

SECTION 5 ••RESERVOIR AND PUMP STATION EVALUATION

5.0   Introduction

The City's water system consists of two pressure zones (High Zone and Low Zone). Each of these pressure zones have groundwater wells, reservoirs and booster pump stations which supplies potable water to the City's customers. In general, the facilities are consolidated into several stations consisting of multiple groundwater wells, a storage reservoir, and a booster pump station. At each station, the wells pump groundwater into the storage reservoir and the booster pump station pumps water from the storage reservoir to the distribution system. Section 2.2 summarizes these facilities.

5.1   Reservoirs

5.1.1   Summary of Existing Reservoirs (Tanks)

The City has seven locations with ground level storage tanks and one elevated storage tank. Three of the reservoirs are steel tanks and the remaining seven are concrete tanks. There are three storage tanks (reservoirs) at the John Garthe site. The following table has combined these three reservoirs at the John Garthe site to form one reservoir with an equivalent diameter to represent the total storage volume available at the site.

Table 12 – Storage Reservoir Facilities

Reservoir Facility	Tank Type	Capacity (MG)	Number of Tanks	Zone	Bottom Elevation (ft)	Diameter (ft)	Height (ft)
Cambridge	Concrete	1.3	1	High	188.8	Variable Area	17.2
Crooke	Concrete	6	1	High	157.62	Variable Area	21
East	Steel	6	1	Low	76.2	180	31.5
Elevated Tank	Steel	1.0	1	Low	NA	60	131 ft total (60 ft tank)
John Garthe	Concrete	15.8	3	Low	100	277	35
South	Concrete	6	1	Low	35.7	219	22
Walnut	Concrete	7	1	Low	79.8	Variable Area	22
West	Steel	6	1	Low	66.9	180	32

5.1.2 Existing Reservoir Assessment

Based on a site visit with the City's maintenance/operation staff, the following is a general summary of the desired upgrades/site improvements at each of the reservoir facilities:

Table 13 – Summary of Reservoir Assessment

Reservoir Facility	Reservoir Assessment
Cambridge	Evaluate reservoir circulation (inlet piping) to eliminate dead spots Refurbish roof coating
Crooke	Evaluate reservoir circulation (inlet piping) to eliminate dead spots
East	Refurbish exterior top coat Improve confine space at tank inlet vault and replace vault cover
Elevated Tank	Upgrade lighting system (decorative) Monitor retractable fall protection systems
John Garthe	Intrusion alarms at roofs (security concerns)
South	Add stairway prevention (security) Repair cracking within tanks Fill and abandon existing vault
Walnut	Evaluate reservoir circulation (inlet piping) to eliminate dead spots
West	Security concerns Replace bypass vault covers

5.1.3 Typical Reservoir Refurbishment and Construction Costs

For concrete tanks, the following are the refurbishment work items: interior cleaning/inspection/repairing cracks; piping modifications; and replacing roof coating. The expected useful life (number of years of normal use that can be expected prior to replacement) of a concrete tank is 75 to 100 years.

For steel tanks, the following are the refurbishment work items: interior cleaning/inspection; piping modifications; interior coating; exterior coating; and replacement of cathodic protection systems. The expected useful life of a steel tank is 75 years.

The following is a summary of the reservoir refurbishment work items, the general refurbishment description, the refurbishment interval and the estimated refurbishment budget costs:

Table 14 – Reservoir Refurbishment

Work Item	Refurbishment Description	Refurbishment Interval (years)	Refurbishment Cost (2017 dollars)
Interior Cleaning Inspection	Clean interior of tank, inspect interior coating, minor repairs of cracks/joints (concrete)	5	$ 10,000
Piping Modifications	Improve inlet/outlet piping	--	$ 100,000
Concrete Tank Roof	Replace concrete roof coating/gravel	10	$5 to $10/sf
Steel Tank Interior Coating	Repair and re-coat interior of steel tank	15	$12 to $15/sf
Steel Tank Exterior Paint	Repair and re-paint exterior of steel tank	20	$8 to $10/sf
Elevated Tank	Repair, re-paint, and upgrade lighting	20	$ 1,000,000
Cathodic Protection	Replace cathodic protection (interior and bottom)	15	$30,000 to $50,000

5.1.4 Reservoir Refurbishment History

Based on discussions with the City's operations/maintenance staff, the following table is a summary of the history of the refurbishment that has occurred in the past at each of the reservoir facilities.

Table 15 – Reservoir Refurbishment History

Reservoir Facility	Concrete Tank Last Tank Rehab	Steel Tank	
		Last Interior Coating	Last Exterior Painting
Cambridge	2000	--	--
Crooke	2003	--	--
East	--	2003	2011
Elevated Tank	--	2003	2003
John Garthe	1992/2003	--	--
South	2010	--	--
Walnut	2004	--	--
West	--	2005	2011

5.2   Pump Stations

5.2.1   Summary of Pump Stations

The City's water system has seven pump stations with a total of 26 booster pumps. The following table summarizes the booster pumps at each of the pump stations:

Table 16 – Booster Pump Summary

Station	Pump Number	Motor Type	Power (HP)	Average Capacity (gpm)	Design Head (ft)	Design Capacity (gpm)
Cambridge	1	Electric	75	1,481	150	1650
	2	Electric	75	1,436	150	1650
	3	Electric	75	1,526	150	1650
Crooke	1	Electric	150	2,783	185	2700
	2	Electric	150	2,693	185	2700
	3	Electric	150	2,738	185	2700
East	1	Electric	125	2,648	175	2300
	2	Electric	125	2,603	175	2300
John Garthe	1	Electric	150	2,693	180	1760
	2	Electric	150	3,097	183	2590
	3	Electric	150	3,007	183	2590
	4	Electric	200	4,264	183	3560
	5	Electric	200	3,590	183	4270
	6	Gas	250	4,982	ND [1]	ND [1]
South	1	Electric	125	2,244	212	2000
	2	Electric	125	2,244	212	2000
Walnut	1	Electric	200	3,501	200	3100
	2	Electric	200	3,501	200	3100
	3	Electric	200	3,456	200	3100
	4	Electric	150	2,738	200	2400
	5	Electric	100	1,750	200	1400
West	1	Electric	200	2,513	170	2800
	2	Electric	200	2,289	170	2800
	3	Electric	200	2,289	170	2800
	4	Electric	150	4,488	176	3700
	5	Electric	100	2,020	170	2100

5.2.2 Existing Pump Station Assessment

Based on a site visit with the City's maintenance/operation staff, the following is a general summary of the desired upgrades/improvements at each of the pump stations:

Table 17 – Summary of Pump Station Assessment

Pump Station	Pump Station Assessment
Cambridge	Pump #2 MOV (limotorque) needs to be replaced Site access needs to be improved (safety)
Crooke	New VFD and add mechanical seals Replace discharge pressure switches and low water suction probes Transfer switch for future generator Upgrade control system on hydro tank; and paint valves
East	Check AQMD requirements
John Garthe	Replace natural gas engine and confirm AQMD requirements Replace Murphy control panel Upgrade RTU
South	Upgrade meter within vault
Walnut	Major rehabilitation under construction
West	Replace 14" MOVs and upgrade AC for VFDs Add six disconnect switches at bottom of MCC panels Upgrade PLC and antenna

5.2.3 Major Pump Station Rehabilitation

The City is under construction on the Walnut Pump Station Rehabilitation. The work includes: replacement of the existing pump control building; replacement of pumps and motors; upgrade of the existing motor control center (MCC); upgrade communications capabilities at the facility; and site upgrades, such as, replacement of the perimeter wall and landscape.

The City is planning to design and construct the Cambridge Pump Station Rehabilitation. The work will include: construction of a pump house; replacement of pumps and motors, MCC and electrical facilities; upgrade communications capabilities at the facility; and site upgrades including wall and gate improvements.

The City is also planning to design and construct the East Pump Station Rehabilitation. The work will include: construction of a pump house; replacement of pumps and motors; upgrade communications capabilities at the facility; and site upgrades.

5.2.4 Typical Pump Station Refurbishment and Construction Costs

For the pump stations, the following are the asset items (equipment or materials) that will require refurbishment: pumps and motors; VFDs; and the MCC, panels and electrical equipment.

The expected useful life (number of years of normal use that can be expected prior to replacement) of a pump station based on the typical water industry experience is assumed to be between 50 to 75 years. The expected life will need to be adjusted based on the actual condition monitoring of the facility.

The following is a summary of the pump station refurbishment asset items, the general refurbishment description, the refurbishment interval and the estimated refurbishment budget costs:

Table 18 – Pump Station Refurbishment

Asset Item	Refurbishment Description	Refurbishment Interval (years)	Refurbishment Cost (2017 dollars)
Pump/Motor	Replace with new pump and motor	15 to 20	$800/hp
VFD (≤150 hp)	New VFD and enclosure (stand-alone unit)	10 to 15	$700/hp
VFD (200 hp)	New VFD and enclosure (stand-alone unit)	10 to 15	$300,000
MCC (in building)	Replace MCC, breakers, and panels	20 to 30	$ 100,000
MCC/Elect. (outside)	Replace MCC, breakers, panels and new wiring	15 to 20	$ 400,000

The following is a summary of the estimated construction costs for the major pump station rehabilitations:

Table 19 – Pump Station Estimated Construction Costs

Pump Station	Estimated Construction Costs (2017 dollars)					
	Pumps/Motors	VFDs/Gas	Building	MCC/Elect	Site/Piping	Total
Cambridge	$ 200,000	--	$ 300,000	$ 100,000	$ 200,000	$ 800,000
Crooke	$ 400,000	$ 300,000	--	$ 400,000	$ 100,000	$ 1,200,000
East	$ 300,000	--	$ 300,000	$ 400,000-	$ 600,000	$ 1,600,000
John Garthe	$ 900,000	$ 600,000	--	$ 400,000	$ 100,000	$ 2,000,000
South	$ 500,000	$ 200,000	--	$ 200,000	$ 100,000	$ 1,000,000
Walnut	$ 700,000	--	$ 500,000	$ 800,000	$ 1,250,000	$ 3,250,000
West	$ 600,000	$ 600,000	--	$ 600,000	$ 200,000	$ 2,000,000

5.2.5 Pump Station Refurbishment History

Based on discussions with the City's operations/maintenance staff, the following table is a summary of the history maintenance/refurbishment that has occurred in the past at each of the pump stations. Included within the table will be any of the equipment/facilities that were identified to be in poor condition and recommended to be refurbished/replaced in the near future.

Table 20 – Pump Station Maintenance History

Pump Station	Age of Pump/Motor	Age of VFD	Age of MCC	Condition Monitoring
Cambridge	2000/2002	--	2007	Need pump building
Crooke	2003	--	2014 (minor)	Add VFDs Electrical upgrades
East	2003	--	2015	Need pump building
John Garthe	1992/2015	2006	1992	New MCCs and new engine
South	2010	2010	2014 (minor)	New meter
Walnut	2017	--	2017	Under construction
West	2003/2004	2014	2010	Electrical upgrades

5.2.6 Pump Station Back-up Power

The City is planning to construct emergency generators at the Crooke and Cambridge pump station facilities due the criticalness of these facilities in the High Zone. By adding emergency power at these facilities, the reliability of the High Zone during extended power outages will be improved.

SECTION 6 ••DISTRIBUTION SYSTEM EVALUATION

6.0   Introduction

The City's water system is comprised of approximately 480 miles of transmission and distribution mains. Overall, the water distribution system is robust with almost no hydraulic concerns. There are minor fire flow deficiencies which are located on single-feed pipelines (6-inches in diameter) or 4-inch diameter loops. The results of the system analysis for the existing, near-term and buildout demand scenarios are summarized in Section 3.2 of the Master Plan.

6.1   Existing Distribution System

6.1.1   Summary of Distribution System

The following table summarizes the existing water mains based on material and date it was installed. We have also included within the table the estimated typical useful life (number of years of normal use that can be expected prior to replacement) for each of the pipe materials:

Table 21 – Water Mains by Install Date and Pipe Material

Decade	AC	CI	CMLC	CYL	DI	PVC	STL	UNK	Total (ft)	%
Pre 1930	480	55,833							56,313	2.1
1930s	5,953	40,202		52					46,207	1.7
1940s	1,538	68,274			607				70,419	2.6
1950s	66,077	318,982	4,756	23,316	5,136				418,267	15.6
1960s	139,460	521,645	6,474	72,012	35		9,882		749,508	28.1
1970s	506,177	20,814	56	4,468	8,111				539,624	20.1
1980s	246,571	226		33,122	35,901	11,552	576		327,948	12.2
1990s	2,694		9,254	47	102,358	110,221			224,574	8.4
2000s	118				7,081	164,630	167		171,996	6.4
2010s					1,586	33,936			35,522	1.3
UNK	4,986	3,673	30,694	24	249	302		853	40,781	1.5
Total (ft)	974,053	1,029,650	51,234	133,041	161,063	320,641	10,624	853	2,681,159	100
%	36.3%	38.4%	1.9%	5.0%	6.0%	12.0%	0.4%	.03%	100%	
Useful Life (yrs)	60	60	50-75	50-75	75	75	50			

The above information was obtained from the 2014 Water Rate Study prepared by Black & Veatch, Table B-2 of Appendix B: Water CIP Prioritization Process.

As is shown by the above table, over 70% of the City's Water Distribution System was installed prior to 1970 (or almost 50 years old). In addition, the majority of the water mains are cast iron (CI) pipe (38%) and asbestos cement (AC) pipe (36%).

6.1.2   Assessment of Distribution System

As of 2017, based on age of the existing pipe, 20% (about 560,000 feet of pipe) of the City's distribution system has already past the pipe materials typical useful life. By the end of the proposed planning period (fiscal year 2039/40), 70% (about 1,870,000 feet of pipe) of the City's distribution system will have past the pipe materials useful life. In summary, while the City's distribution system is robust and hydraulically sound, the system is old and needs to be systematically replaced.

As part of the 2014 Water Rate Study prepared by Black & Veatch, a water system CIP analysis was performed on the City's Distribution System. The condition analysis included pipe material, pipe diameter, pipe vintage, water main break statistics, and soils analysis. Based on these statistics, the probability of failure was analyzed as well as the consequence of failure. The overall Risk Exposure was then calculated for each segment of pipe and the results were shown on Figure D-2 of the Report. A copy of this Figure has been included within Appendix D of this Master Plan Report.

As part of this Master Plan, IDModeling performed an analysis of the water distribution system to assist in the prioritization of the pipeline replacement program. In addition to fire flow and peak hour demand deficiencies as determined by the existing, near-term, and buildout time frame hydraulic analyses, a risk assessment was conducted on the existing pipelines to determine the likelihood of failure and consequence of failure on a per segment basis. A summary of this analysis is contained within Section 7 of IDModeling Final Technical Memorandum – Master Plan Hydraulic Analysis (Appendix C of this Master Plan Report).

Both the Water Rate Study and the Master Plan Hydraulic Analysis did not find a common factor for the previous main breaks and the results were similar.

6.2   Cast Iron Replacement

The City has been slowly working on the replacement of the existing cast iron pipelines. Most of the projects have been focused on replacing the cast iron and asbestos cement pipelines within a selected City Neighborhood prior to a proposed paving project in that same neighborhood.

The following is a summary of the Cast Iron Pipe within the City's Water Distribution System (based on the City's hydraulic model) less the recent Centennial and Warner Water Main Replacement Projects:

Table 22 – Cast Iron Pipe Summary

Decade	Diameters (in inches)						Total (ft)	%
	4-8	10	12	14	16	≥ 18		
Pre 1930	38,834	5,979	7,703	1,506	39	1,092	**55,153**	**5.8%**
1930s	9,533	3,053	2,410		528	15,227	**30,751**	**3.2%**
1940s	46,748	22	19,850	1,861	141		**68,622**	**7.2%**
1950s	285,758	2,385	126,928	3,620	25	398	**419,114**	**44.0%**
1960s	237,594	513	118,914	4,451	523	275	**362,270**	**38.0%**
1970s	6,535		10,110			366	**17,011**	**1.8%**
Total (ft)	**625,002**	**11,952**	**285,915**	**11,438**	**1,256**	**17,358**	**952,921**	**100**
%	**65.6%**	**1.3%**	**30.0%**	**1.2%**	**0.1%**	**1.8%**	**100%**	

6.3   Pipeline Replacement Program

6.3.1   Pipeline Replacement Construction Costs

The following pipeline replacement construction costs were based on the latest bid results for the Centennial and Warner Water Main Replacement Projects and similar pipeline replacement projects within Orange County. The cost per foot includes the pipe, valves, hydrants, services, appurtenances, and typical street pavement replacement (non-arterial streets). We have assumed that all 4-inch through 8-inch diameter pipelines will be replaced with a new 8-inch diameter pipeline.

Existing Size (" dia.)	Replacement Cost (2017 dollars)
4"-8"	$ 240/ft
10"	$ 260/ft
12"	$ 300/ft
14"	$ 340/ft
16"	$ 360/ft
18"	$ 380/ft
20"	$ 400/ft
24"	$ 420/ft

6.3.2   Recommended Pipeline Replacement Program

The ball park construction cost to replace all of the remaining cast iron pipe summarized in the above Table 22 is about $250,000,000. To replace the other pipe materials (not cast iron) that as of 2017 have already past the pipe materials useful life is another $20,000,000. If the goal is to replace all of the pipe material (including cast iron) that has a useful life that is past by the end of the proposed planning period of 2039/2040 (about 1,870,000 feet of pipe), the ball park construction cost is about $500M.

The City does not have a CIP budget within this proposed planning period to even replace the existing cast iron pipe ($250M) and for sure not all of the pipe that will pass its expected useful life. Therefore, it is important for the City to establish a replacement program focused on limiting risks of failure. Since neither of the assessment reports summarized in the above Section 6.1.2 identified a common factor, it is recommended that the City move forward with a plan to replace the oldest pipes first. However, for public relations and to minimize impacts to a community and its water service, the replacement program will continue to proceed by neighborhoods.

The following is a summary of the proposed pipeline replacement program within the proposed planning period: Seventeenth Street; Riverview Phase 2; Bristol Phase 3; West Grove Valley; Grand Avenue; St Gertrude and Grand; Thornton Park; Bristol Phase 4; Warner Widening and Warner Avenue; Century; Wilshire; Fisher Park; French Court; French Park; Park Santiago; West Floral; Willard; Saddleback View; Washington Square; Artesia Pilar; Downtown; Heninger Park; and Eastside. Figure 7 shows each of these pipeline replacement projects.

At the end of these pipeline replacement projects the following is a summary of the remaining cast iron pipelines that still need to be replaced within the City:

Table 23 – Recommended Pipeline Replacement within Planning Period

Decade	Total Existing CI Pipe	Total CI Pipe Replaced	% of CI Pipe Replaced	Remaining CI Pipe to be Replaced
Pre 1930	55,153 ft	51,400 ft	93%	3,753 ft
1930s	30,751 ft	25,900 ft	84%	4,851 ft
1940s	68,622 ft	54,200 ft	79%	14,422 ft
1950s	419,114 ft	116,980 ft	28%	302,134 ft
1960s	362,270 ft	73,100 ft	20%	289,170 ft
1970s	17,011 ft	3,900 ft	23%	13,111 ft
Totals	**952,921 ft**	**325,480 ft**	**34%**	**627,441 ft**

The estimated construction cost (in 2017 dollars) for these proposed pipeline projects within the proposed planning period is about $110M.

SECTION 7 ••MISCELLANEOUS IMPROVEMENTS

7.0   Introduction

The City's water system includes wellhead treatment facilities, four pressure regulating stations, valves, facility security, and telemetry/controls and communication facilities. These items all play a key role in the overall water system.

7.1   Wellhead Treatment Facilities

Water pumped from all of the wells has been naturally filtered as it passes through the underlying aquifers of sand, gravel and soil. The well water only requires disinfectant treatment prior to being placed in the distribution system. The City is currently replacing the existing chlorination facilities with new sodium hypochlorite generation units. The new sodium hypochlorite generation units have been installed or will be installed at 15 well sites by the end of 2018. This work is being performed under the City's existing Operations Budget and not the Capital Replacement Budget. The new sodium hypochlorite generation units to be installed to treat well water from Well 16, Well 29 and Well 33 will be constructed as part of the Walnut Pump Station Project.

The expected useful life (number of years of normal use that can be expected prior to replacement) for these sodium hypochlorite generation units is typically assumed to be 12 to 15 years. The replacement cost for these units is about $140,000 per site or a total cost of about $2,000,000.

7.2   Pressure Regulating Stations

The City has four pressure reducing/pressure sustaining valves (PRS/PSV) stations. These pressure regulating stations allow water to flow from the High Zone to the Low Zone (reduces the pressure to acceptable pressure levels to match the Low Zone). These valve stations are primarily used for relieving high pressure spikes in the High Zone and can be manually controlled by operations staff.

The following is a summary of these pressure reducing valve stations:

Table 24 – Pressure Reducing Valve Stations

PRV Station #	Location	Number of Valves	Valve Sizes
1	Memory Lane	2	10 inch and 6 inch
2	17th Street	2	10 inch and 8 inch
3	Grand Street	2	10 inch and 8 inch
4	Fire Station 2	2	10 inch and 8 inch

To allow the City the ability to use these stations as part of normal operation, these pressure regulating stations will need to have power and remote control added. By adding these features, the City will be able to control flow from the High Zone to the Low Zone as part of its normal daily operation.

The estimated construction cost to add power and remote control (assuming that power is available in close proximity to the station), is about $100,000 per station or a total cost of $400,000.

7.3 Valve Replacement Program

As part of the Water System Computer Modeling Project performed by IDModeling, a pipeline criticality analysis was conducted to determine areas vulnerable to service interruption in the event of a pipeline break or other outage event. The results of this analysis are included within Attachment B of the Final Technical Memorandum #7 (included in Appendix A). Building upon this previous analysis, IDModeling performed a criticality analysis of the water distribution system valves to assist in prioritization of the City's valve replacement program.

The valve criticality analysis was done through a spatial association with the calculated pipeline criticality and adding the number of customers that will be affected. Section 6 of IDModeling's Final Technical Memorandum of the Master Plan Hydraulic Analysis (included within Appendix C) summarizes the results of this analysis.

At this time, the City is not establishing a valve replacement program as it currently does not have sufficient budget to perform the required pipeline replacement projects. The City will continue to replace the valves as it systematically replaces the aged water mains.

It is recommended that the City make the valves identified as critical valves within the memorandum as top priorities to exercise in consistent intervals. These are the critical valves that will need to able to be operated during any necessary water main shutdowns.

7.4 Service Meter Upgrades

The City is planning to upgrade its existing meters with an Automated Meter Infrastructure (AMI). Existing aging meters will be replaced with new, more accurate meters that incorporate technological advances in metering technology which will allow the City personnel and customers access to real-time water consumption data. This will be very helpful if the drought regulations are reinstated in the future.

Meter upgrades sometimes are paid for by reducing the non-revenue water due to meter inaccuracies. Based on production and usage data, the estimated non-revenue water is about 5.5% of the total water produced.

The estimated construction cost to implement the AMI is about $14,000,000 and will take about six years to design and install.

7.5 SCADA, Communications and Instrumentation Upgrades

The City is planning to upgrade its SCADA, communications and instrumentation at various facilities throughout the water system. The proposed upgrades include: upgrade the programmable logic controls; communication devices; RTUs and software. The SCADA system upgrade is based on a Wonderware SCADA System and includes software license and support, hardware, system integration (labor), and recommended system and validation testing.

The budgetary estimate for the SCADA upgrade is $1,000,000.

In addition, the City is planning to install a fiber-optic backbone facility from each key facility to the City Yard hub. This will improve the SCADA capabilities of operating and maintaining the various City facilities. Figure 8 shows the proposed fiber backbone system which consists of about 70,000 feet of fiber-optic conduit installation.

The high level estimated construction cost for this fiber-optic backbone system is about $10,000,000.

7.6   Sustainable Energy Improvements

The City is considering the installation of solar panels at the John Garthe and West Reservoir Facilities. The solar panels would be installed on the roofs of the reservoirs and will provide the City with sustainable energy. The high level estimated construction cost for these solar panels is $350,000.

7.7   Security Assessment

Based on a cursory vulnerability assessment of all of the water facility sites, it is recommended that the City restrict access to the reservoir sites by constructing perimeter walls, installing intrusion alarms that are connected to the City's SCADA system, as well as security cameras. The goal is ensure no intruder can contaminate the City's water system at the reservoir sites. The high level estimate for the security cameras, mounting hardware, corresponding electrical work, physical alarms (instruments and SCADA programming) and intrusion alarms for hatches at 50 locations is about $500,000.

For sites with wells, pump stations and outdoor piping, the City is planning to improve the perimeter fencing to impede easy access to the site. It is assumed that the fencing improvements will be performed under the City's Water Operation Budget and not under the Capital Improvement Budget.

7.8   Operations and Maintenance Programs

7.8.1   Wells and Pump Stations

The existing wells and pump stations play a critical role in providing water service to the City customers. Therefore, maintaining these facilities is of upmost importance to the City. The following are some monitoring/testing recommendations:

- Keep well casing rehabilitation at constant intervals.
- Monitor well specific capacity at a minimum of quarterly intervals. This requires taking static and dynamic groundwater levels and the pumping flow rate.
- Monitor actual flow/lift for each well and pump station pump and compare to engineered pump curves at a minimum of quarterly intervals (this will require taking static and dynamic groundwater levels for the wells).
- Establish a written condition-monitoring program for all wells and pump stations. This will include monthly visual inspection of the pump, motor, MCC, VFD while running to identify any noise, vibration, etc. Have forms that identify the items to be inspected and the date inspection occurred.
- Keep written track of all maintenance activities at each of the facilities. Input into the GIS data.

7.8.2 Distribution System

The following are some monitoring recommendations for the distribution system:

- Include in the GIS data any pipeline repair work required and be sure to note the location, age of pipe, size of pipe, type of pipe, whether external corrosion, internal corrosion, pipe installation, etc. as best can be determined.

- Compare the upcoming street repair work with the proposed neighborhood pipeline replacement projects. Coordinate these improvements with the GIS/Smart CIP software tools.

- Exercise the critical valves on an accelerated schedule from the rest of the valves.

- Update the pipeline criticality analysis if the City sees a common factor in future water main breaks.

SECTION 8 ••CAPITAL IMPROVEMENT PROGRAM

8.0   Overview

The ultimate goal of the 2017 Water Master Plan for the City of Santa Ana is to establish a Capital Improvement Program (CIP) based on the recommended improvements/projects summarized in the previous sections. The planning period for the CIP is from fiscal year 2017/18 to fiscal year 2039/40. This CIP schedule/budget will assist the City in establishing priorities and help make decisions on future improvements and refurbishment/replacement of existing facilities.

Construction costs were based on the experience of our engineers, construction cost estimates recently prepared for other clients, previous City projects, industry standards and discussions with equipment suppliers. These construction costs typically include a 25% contingency. The overall project cost includes a 10% design cost, 15% construction contingency, and 15% technical, legal and administrative costs.

The construction costs are all based on 2017 dollars, ENR Construction Cost Index of 10532 for January 2017.

The projects were prioritized based on discussions with the City, importance of the facilities to the overall water system, and key to maintaining reliable water service to the City's customers.

8.1   Priorities

8.1.1   Well Priorities

The following is a summary of the recommended priorities for the various well projects including well refurbishment and their recommended construction schedule:

Priorities for New Wells and Major Well Rehabilitation:

1. Well 32 Major Rehabilitation   design: 2017/18; construction: 2018/19/20
2. Well 29 Major Rehabilitation   design: 2019/20; construction: 2020/21/22
3. New Well 22 Drill and Equip   design: 2021/22; construction: 2022/23/24
4. New Future Well #1   design: 2023/24; construction: 2024/25/26
5. New Well 24 Drill and Equip   design: 2025/26; construction: 2026/27/28
6. New Well 16 Drill and Equip   design: 2027/28; construction: 2028/29/30
7. New Future Well #2   design: 2033/34; construction: 2034/35/36

Priorities for Major Well Refurbishment (Refurbish Pump/Motor/MCC/VFD):

1. Well 31   construction: 2018/19
2. Well 39   construction: 2019/20
3. Well 27   construction: 2020/21
4. Well 28 (except VFD)   construction: 2021/22

5. Well 36   construction: 2022/23

6. Well 37   construction: 2023/24

7. Well 35   construction: 2024/25

8. Well 30   construction: 2025/26

9. Well 34   construction: 2026/27

10. Well 33   construction: 2027/28

11. Well 20   construction: 2028/29

12. Well 21   construction: 2029/30

13. Well 38   construction: 2030/31

14. Well 40   construction: 2032/33

15. Well 41   construction: 2033/34

16. Well 26   construction: 2034/35

Priorities for Well Casing Rehabilitation (Operations Budget)

1. Casing Evaluation/Development   2017/18
    (Well # 16, 18, 22, 24, 29)

2. Well 34 and Well 37   2017/18

3. Well 24 and Well 33   2018/19

4. Well 30 and Well 35   2019/20

5. Well 18 and Well 38   2020/21

6. Well 16 and Well 20   2021/22

7. Well 21 and Well 41   2022/23

8. Well 26 and Well 40   2023/24

Priorities for Minor MCC Refurbishment (under $400,000 and Operations Budget)

1. Well 36 and Well 37   2017/18

2. Well 24 and Well 33   2018/19

3. Well 30   2019/20

4. Well 18 and Well 38   2020/21

5. Well 20   2021/22

6. Well 21   2022/23

7. Well 40   2023/24

8.1.2 Pump Station Priorities

The following is a summary of the recommended priorities for the various pump station projects and their recommended construction schedule:

Priorities for Major Pump Station Rehabilitation Projects:

1. Walnut Pump Station   under construction
2. Crooke Pump Station   design: 2017/18; construction 2018/19
3. John Garthe Pump Station   design: 2019/20; construction: 2020/21
4. Cambridge Pump Station   design: 2021/22; construction: 2022/23
5. East Pump Station (except MCC)   design: 2023/24; construction: 2024/25
6. South Pump Station   design: 2025/26; construction: 2026/27
7. West Pump Station   design: 2027/28: construction: 2028/29

8.1.3 Reservoir Priorities

The following is a summary of the recommended priorities for the various reservoir refurbishment projects and their recommended construction schedule:

Priorities for Steel Tank Interior Coating and CP Replacement:

1. East Reservoir   design: 2018/19; construction: 2019/20
2. Elevated Tank   design: 2020/21; construction: 2021/22
3. West Reservoir   design: 2022/23; construction: 2023/24

Priorities for Steel Tank Exterior Coating:

1. Elevated Tank   design: 2024/25; construction: 2025/26
2. East Reservoir   design: 2029/30; construction: 2030/31
3. West Reservoir   design: 2031/32; construction: 2032/33

Priorities for Concrete Tank Roof Refurbishment (replace gravel/rock/re-coat) (Operations)

1. Cambridge Reservoir   2018/19
2. John Garthe Reservoirs   2020/21
3. Crooke Reservoir   2022/23
4. Walnut Reservoir   2024/25
5. South Reservoir   2026/27

8.1.4 Distribution System Priorities

The following is a summary of the recommended priorities for the various distribution system replacement projects and their recommended construction schedule:

Priorities for Water Main Replacement Projects (see Figure 7 for general area of projects):

1. 17th Street Water Main Improvements — construction completed
2. Riverview Neighborhood Phase 2 — 2017/18
3. Bristol Phase 3 — 2017/18
4. West Grove Valley Neighborhood — 2017/18
5. Grand Ave. Water Main Improvements — 2018/19
6. St Gertrude and Grand WM Replacements — 2018/19
7. Thornton Park Neighborhood — 2018/19
8. Bristol Phase 4 — 2019/20
9. Warner Widening — 2019/20
10. Walnut Discharge Main Lining — 2020/21
11. Warner Ave. Water Main Replacement — 2020/21
12. Fisher Park Neighborhood — 2021/22
13. French Court Neighborhood — 2022/23
14. French Park Neighborhood — 2023/24
15. Park Santiago Neighborhood – Phase 1 — 2023/24
16. Park Santiago Neighborhood – Phase 2 — 2024/25
17. West Floral Park Neighborhood — 2025/26
18. Floral Park Neighborhood Phase 1 — 2026/27
19. Floral Park Neighborhood Phase 2 — 2027/28
20. Willard Neighborhood — 2028/29
21. Saddleback View Neighborhood — 2029/30
22. Washington Square Neighborhood — 2030/31
23. Artesia Pilar Neighborhood Phase 1 — 2031/32/33
24. Artesia Pilar Neighborhood Phase 2 — 2034/35/36
25. Downtown Neighborhood — 2036/37
26. Heninger Park Neighborhood — 2037/38
27. Eastside Neighborhood Phase 1 — 2038/39
28. Eastside Neighborhood Phase 2 — 2039/40

Priorities for MWD Connection Upgrades:

1. SA-5 Vault Relocation   design: complete; construction: 2017/18

2. SA-2 Vault Rehabilitation   design: 2018/19; construction: 2019/20

3. SA-1 Hydro Upgrade   design: 2020/21; construction: 2021/22

8.1.5 Emergency Power Priorities

The following is a summary of the recommended priorities for the various emergency power projects and their recommended construction schedule:

Priorities for Emergency Power Projects:

1. Generators for Critical Wells   design: 2031/32; construction: 2032/33
   (Well # 31, 35, 37, 40, 41)

2. Generators at Crook and Cambridge   design: 2034/35; construction: 2035/36

3. Generators/ATS for Wells   design: 2035/36; construction: 2036/37

8.1.6 Miscellaneous Improvements Priorities

The following is a summary of the recommended priorities for the various miscellaneous improvement projects and their recommended construction schedule:

Priorities for Miscellaneous Improvement Projects:

1. Sodium Hypochlorite Replacement   under construction

2. AMI   2017/18 to 2022/23

3. SCADA Improvements   2024/25

4. Security Enhancements   2026/27

5. PRV Upgrades   2027/28

6. Walls at Reservoirs   2027/28

7. Perimeter Fencing   2027/28

8. Solar Panels   2030/31

9. Fiber Optic Backbone   2031/32 to 2039/40

8.2 Recommended Capital Improvement Program

The recommended Capital Improvement Program, including Operations Budget, for the planning period of 2017/18 to 2039/40 is shown on Figure 9. The Operations Budget only for the planning period is shown on Figure 10. All of the costs included on Figure 9 and Figure 10, and stated earlier within this report, are in 2017 Dollars, ENR Construction Cost Index of 10532 for January 2017.

Below is the recommended annual Capital Improvement Program Costs for the duration of the planning period. The difference in the below costs from the CIP costs summarized on Figure 9 was that an annual inflation allowance of 2 percent, beginning in fiscal year 2019/20 was added:

FY 17/18	FY 18/19	FY 19/20	FY 20/21	FY 21/22	FY 22/23	FY 23/24	FY 24/25	FY 25/26
$14.5M	$11.5M	$15.6M	$15.0M	$14.5M	$15.2M	$12.5M	$18.3M	$15.4M

FY 26/27	FY 27/28	FY 28/29	FY 29/30	FY 30/31	FY 31/32	FY 32/33	FY 33/34	FY 34/35
$14.6M	$13.8M	$15.8M	$14.2M	$14.9M	$8.5M	$11.4M	$9.5M	$13.9M

FY 35/36	FY 36/37	FY 37/38	FY 38/39	FY 39/40
$14.3M	$13.1M	$11.0M	$17.2M	$22.3M

The total projected CIP budget, including the 2% inflation, over the planning period of 23 fiscal years is **$327,000,000** or an average of **$14.2M** per year.

8.3   Limited Capital Improvement Program

Per the 2014 Water Rate Study prepared by Black & Veatch for the City of Santa Ana, the following is the first nine years of the Capital Improvement Program that was recommended by the study (assuming that the FY 2014/15 budget will be the proposed FY 2017/18 budget):

FY 17/18	FY 18/19	FY 19/20	FY 20/21	FY 21/22	FY 22/23	FY 23/24	FY 24/25	FY 25/26
$10.5M	$12.2M	$13.1M	$14.5M	$17.5M	$8.0M	$8.2M	$8.3M	$8.5M

The budgets for the remaining fiscal years is assumed to be $8M plus a 2% inflation starting at FY 2023/24.

The total budget for the planning period based on the 2014 Water Rate Study is **$240M**.

The total budget for the planning period based on the above recommended CIP, including 2% inflation, is **$327M**.   Therefore, in order to maintain CIP expenditure levels per the 2014 Water Rate Study recommendations, a significant number of the recommended projects identified in this Master Plan will have to be deleted or delayed in order to reduce the CIP in an amount of $90M over the planning period.

None of the recommended capital improvement projects that are needed to maintain the level of service and/or operation of the water system should be deleted or delayed. Only recommended improvement projects that enhance or improve the existing water system or its operation should be considered to be deleted or delayed.

To reduce the recommended CIP, the following are the construction projects that could be deleted or delayed from the CIP. The costs in the parenthesis are the total project cost in 2017 dollars.

In addition, some of the refurbishment intervals after the major rehabilitation has occurred were increased by a maximum of 5 years which delays the recommended refurbishment of the facility.

Projects which could impact reliability of water system if deleted

- Well 16 replacement ($5.0M)
- Well 18 replacement ($4.8M)
- Increase well refurbishment interval ($3.0M)
- Increase pump station refurbishment interval ($3.0M)
- Increase reservoir interior painting refurbishment interval ($3M)
- SCADA upgrades ($1.4M)

Projects planned to enhance reliability and/or improve maintenance

- Future Well #2 ($5.0M)
- Critical generators ($2.8M)
- Additional well generators/ATS ($1.4M)
- Reservoir water quality – piping modifications ($0.4M)
- Reservoir exterior painting ($2.4M)
- PRV upgrades ($0.6M)
- AMI ($19.6M)
- Security and walls ($1.1M)
- Solar Panels ($0.5M)
- Pump Station generators ($1.0M)
- Fiber Optics ($14.0M)

Based on the above potential project deletions, the Limited Capital Improvement Program, including Operations Budget, for the planning period of 2017/18 to 2039/40 is shown on Figure 11. The Operations Budget only for the planning period is shown on Figure 12. All of the costs included on Figure 11 and Figure 12 are in 2017 Dollars, ENR Construction Cost Index of 10532 for January 2017.

Below is the annual Limited Capital Improvement Program Costs for the duration of the planning period. An annual inflation allowance of 2 percent, beginning in fiscal year 2019/20 was included in the below annual CIP costs:

FY 17/18	FY 18/19	FY 19/20	FY 20/21	FY 21/22	FY 22/23	FY 23/24	FY 24/25	FY 25/26
$13.8M	$10.6M	$9.7M	$10.1M	$9.1M	$9.9M	$11.2M	$17.9M	$13.9M

FY 26/27	FY 27/28	FY 28/29	FY 29/30	FY 30/31	FY 31/32	FY 32/33	FY 33/34	FY 34/35
$14.3M	$12.4M	$14.4M	$10.7M	$10.8M	$5.0M	$7.0M	$8.6M	$8.5M

FY 35/36	FY 36/37	FY 37/38	FY 38/39	FY 39/40
$5.3M	$7.3M	$7.0M	$11.0M	$11.5M

The total projected limited CIP budget, including the 2% inflation, over the planning period of 23 fiscal years is basically **$240,000,000** or an average of **$10.4M** per year.
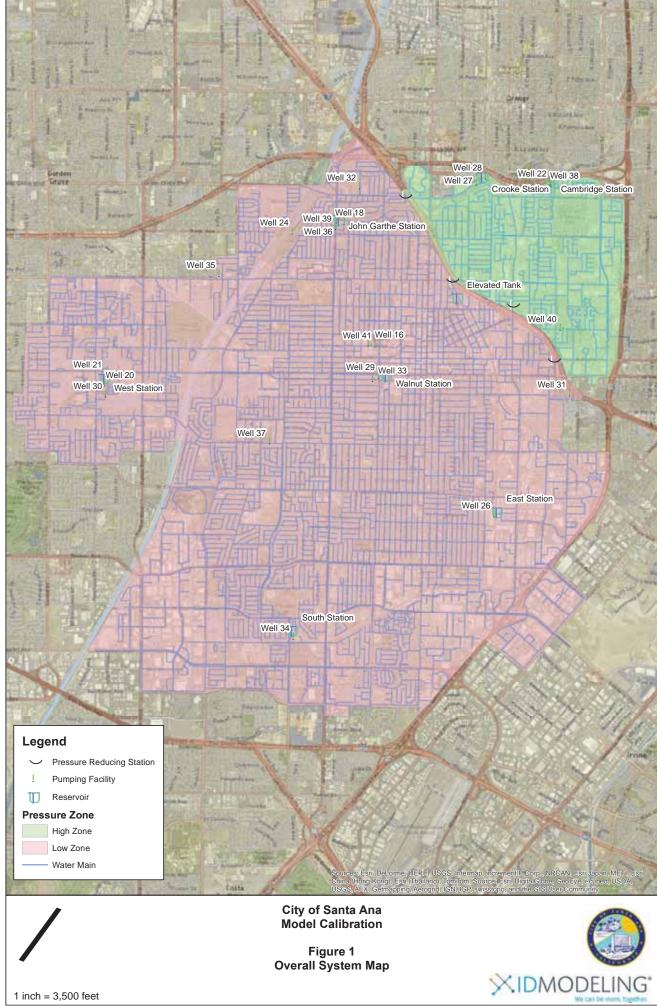
8.4   Conclusion

The goal of the Capital Improvement Program is to assist the City in making decisions of future improvements and rehabilitation/replacements of existing facilities as necessary to maintain the City's Water utility infrastructure systems in sound operable condition and to meet the level of service expectations of the City over the proposed planning period.
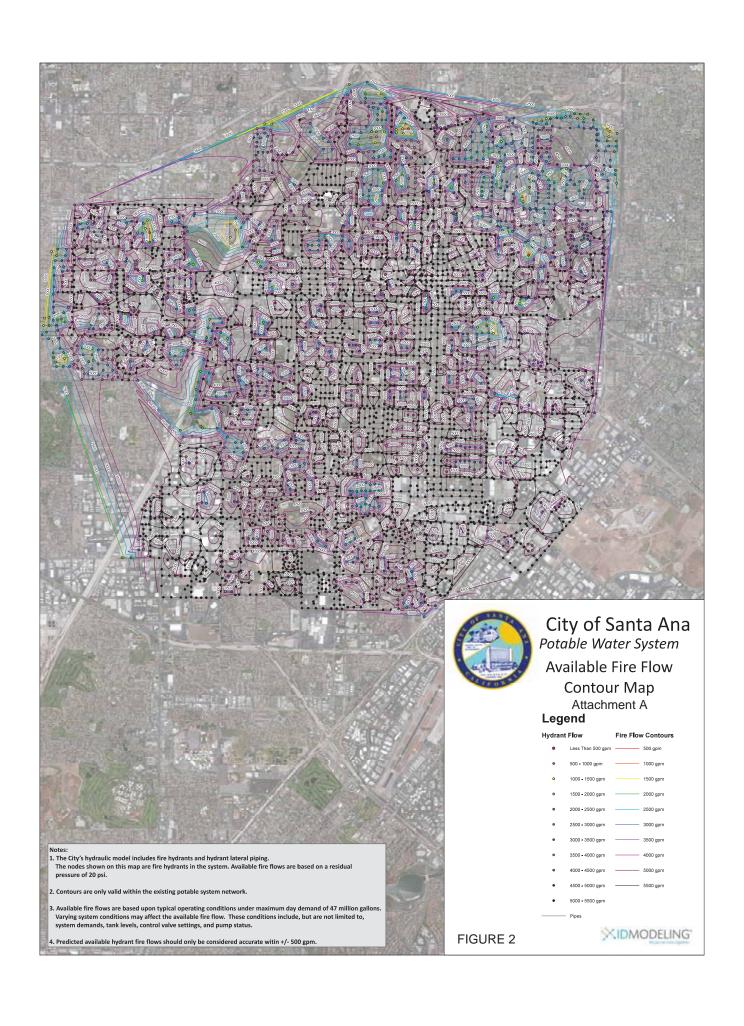
As stated previously, the recommended CIP budget is greater by about $90M than what the current rate study allows for (the Limited CIP Budget).
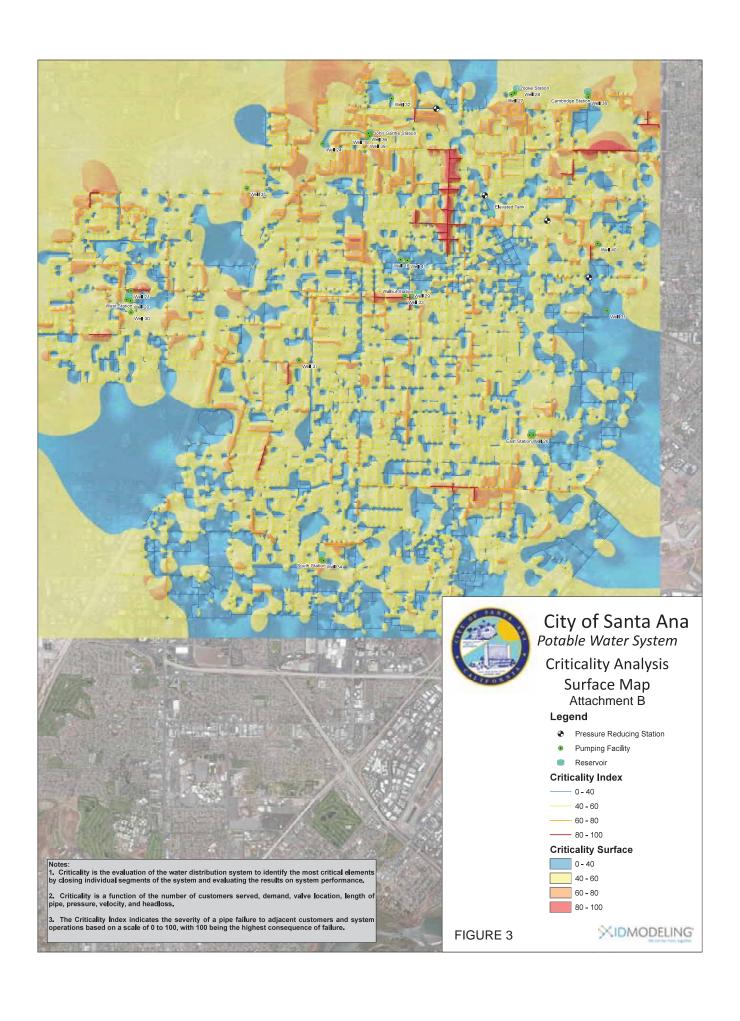
The improvement projects and refurbishment goals included within this Master Plan were recommended to meet the City's goal of continuing to provide safe and reliable drinking water for future generations. The recommended projects and refurbishment goals were based on typical water industry useful life of equipment and facilities as well as having no pipe over 100 years old in the City's distribution system. The goal of the Master Plan was to be pre-emptive and not reactive to problems/failures due to age/condition. Delaying the construction or refurbishment of facilities may or may not impact the City as it depends on the specific equipment, pipe, and the specific conditions it is installed/operates under. However, based on water industry experience, delaying the construction or refurbishment of facilities will increase the potential risk of failure which will impact the ability to maintain the sound operable condition of your water system. The City's water system is robust and has been very reliable in the past. However, the facilities are getting older and will need to be replaced and refurbished more often due to its age if the City wants to maintain its current level of service.
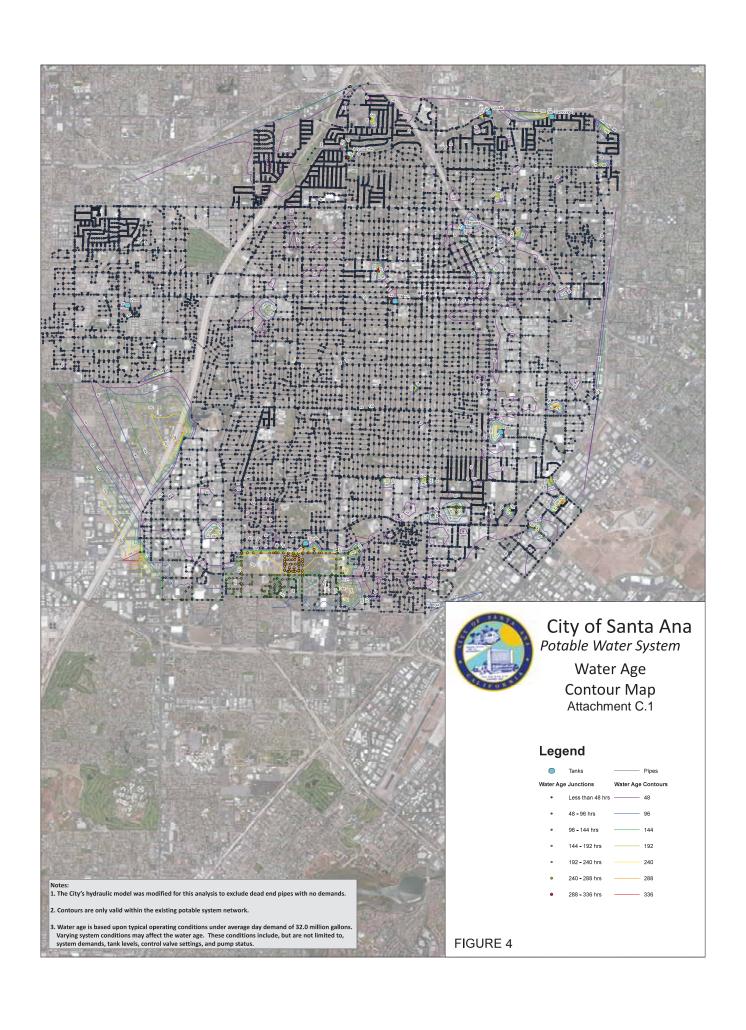
It is recommended that the City perform a new Water Rate Study using the recommended CIP budget, as a minimum. It should be noted that even with the recommended CIP budget, there is an additional $390M of pipe replacement costs for existing pipes within the City's distribution system that will have past the pipe materials useful life by the end of the proposed planning period that are not included within the recommended CIP budget.

FIGURES

Legend

⌣ Pressure Reducing Station

! Pumping Facility

⊔ Reservoir

Pressure Zone

High Zone

Low Zone

— Water Main

Sources: Esri, DeLorme, HERE, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

City of Santa Ana
Model Calibration

Figure 1
Overall System Map

⟋IDMODELING®
We can be more, together.

1 inch = 3,500 feet

FIGURE 1

City of Santa Ana
Potable Water System

Available Fire Flow Contour Map
Attachment A

Legend

Hydrant Flow	Fire Flow Contours
Less Than 500 gpm	500 gpm
500 - 1000 gpm	1000 gpm
1000 - 1500 gpm	1500 gpm
1500 - 2000 gpm	2000 gpm
2000 - 2500 gpm	2500 gpm
2500 - 3000 gpm	3000 gpm
3000 - 3500 gpm	3500 gpm
3500 - 4000 gpm	4000 gpm
4000 - 4500 gpm	5000 gpm
4500 - 5000 gpm	5500 gpm
5000 - 5500 gpm	
	Pipes

Notes:

1. The City's hydraulic model includes fire hydrants and hydrant lateral piping. The nodes shown on this map are fire hydrants in the system. Available fire flows are based on a residual pressure of 20 psi.

2. Contours are only valid within the existing potable system network.

3. Available fire flows are based upon typical operating conditions under maximum day demand of 47 million gallons. Varying system conditions may affect the available fire flow. These conditions include, but are not limited to, system demands, tank levels, control valve settings, and pump status.

4. Predicted available hydrant fire flows should only be considered accurate witin +/- 500 gpm.

FIGURE 2

IDMODELING

City of Santa Ana
Potable Water System

Criticality Analysis
Surface Map
Attachment B

Legend

- ⊕ Pressure Reducing Station
- ● Pumping Facility
- ▬ Reservoir

Criticality Index

⎯⎯	0 - 40
⎯⎯	40 - 60
⎯⎯	60 - 80
⎯⎯	80 - 100

Criticality Surface

▣	0 - 40
▣	40 - 60
▣	60 - 80
▣	80 - 100

Notes:
1. Criticality is the evaluation of the water distribution system to identify the most critical elements by closing individual segments of the system and evaluating the results on system performance.

2. Criticality is a function of the number of customers served, demand, valve location, length of pipe, pressure, velocity, and headloss.

3. The Criticality Index indicates the severity of a pipe failure to adjacent customers and system operations based on a scale of 0 to 100, with 100 being the highest consequence of failure.

FIGURE 3

IDMODELING

City of Santa Ana
Potable Water System

Water Age
Contour Map
Attachment C.1

Legend

	Tanks	——	Pipes

Water Age Junctions		Water Age Contours	
·	Less than 48 hrs	——	48
·	48 - 96 hrs	——	96
·	96 - 144 hrs	——	144
○	144 - 192 hrs	——	192
○	192 - 240 hrs	——	240
○	240 - 288 hrs	——	288
●	288 - 336 hrs	——	336

FIGURE 4

Notes:

1. The City's hydraulic model was modified for this analysis to exclude dead end pipes with no demands.

2. Contours are only valid within the existing potable system network.

3. Water age is based upon typical operating conditions under average day demand of 32.0 million gallons. Varying system conditions may affect the water age. These conditions include, but are not limited to, system demands, tank levels, control valve settings, and pump status.

Legend

Minimum Pressure

!	Less Than 20 psi
!	20 - 40 psi
!	40 - 80 psi
!	80 - 100 psi
!	100 - 120 psi
●	Greater Than 120 psi

Maximum Velocity

——	Less Than 3 fps
——	3 - 5 fps
——	5 - 7 fps
——	7 - 10 fps
——	Greater Than 10 fps

1 inch = 3,500 feet

0   1,750   3,500   7,000
━━━━━━━━━━━━━━━━━━━━━━ Feet

Buildout System Peak Hour Demand

2016 Master Plan Hydraulic Analysis
City of Santa Ana

IDMODELING

FIGURE 5

Legend

Hydrant Flow

- ● Below 500 gpm
- ● 500 - 1000 gpm
- ● 1000 - 1500 gpm
- ● 1500 - 2000 gpm
- ● 2000 - 2500 gpm
- ● 2500 - 3000 gpm
- ● 3000 - 3500 gpm
- ● 3500 - 4000 gpm
- ● 4000 - 4500 gpm
- ● 4500 - 5000 gpm
- ● 5000 - 5500 gpm

Fire Flow Contours

- —— 500
- —— 1000
- —— 1500
- —— 2000
- —— 2500
- —— 3000
- —— 3500
- —— 4000
- —— 4500
- —— 5000
- —— 5500

Notes:

1. The City's hydraulic model includes fire hydrants and hydrant lateral piping. The nodes shown on this map are fire hydrants in the system. Available fire flows are based on a residual pressure of 20 psi.

2. Contours are only valid within the existing potable system network.

3. Available fire flows are based upon typical operating conditions under maximum day demand. Varying system conditions may affect the available fire flow. These conditions include, but are not limited to system demands, tank levels, control valve settings, and pump status.

4. Predicted available hydrant fire flows should only be considered accurate witin +/- 500 gpm.

1 inch = 3,500 feet

0   1,750   3,500   7,000
Feet

Buildout System Max Day Demand + Fire Flow

2016 Master Plan Hydraulic Analysis
City of Santa Ana

IDMODELING

FIGURE 6

WATER MAIN REPLACEMENT PROJECTS

1.   17TH STREET WATER MAIN IMPROVEMENTS
2.   RIVERVIEW NEIGHBORHOOD PHASE 2
3.   BRISTOL PHASE 3
4.   WEST GROVE VALLEY NEIGHBORHOOD
5.   GRAND AVE. WATER MAIN REPLACEMENT
6.   ST GERTRUDE AND GRAND WATER MAIN REPLACEMENT
7.   THORNTON PARK NEIGHBORHOOD
8.   BRISTOL PHASE 4
9.   WARNER AVENUE WIDENING
10. WALNUT DISCHARGE MAIN LINING
11. WARNER AVE. WATER MAIN REPLACEMENT
12. FISHER PARK NEIGHBORHOOD
13. FRENCH COURT NEIGHBORHOOD
14. FRENCH PARK NEIGHBORHOOD
15. PARK SANTIAGO NEIGHBORHOOD
16. WEST FLORAL PARK NEIGHBORHOOD
17. FLORAL PARK NEIGHBORHOOD
18. WILLARD NEIGHBORHOOD
19. SADDLEBACK VIEW NEIGHBORHOOD
20. WASHINGTON SQUARE NEIGHBORHOOD
21. ARTESIA PILAR NEIGHBORHOOD
22. DOWNTOWN NEIGHBORHOOD
23. HENINGER PARK NEIGHBORHOOD
24. EASTSIDE NEIGHBORHOOD

Legend

Intall Year

- 1901 - 1910
- 1911 - 1925
- 1921 - 1930
- 1931 - 1940
- 1941 - 1950
- 1951 - 1960
- 1961 - 1970
- 1971 - 1980
- 1981 - 1990

City of Santa Ana
Potable Water System

Cast Iron Pipe
Location

October 2016

IDMODELING

FIGURE 7

Water System Facilities

FIBER BACKBONE (RED LINE)

FIGURE 8

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Map labels (streets and facilities):

LA VETA AV · GARDEN GROVE BLVD · GLASSELL ST · CAMBRIDGE ST · FAIRHAVEN AV · SANTA CLARA AV · 17TH ST · WASHINGTON AV · CIVIC CENTER DR · SANTA ANA BLVD · HAZARD AV · 1ST ST · MC FADDEN AV · EDINGER AV · WARNER AV · SEGERSTROM AV · DYER RD · ALTON AV · MACARTHUR BLVD · SUNFLOWER AV · CHESTNUT AV · FAIRVIEW ST · BRISTOL ST · FLOWER ST · BROADWAY · MAIN ST · GRAND AV · TUSTIN AV · YORBA ST · CABRILLO PARK DR · STANDARD AV · RAITT ST · BEAR ST · HARBOR BLVD · EUCLID ST · NEWHOPE ST · RED HILL AV · DYER AV · MAXINE · PRV-1 · PRV-2 · PRV-3 · PRV-4

Wells: Well 13, Well 16, Well 18, Well 20, Well 21, Well 22, Well 24, Well 26, Well 27, Well 28, Well 29, Well 30, Well 31, Well 32, Well 33, Well 34, Well 35, Well 36, Well 37, Well 38, Well 40, Well 41

Reservoirs / Stations: NE Cooke Reservoir, J Garthe Reservoir, West Reservoir, Walnut Reservoir, East Reservoir, South Reservoir, Elevated Tank

Connections: SA-1, SA-2, SA-3, SA-4, SA-5, SA-6, SA-7

CITY YARD · SEGERSTROM · 1st and Underpass · 22 · 5 · 55

0.00   0.50   1.00   Miles

N

Wells

Well #		Address
Well # 13	N/A	723 W. Walnut St., Santa Ana, CA 92701
Well # 16	834-9983	1011 W. 5th St., Santa Ana, CA 92703
Well # 18	N/A	2401 N. Bristol St. Santa Ana, CA 92706
Well # 20	N/A	4426 W. 1st St., Santa Ana, CA 92703
Well # 21	N/A	4426 W. 1st St., Santa Ana, CA 92703
Well # 22	N/A	2736 N. Cambridge St., Santa Ana, CA 90701
Well # 24	N/A	1800 W. 22nd St., Santa Ana, CA 92706
Well # 26	N/A	1730 S. Santa Fe, Santa Ana, CA 92705
Well # 27	N/A	730 E. Memory Ln, Santa Ana, CA 92706
Well # 28	N/A	730 E. Memory Ln., Santa Ana, CA 92706
Well # 29	N/A	S/E First St. and Flower St, Santa Ana, CA 92701
Well # 30	N/A	SW Corner of Potomac Com & Simbury Com
Well # 31	543-9547	1815 E. Chestnut St., Santa Ana, CA 92701
Well # 32	N/A	2801 N. Westwood, Santa Ana, CA 92706
Well # 33	N/A	917 W. Walnut St, Santa Ana, CA 92703
Well # 34	N/A	1727 W. Alton Ave, Santa Ana, CA 92705
Well # 35	N/A	1716 N. Sydney St., Santa Ana, CA 92706
Well # 36	N/A	2415 N. Bristol St, Santa Ana, CA 92706
Well # 37	N/A	2007 W. McFadden, Santa Ana, CA
Well # 38	N/A	2736 N. Cambridge St., Santa Ana, CA 90701
Well # 40	N/A	1301 N. Mabury St, Santa Ana, CA 92701
Well # 41	N/A	907 3/4 N Flower St, Santa Ana, CA 92703

*Do not have chlorinators onsite

Lift Stations

		Address
Maxine - Sewer	N/A	McFadden Ave / Maxine St., Santa Ana, CA 92701
Segerstrom - Sewer	N/A	2903 S. Bristol St, Santa Ana, CA 92704
1st St. Underpass – Storm Drain	N/A	N/E of 1st St. and Santa Fe, Santa Ana, CA 92701

Reservoirs

			Address
Cambridge Station	E.	639-5161	2736 N. Cambridge St., Santa Ana, CA 90701
Crooke Station	E.	997-3272	730 E. Memory Ln., Santa Ana, CA 92706
East Station	E.	543-0671	1730 S. Santa Fe, Santa Ana, CA 92705
Elevated Tank	E.		14th St. / Poinsettia St., Santa Ana, CA 92701
J. Garthe Station	W.	543-6747	2401 N. Bristol St, Santa Ana, CA 92706
South Station	W.	540-9320	1727 W. Alton Ave, Santa Ana, CA 92705
Walnut Station	E.	547-4529	723 W. Walnut St., Santa Ana, CA 92701
West Station	W.	775-6740	4426 W. 1st St., Santa Ana, CA 92703

Santa Ana - Connections to MWD's Systems

		Address
SA - 1	N/A	2315 N. Bristol St., Santa Ana, CA 92706
SA - 2	N/A	SE Corner of 1st St & Flower St and SE Corner of 1st & Bristol
SA - 3	N/A	1300 W. McFadden, Santa Ana, CA 92704
SA - 4	N/A	1299 W. Warner Ave, Santa Ana, CA 92707
SA - 5	N/A	NE Corner of Bristol St. & Alton Ave, CA 92707
SA - 6	N/A	2301 N. Tustin Ave, Santa Ana, CA 92705
SA - 7	N/A	2215 S. Ritchey St, Santa Ana, CA 92705

Pressure Regulating Vaults

		Address
PRV-1	N/A	501 3/4 W. Memory Ln, Santa Ana, CA 92706
PRV-2	N/A	399 3/4 E. 17th St, Santa Ana, CA 92706
PRV-3	N/A	1 45 3/4 N. Grand Ave, Santa Ana, CA 92701
PRV-4	N/A	1668 E. 4th St, Santa Ana, CA 92701

Revised 6/21/17

RECOMMENDED CIP AND OPERATIONS BUDGETS - in 2017 dollars

Project ID	Project Name	Construction Cost	Design (10%)	Cont. (15%)	Cont. (15%)	Total Prog. Cost	CIP or Oper	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	2033/34	2034/35	2035/36	2036/37	2037/38	2038/39	2039/40

WELLS

DRILL NEW WELLS

Casing Evaluation and Functional Specification Development

Well Facility R&R and Well Rehabilitation

WELL CIP/OPERATIONS SUMMARY

PUMP STATIONS

PUMP STATION CIP/OPERATIONS Totals

FIGURE 9

RESERVOIRS

Project ID	Project Name	Construction Cost	Design (40%)	Const (15%)	Cont (15%)	Total Proj Cost	CIP or Oper
	RESERVOIRS						
	Cleaning/Inspection (10 res) (5 yrs)	$400,000	$40,000	$60,000	$60,000	$560,000	Operations
	Water Quality - Piping Modifications						
	Cooke Piping Imp	$100,000	$10,000	$15,000	$15,000	$140,000	CIP
	Cambridge Piping Imp	$100,000	$10,000	$15,000	$15,000	$140,000	CIP
	Walnut Piping Imp	$100,000	$10,000	$15,000	$15,000	$140,000	CIP
	Concrete Reservoir Roof						
	Cambridge Res (every 10 yrs)	$300,000	$30,000	$45,000	$45,000	$420,000	Operations
	Garthe Reservoirs (every 10 yrs)	$600,000	$60,000	$90,000	$90,000	$840,000	Operations
	Coolidge Res (every 10 yrs)	$400,000	$40,000	$60,000	$60,000	$560,000	Operations
	Walnut Res (every 10 yrs)	$400,000	$40,000	$60,000	$60,000	$560,000	Operations
	South Res (every 10 yrs)	$500,000	$50,000	$75,000	$75,000	$700,000	Operations
	Steel Tank Interior Coating and CIP Upgrade						
	East Res (every 15 yrs)	$1,800,000	$180,000	$270,000	$270,000	$2,520,000	CIP
	Elevated Tank (every 15 yrs)	$700,000	$70,000	$105,000	$105,000	$980,000	CIP
	West Res (every 15 yrs)	$1,800,000	$180,000	$270,000	$270,000	$2,520,000	CIP
	Steel Tank Exterior Painting						
	Elevated Tank (every 20 yrs)	$1,000,000	$100,000	$150,000	$150,000	$1,400,000	CIP
	East Res (every 20 yrs)	$350,000	$35,000	$52,500	$52,500	$490,000	CIP
	West Res (every 20 yrs)	$350,000	$35,000	$52,500	$52,500	$490,000	CIP
	Reservoir CIP and Operations Totals	$8,900,000	$890,000	$1,335,000	$1,335,000	$12,460,000	

	CONNECTIONS AND PRVS						
	SA-7 CIP Vault Relocation	$500,000	$0	$75,000	$75,000	$650,000	CIP
	SA-2 CIP Vault Rehabilitation	$500,000	$50,000	$75,000	$75,000	$700,000	CIP
	SA-1 Hydro	$300,000	$30,000	$45,000	$45,000	$420,000	CIP
	SA-7 Relocation by Caltrans	$0	$0	$0	$0	$0	Paid by Caltrans
	PRV 1, 2, 3 and 4 Power Controls	$400,000	$120,000	$60,000	$60,000	$560,000	CIP
	Connection/PRVs CIP Totals	$1,700,000	$120,000	$255,000	$255,000	$2,330,000	

	MISCELLANEOUS						
166460	AMI	$14,000,000	$1,400,000	$2,100,000	$2,100,000	$19,600,000	CIP
	Sodium Hypochlorite Replacement	$2,860,000	$286,000	$430,000	$430,000	$4,000,000	Operations
	SCADA CIP (Various Sites)	$1,000,000	$100,000	$150,000	$150,000	$1,400,000	CIP
	Security Enhancements	$500,000	$50,000	$75,000	$75,000	$700,000	CIP
	Wells @ Reserv (East, Garthe, South)	$300,000	$30,000	$45,000	$45,000	$420,000	CIP
	Domestic Chainlink @ Reservoirs	$300,000	$30,000	$45,000	$45,000	$490,000	Operations
	Solar Panels (Garthe and West)	$350,000	$35,000	$52,500	$52,500	$490,000	CIP
	Generators (Cooke & Cambridge)	$700,000	$70,000	$105,000	$105,000	$980,000	CIP
	Fiber Optic Backbone	$10,000,000	$1,000,000	$1,500,000	$1,500,000	$14,000,000	CIP
	Miscellaneous CIP and Operations Totals	$30,010,000	$2,995,000	$4,502,500	$4,502,500	$42,010,000	

	WATER MAINS						
154472	17th Street (2,500 ft)	$0	$0	$0	$0	$0	CIP
154483	Reservoir7 (7,500 ft)	$1,870,000	$0	$280,000	$280,000	$2,430,000	CIP
154485	Bristol Phase 3 (1,600 ft)	$420,000	$0	$60,000	$65,000	$550,000	CIP
154447	West Grove Valley (11,000 ft)	$3,110,000	$0	$465,000	$465,000	$4,040,000	CIP
	SB-55 Water Replacement	$0	$0	$0	$0	$0	Paid by Caltrans
	Grant (1,000 ft)	$280,000	$26,000	$42,000	$42,000	$390,000	CIP
154446	St Gertrude (1,700 ft)	$840,000	$88,000	$126,000	$126,000	$1,180,000	CIP
154448	Bretton Neighborhood (4,800 ft)	$1,290,000	$133,000	$193,500	$193,500	$1,810,000	CIP
154448	Bristol Phase 4 (2,300 ft)	$670,000	$69,000	$100,500	$100,500	$940,000	CIP
	Warner Widening CIP (1,500 ft)	$1,940,000	$198,000	$291,000	$291,000	$2,720,000	CIP
	Walnut Bridge(sp Lining CIP)	$1,670,000	$169,000	$250,500	$250,500	$2,340,000	CIP
	Water Replacement CIP (2,000 ft)	$600,000	$60,000	$90,000	$90,000	$840,000	CIP
	2020/21 Tabor Park (10,000 ft)	$2,600,000	$260,000	$390,000	$390,000	$3,640,000	CIP
	2020/22 French Court (11,000 ft)	$2,900,000	$290,000	$435,000	$435,000	$4,060,000	CIP
	2021/23 French Park (11,000 ft)	$3,400,000	$340,000	$510,000	$510,000	$4,760,000	CIP
	2022/24 Park Santiago Ph 1 (18,500 ft)	$4,800,000	$480,000	$720,000	$720,000	$6,720,000	CIP
	2024/25 Park Santiago Ph 2 (18,500 ft)	$4,800,000	$480,000	$720,000	$720,000	$6,720,000	CIP
	2025/26 West Floral Park (17,500 ft)	$4,600,000	$460,000	$690,000	$690,000	$6,440,000	CIP
	2026/27 Floral Park Ph 1 (16,000 ft)	$4,200,000	$420,000	$630,000	$630,000	$5,880,000	CIP
	2027/28 Floral Park Ph 2 (16,000 ft)	$4,200,000	$420,000	$630,000	$630,000	$5,880,000	CIP
	2028/29 Saddleback View (17,500 ft)	$4,600,000	$460,000	$690,000	$690,000	$6,440,000	CIP
	2029/30 Saddleback View (17,500 ft)	$2,900,000	$290,000	$435,000	$435,000	$4,060,000	CIP
	2030/31 Washington Square (11,000 ft)	$5,100,000	$510,000	$765,000	$765,000	$7,140,000	CIP
	2031/32/33 Avenue Pkwy Ph 1 (9,500 ft)	$4,800,000	$480,000	$720,000	$720,000	$6,720,000	CIP
	2034/35/36 Avenue Pkwy Ph 2 (9,500 ft)	$3,600,000	$360,000	$540,000	$540,000	$5,040,000	CIP
	2036/37 Downtown (11,500 ft)	$4,600,000	$460,000	$690,000	$690,000	$6,440,000	CIP
	2037/38 Heritage Park (9,500 ft)	$2,500,000	$250,000	$375,000	$375,000	$3,500,000	CIP
	2038/39 Eastside Ph 2 (14,000 ft)	$3,600,000	$360,000	$540,000	$540,000	$5,040,000	CIP
	2039/40 Eastside Ph 2 (14,000 ft)	$3,600,000	$360,000	$540,000	$540,000	$4,680,000	CIP
	Water Main CIP Totals	$79,790,000	$7,453,000	$11,968,500	$11,968,500	$295,750,000	

	TOTAL CIP AND OPERATION	$211,750,000	$20,468,000	$31,766,000	$31,766,000	$30,880,000	
	TOTAL OF OPERATION BUDGET	$22,860,000	$2,280,000	$3,310,000	$3,310,000	$30,880,000	
	TOTAL OF CIP BUDGET ONLY	$189,090,000	$18,260,000	$28,456,000	$28,456,000	$264,870,000	

FIGURE 9

RECOMMENDED YEAR OPERATION BUDGET (OPERATION ONLY) - in 2017 Dollars

FIGURE 10

LIMITED CIP AND OPERATIONS BUDGETS - in 2017 Dollars

Revised 6/21/17

WELLS

DRILL NEW WELLS

Costing Evaluation and Functional Specification Development

Project ID	Project Name	Construction Cost	Design (10%)	Cont. (15%)	Cont. (15%)	Total Prog. Cost	CIP or Oper	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	2033/34	2034/35	2035/36	2036/37	2037/38	2038/39	2039/40

WELL FACILITY R&R AND WELL REHABILITATION

PUMP STATIONS

FIGURE 11

FIGURE 11

Project ID	Project Name	Construction Cost	Design (10%)	Cont. (15%)	Cont. (15%)	Total Prep. Cost	CIP or Oper.	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	2033/34	2034/35	2035/36	2036/37	2037/38	2038/39	2039/40
	RESERVOIRS																															
	Water Quality – Piping Modifications																															
	Cooke Piping Imp	$400,000	$40,000	$60,000	$60,000	$560,000	Operations											$140,000												$140,000		
	Cambridge Piping Imp	$0	$0	$0	$0	$0	CIP																									
	Walnut Piping Imp	$0	$0	$0	$0	$0	CIP																									
	Concrete Reservoir Roofs																															
	Cambridge Res (every 10 yrs)	$500,000	$50,000	$45,000	$45,000	$420,000	Operations		$140,000										$140,000												
	Garthe Reservoirs (every 10 yrs)	$600,000	$60,000	$90,000	$90,000	$840,000	Operations				$420,000										$420,000									
	Cooke Res (every 10 yrs)	$400,000	$40,000	$60,000	$60,000	$560,000	Operations					$280,000												$280,000						
	Walnut Reservoir (every 10 yrs)	$400,000	$40,000	$60,000	$60,000	$560,000	Operations								$280,000													$280,000		
	South Res (every 10 yrs)	$500,000	$50,000	$75,000	$75,000	$700,000	Operations										$350,000										$350,000			
	Steel Tank Interior Coating and CIP Upgrade																															
	East Res (every 20 yrs)	$900,000	$90,000	$135,000	$135,000	$1,260,000	CIP								$1,170,000		$455,000													
	Howard Tank (every 20 yrs)	$350,000	$35,000	$52,500	$52,500	$490,000	CIP	$650,000	$50,000	$650,000	$30,000	$390,000		$90,000		$35,000	$90,000				$420,000									
	West Res (every 20 yrs)	$900,000	$90,000	$135,000	$135,000	$1,260,000	CIP											$1,170,000												
	Steel Tank Exterior Painting																															
	Howard Tank (every 20 yrs)	$0	$0	$0	$0	$0	CIP																							
	East Res (every 20 yrs)	$0	$0	$0	$0	$0	CIP																							
	West Reservoir (20 yrs)	$0	$0	$0	$0	$0	CIP																							
	Reservoir CIP and Operations Totals	$4,750,000	$475,000	$712,500	$712,500	$6,650,000		$0	$140,000	$0	$420,000	$280,000	$280,000	$0	$1,450,000	$35,000	$945,000	$910,000	$1,310,000	$0	$420,000	$0	$0	$280,000	$280,000	$0	$490,000	$0	$140,000	$0
	CONNECTIONS AND PRVS																															
	SA-5 CIP Vault Relocation	$500,000	$0	$75,000	$75,000	$650,000	CIP	$650,000																						
	SA-3 CIP Vault Rehabilitation	$500,000	$50,000	$75,000	$75,000	$700,000	CIP		$550,000		$650,000																			
	SA-1 Hydro	$300,000	$30,000	$45,000	$45,000	$420,000	CIP				$30,000	$390,000																		
	SA-7 Relocation by Caltrans	$0	$0	$0	$0	$0	Paid by Caltrans										$30,000													
	PRV 1, 2, 3 and 4 Power Controls	$1,300,000	$80,000	$195,000	$195,000	$1,770,000	CIP											$390,000												
	Connections/PRVs CIP Totals							$650,000	$50,000	$50,000	$30,000	$390,000	$0	$0	$0	$0	$30,000	$390,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	MISCELLANEOUS																															
164464	AMI	$0	$0	$0	$0	$0	CIP	$670,000	$670,000	$670,000	$670,000			$670,000	$670,000										$670,000				
	Sodium Hypochlorite Replacement	$2,860,000	$280,000	$430,000	$430,000	$4,000,000	Operations			$660,000							$330,000										$660,000			
	SCADA CIP (Various Sites)	$0	$0	$0	$0	$0	CIP																						
	Security Enhancements	$0	$0	$0	$0	$0	CIP											$390,000											
	Vault (& Reserve line) Garthe/Santa	$300,000	$30,000	$45,000	$45,000	$420,000	Operations																						
	Perimeter Chainlink @ Reservoirs	$0	$0	$0	$0	$0	CIP																						
	Solar Panels (Garthe and West)	$0	$0	$0	$0	$0	CIP																						
	Generators Cooke & Cambridge	$0	$0	$0	$0	$0	CIP																						
	Miscellaneous CIP and Operations Totals	$3,160,000	$310,000	$475,000	$475,000	$4,420,000		$670,000	$670,000	$660,000	$670,000	$0	$0	$670,000	$660,000	$0	$30,000	$390,000	$0	$0	$0	$0	$0	$0	$660,000	$0	$0	$0	$0
	WATER MAINS																															
154473	17th Street (2,500 ft)	$0	$0	$0	$0	$0	CIP	$2,430,000																					
154483	Reservoir (7,500 ft)	$1,870,000	$280,000	$280,000	$280,000	$2,430,000	CIP	$550,000																					
154481	Brazil Phase 1 (1,000 ft)	$420,000	$65,000	$65,000	$65,000	$550,000	CIP	$4,040,000																					
154487	West Grove Valley (11,000 ft)	$3,110,000	$465,000	$465,000	$465,000	$4,840,000	CIP																						
	SR-5 Water Replacement	$0	$0	$0	$0	$0	Paid by Caltrans		$364,000																				
	Grant (1,000 ft)	$280,000	$26,000	$42,000	$42,000	$390,000	CIP	$26,000																					
154446	St Gertrude (1,700 ft)	$840,000	$88,000	$126,000	$126,000	$1,180,000	CIP	$88,000	$3,092,000																				
154448	Thurston Neighborhood (4,800 ft)	$1,290,000	$133,000	$193,500	$193,500	$1,810,000	CIP	$133,000	$1,677,000	$871,000																			
154448	Brazil Phase 4 (2,300 ft)	$670,000	$69,000	$100,500	$100,500	$940,000	CIP		$69,000	$2,522,000																			
	Warren Widening (CIP) (5,500 ft)	$1,940,000	$198,000	$291,000	$291,000	$2,720,000	CIP		$198,000	$169,000										$5,980,000									
	Walnut Discharge Lining (CIP)	$1,670,000	$169,000	$250,500	$250,500	$2,340,000	CIP			$2,171,000									$460,000	$460,000									
	Water Replacement CIP (2,000 ft)	$600,000	$60,000	$90,000	$90,000	$848,000	CIP			$780,000																			
	2020-21 Isabel Park (10,000 ft)	$2,600,000	$260,000	$390,000	$390,000	$3,640,000	CIP			$260,000	$3,360,000																		
	2021-22 French Court (11,000 ft)	$2,900,000	$290,000	$435,000	$435,000	$4,060,000	CIP				$290,000	$3,770,000																	
	2022-23 French Park (11,000 ft)	$3,400,000	$340,000	$510,000	$510,000	$4,760,000	CIP					$340,000	$3,770,000	$510,000															
	2023-24 Park Santiago Ph 1 (8,500 ft)	$4,800,000	$480,000	$720,000	$720,000	$6,720,000	CIP						$340,000	$4,420,000	$480,000														
	2024-25 Park Santiago Ph 2 (8,500 ft)	$4,800,000	$480,000	$720,000	$720,000	$6,720,000	CIP							$480,000	$6,240,000	$6,240,000													
	2025-26 West Park (17,500 ft)	$4,600,000	$460,000	$690,000	$690,000	$6,440,000	CIP								$480,000	$660,000	$5,980,000												
	2026-27 Floral Park Ph 1 (16,000 ft)	$4,200,000	$420,000	$630,000	$630,000	$5,880,000	CIP										$420,000	$5,460,000	$460,000										
	2027-28 Floral Park Ph 2 (16,000 ft)	$4,200,000	$420,000	$630,000	$630,000	$5,880,000	CIP											$420,000	$5,460,000										
	2028-29 Willard (17,000 ft)	$4,600,000	$460,000	$690,000	$690,000	$6,440,000	CIP												$460,000	$5,980,000									
	2029-30 Saddleback View (17,500 ft)	$4,600,000	$460,000	$690,000	$690,000	$6,440,000	CIP													$460,000	$5,980,000								
	2030-31 Washington Square (11,000 ft)	$2,900,000	$290,000	$435,000	$435,000	$4,060,000	CIP			$260,000											$290,000								
	2031-32/33 Arroyo Vista Ph 1 (9,500 ft)	$5,100,000	$510,000	$765,000	$765,000	$7,140,000	CIP															$3,770,000	$3,770,000	$3,135,000					
	2034-35/36 Arroyo Vista Ph 2 (9,500 ft)	$5,100,000	$510,000	$765,000	$765,000	$7,140,000	CIP															$510,000		$510,000	$3,135,000	$3,135,000			
	2036-37 Harwood View (11,500 ft)	$3,600,000	$360,000	$540,000	$540,000	$5,040,000	CIP																		$3,135,000	$360,000	$4,680,000		
	2037-38 Montage Park (9,500 ft)	$2,500,000	$250,000	$375,000	$375,000	$3,500,000	CIP																			$280,000	$4,680,000		
	2038-39 Eastside Ph 1 (14,000 ft)	$3,600,000	$360,000	$540,000	$540,000	$5,040,000	CIP																				$360,000	$4,680,000	
	2039-40 Eastside Ph 2 (14,000 ft)	$3,600,000	$360,000	$540,000	$540,000	$5,040,000	CIP																					$360,000	$4,680,000
	Water Main CIP Totals	$79,790,000	$7,453,000	$11,968,500	$11,968,500	$111,180,000		$7,267,000	$3,400,000	$3,622,000	$3,211,000	$3,670,000	$4,110,000	$4,900,000	$6,720,000	$6,700,000	$6,400,000	$5,880,000	$5,920,000	$6,440,000	$6,270,000	$4,280,000	$3,825,000	$3,315,000	$3,675,000	$4,930,000	$5,040,000	$3,610,000	$5,040,000
	TOTAL CIP AND OPERATION	$162,450,000	$15,538,000	$24,371,000	$24,371,000	$226,730,000		$16,867,000	$13,360,000	$11,482,000	$11,851,000	$9,910,000	$10,760,000	$11,370,000	$15,850,000	$11,845,000	$12,495,000	$11,057,000	$12,260,000	$9,520,000	$9,630,000	$8,630,000	$7,815,000	$6,715,000	$6,925,000	$6,088,000	$5,610,000	$3,610,000	$7,760,000
	TOTAL OF OPERATION BUDGET	$21,160,000	$2,110,000	$3,175,000	$3,175,000	$29,620,000		$3,070,000	$3,000,000	$2,230,000	$2,340,000	$1,550,000	$1,820,000	$1,430,000	$280,000	$0	$520,000	$430,000	$740,000	$1,100,000	$1,280,000	$1,890,000	$1,610,000	$1,540,000	$870,000	$1,080,000	$950,000	$940,000	$560,000
	TOTAL OF CIP BUDGET ONLY	$141,290,000	$13,428,000	$21,196,000	$21,196,000	$197,110,000		$13,797,000	$10,360,000	$9,252,000	$9,511,000	$8,360,000	$8,940,000	$9,940,000	$15,570,000	$11,845,000	$11,975,000	$10,440,000	$11,520,000	$8,420,000	$8,350,000	$3,740,000	$6,205,000	$5,175,000	$6,055,000	$5,008,000	$3,675,000	$4,670,000	$7,200,000

FIGURE 12

LIMITED YEAR OPERATION BUDGET (OPERATION ONLY) - in 2017 Dollars

Project ID / Project Name	Construction Cost	Design (10%)	Const (15%)	Cont (15%)	Total Proj. Cost
WELLS					
Well Rehabilitation					
Well 34 Rehab (every 10 years)	$800,000	$80,000	$120,000	$120,000	$1,120,000
Well 37 Rehab (every 10 years)	$800,000	$80,000	$120,000	$120,000	$1,120,000
Well 24 Rehab (every 10 years)	$600,000	$60,000	$90,000	$90,000	$840,000
Well 33 Rehab (every 10 years)	$800,000	$80,000	$120,000	$120,000	$1,120,000
Well 30 Rehab (every 10 years)	$600,000	$60,000	$90,000	$90,000	$840,000
Well 35 Rehab (every 10 years)	$800,000	$80,000	$120,000	$120,000	$1,120,000
Well 18 - Rehab (every 7-10 years)	$300,000	$30,000	$45,000	$45,000	$420,000
Well 18 Rehab (every 7 years)	$300,000	$30,000	$45,000	$45,000	$420,000
Well 16 - Rehab (every 7 years)	$300,000	$30,000	$45,000	$45,000	$420,000
Well 20 Rehab (every 10 years)	$600,000	$60,000	$90,000	$90,000	$840,000
Well 21 Rehab (every 10 years)	$600,000	$60,000	$90,000	$90,000	$840,000
Well 41 Rehab (every 10 years)	$400,000	$40,000	$60,000	$60,000	$560,000
Well 26 - Rehab (every 10 years)	$300,000	$30,000	$45,000	$45,000	$420,000
Well 40 Rehab (every 10 years)	$400,000	$40,000	$60,000	$60,000	$560,000
Well 31 Rehab (every 10 years)	$400,000	$40,000	$60,000	$60,000	$560,000
Well 39 Rehab (every 10 years)	$400,000	$40,000	$60,000	$60,000	$560,000
Well 27 Rehab (every 10 years)	$400,000	$40,000	$60,000	$60,000	$560,000
Well 28 Rehab (every 10 years)	$400,000	$40,000	$60,000	$60,000	$560,000
Well 36 Rehab (every 10 years)	$400,000	$40,000	$60,000	$60,000	$560,000
Well 22 - Rehab (every 10 years)	$300,000	$30,000	$45,000	$45,000	$420,000
Well 29 - Rehab (every 10 years)	$400,000	$40,000	$60,000	$60,000	$560,000
Well 32 - Rehab (every 10/12 years)	$400,000	$40,000	$60,000	$60,000	$560,000
Future Well #1 Rehab (every 10 years)	$400,000	$40,000	$60,000	$60,000	$560,000
Future Well #2 Rehab (every 7 years)	$0	$0	$0	$0	$0
WELL REHAB OPERATION SUMMARY	$11,100,000	$1,110,000	$1,665,000	$1,665,000	$15,540,000
Well R&R/Minor MCC					
Well 36 R&R MCC	$400,000	$40,000	$60,000	$60,000	$560,000
Well 37 R&R MCC	$400,000	$40,000	$60,000	$60,000	$560,000
Well 24 R&R MCC	$400,000	$40,000	$60,000	$60,000	$560,000
Well 33 R&R MCC	$400,000	$40,000	$60,000	$60,000	$560,000
Well 30 R&R MCC	$400,000	$40,000	$60,000	$60,000	$560,000
Well 18 R&R MCC	$400,000	$40,000	$60,000	$60,000	$560,000
Well 38 R&R MCC	$400,000	$40,000	$60,000	$60,000	$560,000
Well 20 R&R MCC	$300,000	$30,000	$45,000	$45,000	$420,000
Well 21 R&R MCC	$400,000	$40,000	$60,000	$60,000	$560,000
Well 40 R&R MCC	$400,000	$40,000	$60,000	$60,000	$560,000
WELL R&R MINOR MCC SUMMARY	$4,000,000	$400,000	$600,000	$600,000	$5,600,000
Well Miscellaneous Work					
Well 38 Site Work	$100,000	$10,000	$15,000	$15,000	$140,000
WELL OPERATION SUMMARY	$15,200,000	$1,520,000	$2,280,000	$2,280,000	$21,280,000
PUMP STATIONS					
Cambridge R&R / PM (20 yrs)	$0	$0	$0	$0	$0
East R&R MCC (15 yrs)	$200,000	$20,000	$30,000	$30,000	$280,000
PUMP STATION CIP Totals	$200,000	$20,000	$30,000	$30,000	$280,000
RESERVOIRS					
Cleaning Inspection (10 yrs) (5 yrs)	$400,000	$40,000	$60,000	$60,000	$560,000
Concrete Reservoir Roofs					
Cambridge Res (every 10 yrs)	$300,000	$30,000	$45,000	$45,000	$420,000
Garlfin Reservoirs (every 10 yrs)	$600,000	$60,000	$90,000	$90,000	$840,000
Cooke Res (every 10 yrs)	$400,000	$40,000	$60,000	$60,000	$560,000
Walnut Res (every 10 yrs)	$400,000	$40,000	$60,000	$60,000	$560,000
South Res (every 10 yrs)	$500,000	$50,000	$75,000	$75,000	$700,000
Reservoir Operation Totals	$2,600,000	$260,000	$390,000	$390,000	$3,640,000
CONNECTIONS AND PRVS					
SX-7 Relocation by Caltrans	$0	$0	$0	$0	$0
Connections/PRVs CIP Totals	$0	$0	$0	$0	$0
MISCELLANEOUS					
Sodium Hypochlorite Replacement	$2,860,000	$280,000	$430,000	$430,000	$4,000,000
Perimeter Chainlink & Reservoirs	$300,000	$30,000	$45,000	$45,000	$420,000
Miscellaneous CIP Totals	$3,160,000	$310,000	$475,000	$475,000	$4,420,000
WATER MAINS					
SR-55 Water Replacement	$0	$0	$0	$0	$0
Water Main CIP Totals	$0	$0	$0	$0	$0
TOTAL OPERATIONS BUDGET	$21,160,000	$2,110,000	$3,175,000	$3,175,000	$29,620,000

APPENDIX A
Water System Computer Modeling
TM#7

TO:	Rudolfo Rosas, P.E., City of Santa Ana
	Tom Epperson, P.E., TetraTech
FROM:	Jason Pierce, P.E., IDModeling, Inc.
	Kevin Trott, P.E., IDModeling, Inc.
CC:	Brian Ige, City of Santa Ana
	Paul Hauffen, IDModeling, Inc.
DATE:	August 21, 2015

1.0   Introduction

IDModeling (IDM) has developed this final technical memorandum to serve as a summary of all the major tasks comprising the Water System Computer Modeling project (Project). This document will serve as an executive summary for results/actions of each prior technical memorandum developed throughout the Project including the model build, demand allocation, diurnal pattern development, steady state and extended period simulation (EPS) calibrations, and subsequent hydraulic analyses performed using the calibrated models.

This TM includes the following sections and attachments:

Section 1 – Introduction
Section 2 – Facilities Overview
Section 3 – System Performance Criteria
Section 4 – Hydraulic Model Development
Section 5 – Demand Development
Section 6 – Hydraulic Model Calibration
Section 7 – Supplemental Hydraulic Analyses

Attachment A – Fire Flow Analysis Results Figure
Attachment B – Criticality Analysis Surface Figure
Attachment C – Water Age Analysis Results Figures

2.0   Facilities Overview

Figure 1 below shows the entire Santa Ana water distribution system as it is represented in the model. The system supplies potable water to two pressure zones (High Zone and Low Zone) and consists of 21 groundwater wells, 10 storage reservoirs, seven booster pump stations, and four pressure reducing valve/pressure sustaining valve (PRV/PSV) stations. In general, the facilities are consolidated into several stations consisting of multiple groundwater wells, a storage reservoir, and a booster pump station. At each station, the wells pump groundwater to the storage reservoirs and the booster pump stations pump from the storage reservoirs to the distribution system. The system also includes several wells that pump directly into the distribution system with no storage reservoir or booster pump station.

There are four PRV stations that allow flows from the High Zone to the Low Zone. Descriptions of all facilities are listed below by zone. Additional information was included in Technical Memorandum #2, *Hydraulic Model Development Best Practices*, prepared for the City and submitted by IDModeling in May 2014.

2.1   Low Zone Facilities

Walnut Station – The Walnut Station consists of a 7 MG storage reservoir fed by three groundwater wells (Well 16, Well 29, and Well 33) and a booster pump station that supplies the distribution system from the storage reservoir. The booster pump station includes five pumps with a firm capacity of approximately 11,500 gpm. Two pumps are operated with variable frequency drives (VFD) that are controlled by pressure on the discharge header pipe. Walnut Station operates in parallel with other major facilities including the John Garthe Station and Low Zone Well 41. Modeling showed these facilities to be extremely sensitive to very slight changes in the discharge pressure setpoints. A slight change at one facility could significantly impact the flow balance of other major facilities.

John Garthe Station – The John Garthe Station includes three storage reservoirs with a total storage of 15.8 MG fed by four groundwater wells (Well 18, Well 24, Well 36, and Well 39) and a booster pump station that supplies the distribution system from the storage reservoirs. The booster pump station includes five pumps with a firm capacity of 14,800 gpm. Two pumps are operated with VFDs that are controlled by pressure on the discharge header pipe. The John Garthe Station operates in parallel with other major facilities including the Walnut Station and Low Zone Well 41. As with Walnut Station, modeling showed these facilities to be extremely sensitive to very slight changes in the discharge pressure setpoints. A slight change at one facility could significantly impact the flow balance of other major facilities.

East Station – The East Station consists of a 6 MG storage reservoir fed by one groundwater well (Well 26) and a booster pump station that supplies the distribution system from the storage reservoir. During the EPS calibration periods, Well 26 was out of service and the tank was filled from the distribution system. The booster pump station includes two pumps with a firm capacity of 2,300 gpm. All pumps are constant speed which turn on and off based on the pressure of the discharge header pipe.

Legend

- ⌣ Pressure Reducing Station
- ! Pumping Facility
- ⊔ Reservoir

Pressure Zone

- High Zone
- Low Zone
- — Water Main

Well 32
Well 28
Well 27
Well 22 Well 38
Crooke Station Cambridge Station
Well 24
Well 39
Well 36
Well 18
John Garthe Station
Well 35
Elevated Tank
Well 40
Well 41 Well 16
Well 21
Well 20
Well 30 West Station
Well 29 Well 33
Walnut Station
Well 31
Well 37
East Station
Well 26
South Station
Well 34

City of Santa Ana
Model Calibration

Figure 1
Overall System Map

1 inch = 3,500 feet

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West Station – The West Station consists of a 6 MG storage reservoir fed by three groundwater wells (Well 20, Well 21, and Well 30) and a booster pump station that supplies the distribution system from the storage reservoir. The booster pump station includes five pumps with a firm capacity of 10,500 gpm. Two pumps are operated with VFDs that are controlled by pressure on the discharge header pipe.

South Station – The South Station consists of a 6 MG storage reservoir fed by one groundwater well (Well 34) and a booster pump station that supplies the distribution system from the storage reservoir. The booster pump station includes two pumps with a firm capacity of 2,000 gpm. All pumps are operated with VFDs that are controlled by pressure on the discharge header pipe.

Elevated Tank – There is one 1.0 MG elevated storage tank located within the Low Zone. This tank helps maintain a consistent pressure range throughout the zone and is fed primarily by Well 41, John Garthe Station, and Walnut Station.

Low Zone Wells – There are four wells in the Low Zone: Well 31, Well 35, Well 37, and Well 41. Well 31 was not active during the EPS calibration periods. The remaining wells utilize VFDs to control the discharge pressure into the system. The Low Zone wells operate in parallel with other major facilities including the Walnut and John Garthe Stations. Modeling showed these facilities to be extremely sensitive to very slight changes in the discharge pressure setpoints; with Well 41 being the most sensitive of all the Low Zone wells. A slight change at one facility would significantly impact the flow balance of other major facilities.

Low Zone Metropolitan Water District (MWD) Connections – The MWD connections include six connections with flow control valves that allow water to pass from the MWD into the Low Zone.

2.2   High Zone Facilities

Crooke Station – Crooke Station consists of a 6 MG storage reservoir fed by one groundwater well (Well 27) and a booster pump station that supplies the distribution system from the storage reservoir. The booster pump station includes three pumps with a firm capacity of 3,300 gpm. All booster pumps are constant speed that turn on and off based on the pressure of the discharge header pipe. In addition, Well 28 is located at Cambridge Station and consists of one 2,500 gpm capacity VFD pump. The pump feeds directly into the High Zone.

Cambridge Station – Cambridge Station consists of a 1.3 MG storage reservoir fed from the distribution system and a booster pump station that supplies the distribution system from the storage reservoir. The booster pump station includes three pumps with a firm capacity of 5,400 gpm. All pumps are constant speed that turn on and off based on the pressure of the discharge header pipe. In addition, Well 38 is located at Cambridge Station and consists of one 2,500 gpm capacity VFD pump. This well feeds directly into the High Zone.

Well 40 – Well 40 contains one constant speed pump with a capacity of 2,575 gpm that discharges directly to the distribution system.

Zone Interconnections – There are four PRV/PSV stations that allow water to flow from the High and Low Zones and reduce the pressure to acceptable levels in the Low Zone. These valve stations are primarily used for relieving pressure spikes from the High Zone and can be manually controlled by operations staff.

High Zone Metropolitan Water District (MWD) Connection – There is one MWD connection with a flow control valve that allows water to pass from the MWD into the High Zone of the Santa Ana system.

3.0 System Performance Criteria

Water system performance criteria represent design and operating guidelines for a distribution system. Performance criteria are often referred to as "design criteria" within water and wastewater utility Master Plan documents. These criteria identify critical conditions that are desired to be met for the system. They include operating criteria such as maximum and minimum system pressures and maximum pipeline headloss and velocity, as well as key conditions for pump and tank operation.

The established performance criteria were grouped into the following categories:

- Storage Reservoirs
- System Pressures
- Pipelines
- Pump Stations/Wells/Turnouts
- Time Of Use Criteria
- Fire Flow Operations

Table 1 below details the performance criteria recommended by IDM and agreed upon by the Project team.

Figure 2 below identifies the Time of Use requirements for pumps in the water system. This document lists which pumps are on specific Time of Use energy rates and what times/days are associated with these rates.

Table 1 - Performance Criteria

	City Criteria	Source	Recommended Performance Criteria
Storage Reservoirs			
Total Storage			Volume = Operational + Emergency + Fire Flow Example1: 25%*MDD+15%*MDD+FF Example2: 30%*ADD+100%*ADD+FF
Emergency Storage Credit		Check AWWA, DWR regulations	Credit given to wells with backup power to Emergency Storage
Fire Flow Storage		AWWA M32 Manual of Water Supply Practices	Fire flow storage per zone equals the highest required fire flow per zone at its necessary designation. For example 5,000 gpm for 5 hours is 1.5 MG of fire storage required
Minimum Storage Level			Recommend minimum tank levels be based on fire storage plus some emergency storage.
Water Age			Water age requirement of 160 hours within the reservoirs
Storage Turnover Criteria			Tanks should turnover at least once per week
System Pressure			
Normal Operation; Minimum Pressure Criteria Normal Operation; Maximum Pressure Criteria	Minimum 40 psi during peak hour normal operation for each customer Maximum 100 psi	California Law Section 64602	Maintain 40 psi minimum normal operating pressure at customer locations Goal is to maintain customer operations within 40-100 psi
Pipelines			
Normal Operation: Velocity Criteria		AWWA M32 Manual of Water Supply Practices	**Allowable Velocity Normal Operation:** Maintain velocities in peak demands under 5 ft/s
Normal Operation: Headloss Criteria		AWWA M32 Manual of Water Supply Practices	**Allowable Headloss per 1000 ft** Transmission piping (16 inch or greater) - 3 ft of headloss per 1000 ft Distribution piping (less than 16 inch) - 10 ft headloss per 1000 ft
Pump Stations/Wells/ Turnouts			
Firm Capacity			Assume the largest pump at a facility is out of service
Well Operation: Allowable Percentage for Groundwater Production			70% groundwater - 30% water imported from MWD
Time Of Use Requirements			
Well and Boosters on TOU	**Mid-Peak Rate:** 8 am-Noon - Weekdays except holidays **On-Peak Rate:** Noon-6 pm - Weekdays except holidays **Mid-Peak Rate:** 6 pm-11 pm - Weekdays except holidays **Off-Peak Rate:** 11 pm-8 am - Weekdays and all day on weekends including holidays	Rate Schedule TOU Scan Document	**Mid-Peak Rate:** 8 am-Noon - Weekdays except holidays **On-Peak Rate:** Noon-6 pm - Weekdays except holidays **Mid-Peak Rate:** 6 pm-11 pm - Weekdays except holidays **Off-Peak Rate:** 11 pm-8 am - Weekdays and all day on weekends including holidays
Fire Flow Operations			
Fire Flow: Flow Requirements			Assign fireflow requirements based on land use example: 1,500 gpm for residential
Fire Flow: Minimum Pressure	Minimum 25 psi	Section 64602 of California law requires customers have at least 20 psi at all times. Orange County Fire Marshal	Maintain 20 psi at all customer locations during a fire event Maintain 25 psi? at the fireflow location
Fire Flow: Maximum Pipe Velocity			Maximum Goal Velocity - No more than 10 ft/s. These pipes generally cause most of the headloss during a fire event.
Fire Flow: Model Boundary Conditions			Assume Tanks at Minimum Levels Assume Max Day Demand Assume a conservative turnout and pumps (well and booster) operation

SCE - RATE SCHEDULE TOU - TIMES AND APPLICATIONS

SUMMER SEASON : Starts at 12:00 am on June 1, and continues until 12:00 a.m. on October 1.

Monday   Tuesday   Wednesday   Thursday   Friday   Saturday   Sunday

Mid-Peak Energy Rate: 8 a.m. - Noon, weekdays except holidays*
On-Peak Energy Rate: Noon - 6 p.m. weekdays except holidays*
Mid-Peak Energy Rate: 6 p.m. - 11 p.m. weekdays except holidays*
Off-Peak Energy Rate: 11 p.m. - 8 a.m weekdays and all day on weekends, including holidays

8:00 a.m. → 12:00 noon
12:00 noon → 6:00 p.m
6:00 p.m. → 11:00 p.m
11: p.m.   8:00 a.m.

CROOKE	MID-PEAK	ON-PEAK	OFF-PEAK
Well 27	Off	Off	ON
Booster 1	Off	Off	ON
Booster 2	Off	Off	ON
Booster 3	Off	Off	ON
Well 28	ON	ON	ON
CAMBRIDGE			
Booster 1	Off	Off	ON
Booster 2	Off	Off	ON
Booster 3	Off	Off	ON
Well 38	ON	ON	ON
Well 40	Off	Off	ON
EAST			
Booster Stage 1	ON	Off	ON
Booster Stage 2	Off	Off	ON
Well 26	Off	Off	ON
SOUTH			
Booster Stage 1	ON	ON	ON
Booster Stage 2	Off	Off	ON
Well 34	Off	Off	ON

WALNUT	MID-PEAK	ON-PEAK	OFF-PEAK
Well Stage 1	ON	Off	ON
Well Stage 2	Off	Off	ON
Well Stage 3	Off	Off	ON
Boosters	VFD+200HP+150HP On	VFD+200HP On	ALL ON
WEST			
Well Stage 1	ON	Off	ON
Well Stage 2	Off	Off	ON
Well Stage 3	Off	Off	ON
Boosters	VFD+200HP+150HP On	VFD+200HP On	ALL ON
GARTHE			
Well Stage 1	ON	Off	ON
Well Stage 2	Off	Off	ON
Well 18	Off	Off	ON
Boosters	ALL ON	VFD+200HP+150HP On	ALL ON
		(if Hydro off go to VFD + 200 HP)	

Figure 2 – Time of Use Rate Schedule

4.0   Hydraulic Model Development

Technical Memorandum #2: Hydraulic Model Development Best Practices was developed to outline the industry best practices for developing the City's potable water model. This included all aspects of model creation from the initial model construction and QA/QC to the determination of appropriate hydraulic parameters. The model development procedures and assumptions are detailed below.

4.1   Overview

The City of Santa Ana potable water model was developed using the current ArcGIS pipeline and facility database. Creating a model from GIS involved several steps including developing model pump stations and storage facilities, creating distribution system piping and point elements from the GIS database, and checking the connectivity of the model elements once the elements were imported.

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4.2   Model Elements

Table 2 below provides a list of model element types and feature classes used to create elements within the model. The key elements in the GIS are associated with mainline pipes and the point elements at mainline pipe endpoints. The piping was created from the transmission main feature class. Hydrant laterals were imported into the model to connect the hydrants to the mains.

For connectivity purposes, all pipes must have a node at either end in a hydraulic model to function properly. Model node type elements are point features that include junctions, hydrants, valves, pumps, or tanks which are connected to pipe endpoints. Three feature classes were used to create the nodes: Control Valve, System Valve, and Water Net Junctions. The key translation of the GIS point elements in these feature classes into hydraulic model elements is shown in **Table 2** below. Nodes that were found to not be associated with model pipe endpoints were not required for model connectivity and removed from the model. Examples of these unnecessary node elements include many of the Water Net Junction point features associated with customer meters. In addition, nodes were created manually at facility locations, as necessary.

4.2.1   Facility Import from GIS

Using the City's GIS data, the following model facilities were imported into the hydraulic model and connectivity checks performed:

- Junction Elements - The following feature classes provided by the City were used to create the model junctions: Control Valve, System Valve, and WaterDistributionSystem_Net_Junctions.

- Hydrant Elements - The City's hydrant feature class was used to create hydrants within the model.

- Pipe Elements - For the creation of the distribution system pipelines, the WaterMain feature class was utilized. Fire hydrant laterals from the WaterService feature class were included as model pipes.

- Valve Elements - Elements modeled as valves included flow control valves (FCVs), pressure reducing valves (PRVs), altitude valves, and normally closed valves.

- Pipe C-Factor Assignments - All model pipes require the assignment of a roughness factor. The most common type of roughness factor is the Hazen Williams C-factor which is recommended for use in this model. C-factors are most commonly assigned to model pipes based upon pipe material and pipe age, if known. **Table 3** below presents the initial pipeline C-factors that were assigned to each model pipe using standard industry values based upon material. Pipeline C-factors were verified and adjusted during the calibration process based on the outcome of the hydrant testing performed as part of the steady state calibration effort (steady state calibration is discussed in Section 5).

Table 2 – GIS to Model Sorting and Element Naming Conventions

Model Type	Types of Facilities	Model Symbol	Identification Format	Identification Example
Junction	Control Valves		J-CV-[#]	J-CV-1
	System Valves		J-[AssemblyType]-[#]	J-GV-1
	Fittings		J-[#]	J-1
	Facility Junction		J-[Facility ID]-[Location]	J-WP-36-DS
Hydrant	Hydrants		HYD-[#]	HYD-1
Pipeline	Transmission Mains		P-[#]	P-1
	Facility Piping		P-[Facility ID]-[Location]	P-WP-36-US
	Hydrant Laterals		LAT-[#]	LAT-1
Reservoirs	MWD Connections		SA-[#]	MWD-SA-1
	Wells		W-[#]	W-36
Tank	Tanks		T-[Facility]	T-JGT
Pumps	Booster Pumps		BP-[Facility]-[Pump #]	JGT-BP-1
	Well Pumps		WP-[Station #]	WP-36
FCV	MWD Connections		FCV-[MWD Connection ID]	FCV-SA-1
PRV	PRV Stations		PRV-[#]	PRV-14
GPV	Closed Valves		GPV-[#]	GPV-1
	Altitude Valves		Alt-[Facility]	Alt-ELV

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Table 3 – Initial Pipeline C-factors

Type	Description	Length (ft)	Length (miles)	Percent of System	Initial C-factor
AC	Asbestos Cement	974,830	184.63	35.2	120
CI	Cast Iron (unlined)	1,029,920	195.06	37.2	90-110 [1]
CMLC	Concrete Mortar Lined	51,810	9.81	1.9	120
CU	Copper	490	0.09	0.0	120
CYL	Concrete Cylinder	136,180	25.79	4.9	120
DI	Ductile Iron	161,880	30.66	5.8	120
PE	Polyethylene	90	0.02	0.0	130
PVC	Polyvinyl Chloride	325,420	61.63	11.7	130
STL	Steel (unlined)	11,790	2.23	0.4	90-110 [1]
UNK	Unknown	78,290	14.83	2.8	120
WI	Wrought Iron	10	0.00	0.0	100
Total	--	2,770,710 [2]	524.76	100.0	120

1. Initial C-factors for cast iron and steel pipe were assigned based on installation date and size. For example, 4-inch pre-1960 cast iron was assigned a value of 90 and 12-inch pre-1960 cast iron was assigned a value of 110.

2. Pipe length includes hydrant laterals. Without hydrant laterals included the total pipe length is approximately 2,376,000 feet (450 miles).

4.3   Facility Creation

Facilities such as pump stations, tanks, wells, PRVs, and MWD connections were not well defined in the GIS database and were developed manually within the model. All facilities were modeled based on the as-built drawings and schematics provided by the City to create a schematic type representation of the facility.

4.3.1   Tanks

The City has seven locations with ground level storage tanks and one elevated storage tank. The following hydraulic information was required to be input into the model for each storage facility: Bottom Elevation, Maximum Level, Initial Level, and Diameter (or Volume Curve). **Table 4** below presents the storage tanks and hydraulic data added to the model using data gathered from as-built drawings, schematics, and/or discussions with City staff. The storage reservoirs at the John Garthe site were combined to form one reservoir with an equivalent diameter to represent the total storage volume. This process simplified model calculations while preserving the total available storage volume.

Table 4 – Storage Tank Facilities

Storage Tank	Location	Capacity (MG)	Number of Tanks	Zone	Bottom Elevation (ft)	Diameter (ft)	Height (ft)
Cambridge	2736 N. Cambridge St. Santa Ana, CA	1.3	1	High	188.8	Variable Area	17.2
Crooke	730 E. Memory Ln. Santa Ana, CA	6	1	High	157.62	Variable Area	21
East	1730 S. Santa Fe, Santa Ana, CA	6	1	Low	76.2	180	31.5
Elevated Tank	14th/Poinsettia, Santa Ana, CA	1.0	1	Low	City to provide	60	131 total height (60 ft tank height
John Garthe	2401 N Bristol St., Santa Ana, CA	15.8	3	Low	100	277	35
South	1727 W. Alton Ave., Santa Ana, CA	6	1	Low	35.7	219	22
Walnut	723 W. Walnut St. Santa Ana, CA	7	1	Low	79.8	Variable Area	22
West	4426 W. 1st St., Santa Ana, CA	6	1	Low	66.9	180	32

4.3.2   Pump Creation

- Well Pumps - The system has 21 groundwater wells providing water to the system. **Table 5** provides a summary of the groundwater wells to be included in the model. Wells were input into the model by creating a reservoir to represent the groundwater table and a pump to discharge the water to either the system or a ground level storage tank. Initial groundwater water surface elevations were input into the model based on an average of nine months of groundwater depth data while the pumps were operating.

- Booster Pumps - The system has 26 booster pumps located at seven stations. **Table 6** below provides a summary of the booster pumps within the system included in the model.

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Table 5 – Groundwater Well Summary

Well Number	Location	Power (HP)	Static Depth (ft)	Pumping Depth (ft)	Capacity (MGD)	Design Head (ft)	Design Capacity (gpm)
16	1011 W. 6th St	150	83	108	2.16	228	2,000
18	2401 N. Bristol St	150	0	0	3.29	212	2,000
20	4426 W. 1st St	150	92	115	4.35	161	3,000
21	4426 W. 1st St	150	93	113	4.16	160	3,000
24	1800 W. 22nd St	150	127	203	1.85	279	1,800
26	1730 S. Santa Fe	125	127	0	3.00	246	2,500
27	730 E. Memory Ln	300	189	298	3.97	370	2,500
28	730 E. Memory Ln	350	180	264	3.62	400	2,500
29	S/E First St. and Flower St	200	152	218	3.65	246	2,500
30	4426 W. 1st St	150	91	118	4.35	165	3,000
31	1815 E. Chestnut St	350	177	246	3.98	408	3,000
32	2801 N. Westwood	300	126	0	3.22	315 [1]	2,775 [1]
33	917 W. Walnut St	250	148	227	4.10	280	2,800
34	1727 W. Alton Ave	125	115	194	2.18	425	2,500
35	1718 N. Sydney Pl	350	130	165	3.17	305	3,000
36	2415 N Bristol St	250	155	194	5.18	210	3,600
37	2007 W. McFadden	350	119	137	3.31	330	3,000
38	2736 N. Cambridge St	350	221	322	2.16	425	2,500
39	2315 N. Bristol St	250	153	194	4.32	250	3,000
40	1301 North Mabury St	400	192	278	3.71 [1]	200 [1]	2,575 [1]
41	907 3/4 N Flower St	450	155	201	4.32 [1]	350	3,000

1. Values estimated based on information provided by City.

Table 6 – Booster Pump Summary

Station	Location	Pump Number	Motor Type	Power (HP)	Average Capacity (gpm)	Average Capacity (MGD)	Design Head (ft)	Design Capacity (gpm)
Cambridge	2736 N. Cambridge St. Santa Ana, CA	1	Electric	75	1,481	2.13	150	1650
		2	Electric	75	1,436	2.07	150	1650
		3	Electric	75	1,526	2.2	150	1650
Crooke	730 E. Memory Ln. Santa Ana, CA	1	Electric	150	2,783	4.01	185	2700
		2	Electric	150	2,693	3.88	185	2700
		3	Electric	150	2,738	3.94	185	2700
East	1730 S. Santa Fe, Santa Ana, CA	1	Electric	125	2,648	3.81	175	2300
		2	Electric	125	2,603	3.75	175	2300
John Garthe	2401 N Bristol St., Santa Ana, CA	1	Electric	150	2,693	3.88	180	1760
		2	Electric	150	3,097	4.46	183	2590
		3	Electric	150	3,007	4.33	183	2590
		4	Electric	200	4,264	6.14	183	3560
		5	Electric	200	3,590	5.17	183	4270
		6	Gas	250	4,982	7.17	ND [1]	ND [1]
South	1727 W. Alton Ave, Santa Ana, CA	1	Electric	125	2,244	3.23	212	2000
		2	Electric	125	2,244	3.23	212	2000
Walnut	4426 W. 1st St., Santa Ana, CA	1	Electric	200	3,501	5.04	ND [1]	ND [1]
		2	Electric	200	3,501	5.04	200	3100
		3	Electric	200	3,456	4.98	200	2150
		4	Electric	150	2,738	3.94	200	1400
		5	Electric	100	1,750	2.52	ND [1]	ND [1]
West	4426 W. 1st St., Santa Ana, CA	1	Electric	200	2,513	3.62	170	2800
		2	Electric	200	2,289	3.3	170	2800
		3	Electric	200	2,289	3.3	170	2800
		4	Electric	150	4,488	6.46	176	3700
		5	Electric	100	2,020	2.91	170	2100

1. No data provided for pump design point.

4.4 Pump Curves

Pump curves were developed for each pump from manufacturer's performance curves provided by the City. Many of the pumps had Southern California Edison pump efficiency test data available that were used to verify the pump curves. This information provided the basis for adjusting the pump curves, as necessary, to correlate to field conditions and account for pump wear. Adjustments to the pump curves were made assuming that the curve follows the pump affinity laws for changes based on pump speed or reduction in the impeller diameter. It is assumed that if the pump is found to be performing below the original pump curve that the loss in performance is essentially related to impeller wear. This allows for the curve to maintain a resemblance to its original shape for adjustment.

Pump curve data was input into the model and a curve developed for each individual pump. **Figure 3** shows an example of an adjusted pump curve based on pump efficiency test data.
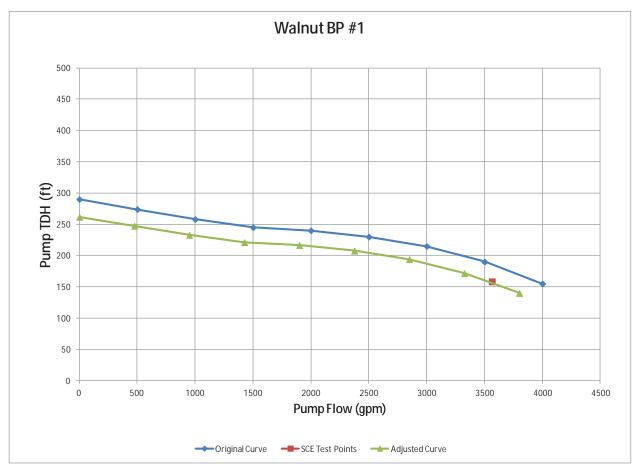
Figure 3 – Pump Curve Adjustment Example

4.5 Pressure Reducing Valves

The City has four PRV stations between the high and low pressure zones. **Table 7** presents the PRVs modeled. All stations have multiple PRVs, however, for the purposes of developing the model only the largest PRV will be modeled using the highest pressure setting of all valves within the vault. This will avoid

unnecessary complexity within the model while maintaining accurate flows between the high and low zones under varying demand and fire flow conditions.

Table 7 – Pressure Reducing Valve Stations

PRVs	Location	Zone	Number of Valves	Valve Sizes	Setpoints
1	Memory Lane	From high to low zone	2	10 inch and 6 inch	6 inch at 92 psi, 10 inch at 94 psi
2	17th Street	From high to low zone	2	10 inch and 8 inch	8 inch 89 psi, 10 inch 91 psi
3	Grand Street	From high to low zone	2	10 inch and 8 inch	8 inch at 90 psi and 10 inch at 92 psi
4	Fire Station 2	From high to low zone	2	10 inch and 8 inch	8 inch at 94 psi and 10 inch at 96 psi

4.6   Metropolitan Water District Interconnects

The City has seven MWD connections as represented in **Table 8**. The connections are typically controlled based on a specified rate of flow. The MWD connections were modeled using a flow control valve with flow settings as indicated by the City.

Table 8 – Metropolitan Water District Connections

MWD Connection [1]	Name	Location	Normal Operating Capacity (MGD)	Design Capacity (MGD)	Number of Valves	Valve Type
SA-1	Bristol	2315 N. Bristol St. Santa Ana, CA	5.17	6.46	2	FCV
SA-2	First	Bristol St. & First St. Santa Ana, CA	5.17	9.69	1	FCV
SA-3	McFadden	1300 W. Mc Fadden Santa Ana, CA	5.17	6.46	1	FCV
SA-4	Warner	1299 W. Warner Ave, Santa Ana, CA	4.85	6.46	1	FCV
SA-5	Alton	Bristol St. & Alton Ave. Santa Ana, CA	4.85	12.93	1	Out of Service
SA-6	Santa Clara	2301 N. Tustin Ave. Santa Ana, CA	7.76	12.93	3	FCV
SA-7	Red Hill	2215 Ritchey St., Santa Ana, CA	4.85	32.31	2	FCV

1. If system pressures are reduced to 45 psi under emergency conditions the MWD connection will supply the City's system with additional flow to mitigate any low pressure issues.

5.0   Demand Development

Technical Memorandum #3: Demand Development was developed to outline the process for allocation of system-wide demands, development of diurnal patterns suitable for use in calibrating the hydraulic model, and identification of the preferred calibration periods for both average and maximum day demand scenarios. Also included was a discussion of the methodology for developing average day, maximum day, and peak hour demands, identification of the top 15 large users, and estimating non-revenue water.

5.1   Demand Allocation

Model demands were developed and allocated based upon individual account consumption data provided by the City for the period between July 2012 and June 2013. This consumption data was spatially allocated to the newly developed hydraulic model junctions using GIS meter point data and WaterGEMS model functionality. The top 15 usage accounts and their locations within the distribution system were verified to ensure that the largest system demands were allocated to the correct model junctions.

Demand data was processed for each customer account to determine the individual and system-wide average day demand using the 12 consecutive months of usage data provided by the City. The usage data contained the customer meter identification, address, and bi-monthly meter readings. The bi-monthly meter reads were averaged for the July 2012 to June 2013 time period to create an average day demand (ADD) for each metered account. The individual demands were allocated to model junctions by first using GIS software to allocate the individual customer ADD to the service meter feature class points. Demands were then assigned to the model node closest to the actual meter point for each account. This was performed using the LoadBuilder function within the WaterGEMS modeling software and ensured the most accurate distribution of demands across the system.

Upon spatially allocating the base demands to model junctions, a global multiplier was applied to match system-wide average daily production for the July 2012 to June 2013 time period. The global multiplier was developed based on the ratio of average daily production to average metered demand (ADP/AMD). This ensured that non-revenue water due to hydrant flushing, pipe breaks, meter inaccuracies, etc. was accounted for while still maintaining the spatial allocation of demands throughout the model.

5.2   Top 15 Water Users

A list of the City's top 15 water users was provided by the City and confirmed from usage data. **Table 9** presents the top 15 water usage accounts. IDM attempted to contact each customer in order to gain a better understanding of the daily usage in an attempt to develop a specific diurnal pattern for each location. Of the customers IDM was able to reach many customers did not have a good sense of water usage and even if they had some sense of how water was used, they could not provide a very quantitative description of the water use. In addition, when water usage was known, it was clearly noted by the customer that the usage varies on a day-to-day basis such that it would be difficult to identify a "typical" 24 to 48 hour usage pattern.   Below is a brief summary of the common issues found based on conversations with the top 15 water usage customers:

- Industrial users
    - Process generally changes every day. No two days are ever exactly alike

- o Users did not closely monitor water usage with meter or telemetry charts
- Apartments
  - o Apartments were individually metered, therefore had a high total usage for the development
  - o All customers reported common area water usage was dwarfed by domestic usage within apartments (only 10-15% of water usage was for common areas)
- Public buildings
  - o Could not identify a single contact for government buildings and jail units (5 of the 6 customers in this category). No good contact numbers were identified and it was difficult to identify one person knowledgeable of the actual water use

Based on the analysis of the top 15 water usage customers, the development of diurnal patterns would not be any more accurate than utilizing the zone based patterns created for the extended period simulation (EPS) calibration effort. If diurnal patterns are desired for the top 15 water usage customers it is recommended that continuous flow monitoring be conducted at each meter so that patterns can be created from actual usage data.

Table 9 – Top 15 Water Users

Rank Order	Premise Address	Customer Number	Customer Name	Classification	Usage (CCF/yr)	Usage (gpm)
1	3201 S SUSAN ST	003-5439.300	CHROMA SYSTEMS	INDUSTRIAL	116,095	165.2
2	4002 W WESTMINSTER AVE	003-9928.300	ADOHR FARMS INC	WHOLESALE FOOD	101,433	144.4
3	2645 S CRODDY WAY	003-5787.30	POWER CIRCUITS INC	INDUSTRIAL	77,419	110.2
4	801 5 FAIRVIEW ST	002-7700.300	FAIRVIEW VILLAS	APARTMENTS	73,707	104.9
5	550 N FLOWER ST	004-0700.300	COUNTY OF ORANGE	GOVERNMENT	59,688	84.9
6	1601 W MACARTHUR BLVD	003-4932.30	FAR WEST MANAGEMENT CORP	APARTMENTS	56,099	79.8
7	710 S LYON ST	001-1387.30	WARWICK SQUARE ASSOC INC	APARTMENTS	55,381	78.8
8	550 N FLOWER ST	004-0699.300	COUNTY OF ORANGE	GOVERNMENT	47,941	68.2
9	601 W 1ST ST	002-8479.300	TOWN SQUARE OWNERS	APARTMENTS	47,140	67.1

Rank Order	Premise Address	Customer Number	Customer Name	Classification	Usage (CCF/yr)	Usage (gpm)
10	3000 W EDINGER AVE	003-7273.300	CENTENNIAL PARK	CITY PARK	43,429	61.8
11	551 N FLOWER ST	004-0702.300	COUNTY OF ORANGE	GOVERNMENT	43,232	61.5
12	511 N FLOWER ST	004-0696.300	COUNTY OF ORANGE	GOVERNMENT	42,531	60.5
13	3700 S PLAZA DR	003-4964.30	ON THE LK VERSAILLES	APARTMENTS	39,631	56.4
14	1040 W MACARTHUR BLVD	003-3906.300	MAC ARTHUR VILLAGE	APARTMENTS	38,109	54.2
15	60 CIVIC CENTER PLZ	004-0902.300	CITY OF SANTA ANA POLICE STA	CITY OWNED PROPERTY	36,463	51.9

5.3   Diurnal Pattern Creation

Diurnal patterns were created for both maximum day demand (MDD) and average day demand (ADD) conditions for each pressure zone using SCADA data collected during each calibration period.

5.3.1   Maximum Day Demand Patterns

The calculated MDD diurnal patterns for July 28-29, 2014 are shown below in **Figure 4**. This 48-hour period was selected as representative of the repeatable pattern observed during MDD conditions. This diurnal pattern was developed by using a mass balance calculation of flows in and out of each zone for every 15-minute increment of data provided to calculate the total water used in each 15-minute period. The demand data was normalized by dividing each hourly usage by the average usage of the entire calibration period. The diurnal pattern for the Low Zone is markedly different from the diurnal pattern for the High Zone and verifies IDM's recommendations to use different patterns for each pressure zone.
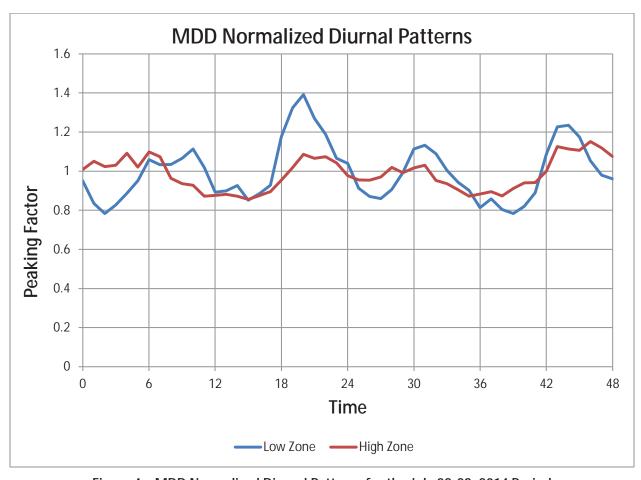
Figure 4 – MDD Normalized Diurnal Patterns for the July 28-29, 2014 Period

5.3.2 Average Day Demand Patterns

The calculated ADD diurnal pattern for May 6-7, 2014 is shown in **Figure 5** below. This 48-hour period was selected as representative of the repeatable pattern observed during ADD conditions. This diurnal pattern was developed by using a mass balance calculation of flows in and out of each zone in 15-minute increments to determine the total water demanded over each 15-minute period. The demand data was normalized by dividing each hourly usage by the average usage over the calibration period. The patterns shown in **Figure 5** indicate that the diurnal pattern for the Low Zone is quite different from the pattern for the High Zone and verifies IDM's recommendations to use a specific pattern for each pressure zone as this will improve the accuracy and reliability of the calibrated model.
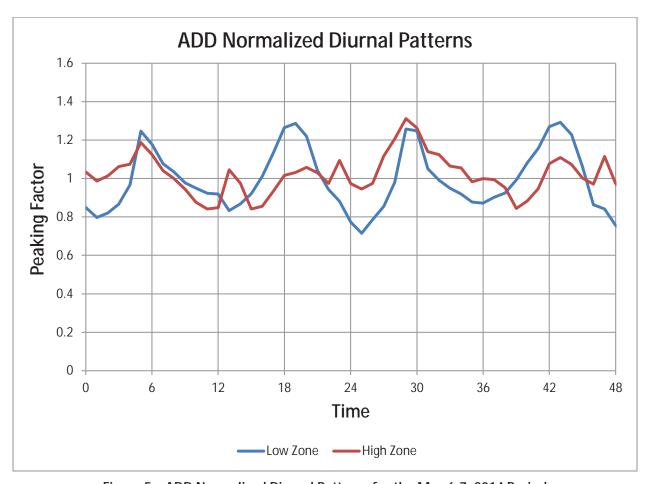
Figure 5 – ADD Normalized Diurnal Patterns for the May 6-7, 2014 Period

5.4   Peaking Factors

Maximum day and peak hour demands are calculated using the average day demand previously input into the model and a peaking factor. The MDD and PHD peaking factors were developed using production data and hourly SCADA data as provided by the City. The MDD and PHD peaking factors were globally applied to all base demands within the model to develop the MDD and PHD alternatives.

The peaking factors were calculated as follows:

- The MDD peaking factor, which is the ratio of maximum day production to average daily production (MDP/ADP), was determined to be 1.32.

- The PHD peaking factor, which is the ratio of peak hour production to average daily production (PHP/ADP), was determined to be 1.94

5.5   Fire Flow Requirements

With input from City staff, IDM developed fire flow requirements for specific land use categories including residential, commercial, and industrial land uses.   These fire flow requirements will be used for subsequent fire flow capacity analyses and assist in developing the City's pipeline replacement program. **Table 10** below shows typical fire flow requirements for various land use categories.   Fire flow requirements can vary based upon several factors including building construction type, square footage, installed sprinkler systems, etc.

Table 10 – Sample Fire Flow Requirements Based on Land Use

Land Use	Fire Flow Requirement (gpm)	Flow Duration (hours)	Total Volume (gallons)
Residential	1,500	2	180,000
Commercial	3,000	3	540,000
Industrial	4,750	4	1,140,000

5.6   Non-Revenue Water

Non-revenue water is water that has been produced and is "lost" before it reaches the customer. Losses can be real losses (through leaks or flushing events) or apparent losses (through theft or metering inaccuracies). Non-revenue water is typically measured as the volume of water "lost" as a percent of net water produced. Quantifying this volume will assist the City in determining the magnitude of non-revenue water due to hydrant flushing, pipe breaks, meter inaccuracies, theft, and system leakage.

Based on production and usage data provided by the City for July 2012 to June 2013 time period, non-revenue water was quantified and compared to the City's calculations. The total volume of non-revenue water over this period was estimated to be 704.3 million gallons, or roughly 5.5% of total water produced.

6.0   Hydraulic Model Calibration

Technical Memorandum #5: EPS Calibration Plan and *Technical Memorandum #6: Model Calibration Results* were developed to outline the processes and results of the hydraulic model calibration effort. The steady state (SS) and EPS model calibration efforts were undertaken to ensure the model results reflected actual conditions with a high level of confidence under varying operational scenarios. The SS calibration effort relied upon field pressure and fire flow test data collected at 13 locations throughout the distribution system.

The EPS calibration was performed under average day and maximum day demand conditions and relied upon SCADA information collected for each demand period. The sections below describe the calibration efforts, the facility data used to perform the calibration comparisons, and the results of each calibration effort.

6.1   Calibration Criteria

The calibration effort included both SS and EPS model scenarios. The criteria used to determine if the model was adequately calibrated are listed below for each type of calibration.

- Steady-State Calibration – The goal of the steady-state calibration was for modeled pressures to match field pressures within 5 psi at 90 percent of the test locations. The primary calibration targets for SS calibration were pressure values (static pressures and residual pressures) and the pressure drop between static and flowing hydrants.

- Extended Period Calibration – Extended period calibration included comparing modeled results to SCADA data for storage reservoir levels, flows, and pressures at various locations throughout the system. The goal was for modeled data to be within the tolerances listed below:

    o Storage Reservoir Levels – Within 3 feet of SCADA data and same trending

    o Flows – Within 15 percent of SCADA data at pump stations, PRVs, and reservoir inflows/outflows

    o Pressures – Within 10 percent of SCADA data at pump stations, PRVs, and Inter-Agency connections

Model calibration was considered achieved when the difference between model output and field data were within the tolerances listed above. In the event that these tolerances could not be met, an explanation was provided justifying why calibration could not be achieved

6.2   Calibration Procedures

The following procedures were followed to calibrate the models under steady state and EPS conditions.

6.2.1   Model Controls and Setpoints

Controls were added to booster pump stations, groundwater wells, and PRV stations based on information provided by the City and interviews with City operations staff. Controls allow the user to modify the status of model elements (pipes, pumps, valves) during the hydraulic simulation, depending on the state of another element in the system, such as a tank level. The controls include setpoints for boundary conditions such as reservoir levels, well water levels, and pump discharge pressures. All setpoints were initially adjusted to match SCADA data. During the calibration process, some of these setpoints were adjusted further to achieve results that were within calibration tolerances.

6.2.2   Steady-State Calibration

A steady-state calibration was completed first and included comparing modeled results to field hydrant test data. The field hydrant tests were conducted at 13 locations and included collecting reservoir levels, and pressure and flow data at the test hydrant before and after each hydrant test.   To simulate the hydrant test in the model, a demand of the same magnitude as the test hydrant flow was placed at a modeled node in the same location as the test hydrant. The model was run with and without the demand. Using this comparison as a starting point, modeled elements were adjusted by trial and error until the model produced results within the tolerances stated above. Elements that are typically adjusted during

a SS calibration include pipe C-factors and specific control setpoints. Model adjustments that were needed to achieve calibration are described in *Technical Memorandum #6: Model Calibration Results.*

6.2.3 Extended Period Calibration

EPS calibration provides verification of the relative accuracy of data used in the model such as system demands, diurnal demand patterns, SCADA controls, and how water typically flows through the distribution system. After configuring the model to the settings and controls discussed above, model simulations were run and the results were compared graphically to the SCADA data. Where obvious differences existed between the model and SCADA, these differences were investigated and modifications to the settings and controls were explored. City staff provided additional information when available to help reconcile the differences. EPS calibration included both average and maximum day demand conditions. Model adjustments that were needed to achieve calibration are described in *Technical Memorandum #6: Model Calibration Results.*

6.3 Steady State Calibration

Steady state model calibration was performed using hydrant flow test data collected between November 17, 2014 and November 20, 2014. The hydrant flow test data was collected by Mission Consulting Services and City staff, with oversight by IDM staff. Overall, 13 hydrant flow tests were completed using the procedures and mapping identified in the *Hydrant Flow Testing Plan*, as developed for the City in October 2014 by IDM. The SS calibration utilized 11 of the 13 hydrant flow tests.

Table 11 below shows the hydrant test times and the system-wide demand selected to use for each test.

Table 11 – Hydrant Test Times and Demands

Test	Start Time	End Time	System-wide Demand (MGD)
Test 1	11/17/2014 9:20	11/17/2014 9:27	38.49
Test 2	11/17/2014 10:06	11/17/2014 10:12	37.24
Test 3	11/17/2014 10:42	11/17/2014 10:46	38.58
Test 4	11/17/2014 15:32	11/17/2014 15:32	34.40
Test 5	11/17/2014 11:47	11/17/2014 11:52	36.87
Test 6	11/17/2014 16:04	11/17/2014 16:11	35.88
Test 8	11/17/2014 16:47	11/17/2014 16:53	41.42
Test 9	11/17/2014 14:21	11/17/2014 14:26	31.58
Alternative 3	11/20/2014 11:04	11/20/2014 11:08	32.07
Alternative 4	11/17/2014 13:36	11/17/2014 13:42	35.39
Alternative 6	11/20/2014 11:37	11/20/2014 11:41	31.01

6.3.1 Calibration Results

Table 12 below presents the comparison of model data output to field data after the calibration efforts were performed. All pressures are given in psi.

Table 12 – Hydrant Test Calibration Results Summary

Test	Hydrant	Field Pressure Drop	Model Pressure Drop	Static Difference	Residual Difference	Difference in Pressure Drop	Model Correlation to Field Results
Test 1	R1	19	18	-1	-2	1	Great
	R2	14	14	1	1	0	Great
	R3	14	15	1	2	-1	Great
Test 1A	R1	5	7	-1	1	-2	Great
Test 2	R1	7	3	-2	-6	4	Good
	R2	4	2	0	-2	2	Great
	R3	2	2	-1	-1	0	Great
Test 3	R1	10	5	2	-3	5	Great
	R2	4	2	4	2	2	Great
Test 4	R1	2	2	-1	-1	0	Great
	R2	2	2	2	2	0	Great
	R3	1	2	-1	0	-1	Great
Test 5	R1	8	5	-2	-5	3	Great
	R2	12	7	1	-4	5	Great
	R3	12	8	3	-1	4	Great
Test 6	R1	1	1	-1	-1	0	Great
	R2	2	2	1	1	0	Great
	R3	0	1	-3	-2	-1	Great
Test 8	R1	10	12	1	3	-2	Great
	R2	4	3	4	3	1	Great
	R3	4	5	2	3	-1	Great
Test 9	R1	9	3	0	-6	6	Good
	R2	8	4	0	-4	4	Great
	R3	6	5	-2	-3	1	Great

Test	Hydrant	Field Pressure Drop	Model Pressure Drop	Static Difference	Residual Difference	Difference in Pressure Drop	Model Correlation to Field Results
Alternative 3	R1	5	1	-1	-5	4	Great
	R2	1	2	0	1	-1	Great
	R3	1	2	0	1	-1	Great
Alternative 4	R1	16	17	1	2	-1	Great
	R2	26	30	3	7	-4	Good
Alternative 6	R1	10	5	0	-5	5	Great
	R2	8	5	2	-1	3	Great
	R3	5	4	1	0	1	Great

6.3.2 Steady State Calibration Conclusions

The steady state calibration results indicated that the model was able to predict field conditions for the vast majority of the hydrant tests within the 5 psi goal tolerance. Model correlation within 5 psi to field results was considered to be ideal, but correlation between 5 and 10 psi was still categorized as a "Good" calibration result, as identified in Table 12 above.

Achieving the 5 psi tolerance for most comparison points involved making a few modifications to the model including adjustments to the High Zone VFD setpoints at the Cambridge and Crooke station wells as well as adjustments to pipe C-factors in the southern portion of the system. The initial C-factors were assigned using industry standard values based on pipe material and age. This change resulted in better correlation between model and field data.

6.4 Extended Period Simulation Calibration

This section summarizes the EPS calibration performed for maximum and average day demand conditions. The City provided SCADA data for all pumps, control valves, and tanks for use in the calibration effort.

6.4.1 Maximum Day EPS Calibration Results

Maximum day calibration was completed for the demand conditions occurring on August 27-28, 2014. **Table 13** and **Table 14** below summarize the MDD calibration results for the Low Zone and High Zone respectively.

Table 13 – Low Zone MDD Calibration Results Summary

Facility	Facilities Operating	Calibration Results	Comments
Walnut Station	All	Well flows were slightly more flow than SCADA data Storage reservoir levels and flows were consistent with the field results Booster pump station flows were within calibration tolerances at most time steps	
John Garthe Station	All	Well 24 flow was within calibration tolerances Storage reservoir level trend was slightly higher than SCADA data but within calibration tolerances Booster pump station flows (pumps from the reservoir) were slightly higher than SCADA data	SCADA data was only available for Well 24 Slightly high reservoir water level possibly caused by greater flows from the remaining wells for which no SCADA data was available
East Station	All	All facilities were within calibration tolerances	
West Station	All	All facilities were within calibration tolerances	
South Station	All	Well flows were slightly less than SCADA Storage reservoir levels were slightly higher than indicated by SCADA data Booster pump station flows (pumps from the reservoir) were slightly higher than indicated by SCADA data	Slightly high well flows improved the results for the reservoir levels and booster pump station flows
Low Zone Wells	All except for Well 31	Flows from all wells were higher than indicated by SCADA data	Well pump curves could not be verified Flow meters may not have been accurate
Elevated Tank	All	Tank water levels were within calibration tolerances	
MWD PRVs	Only SA-1	Modeled results were within calibration tolerances	

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Table 14 – High Zone MDD Calibration Results Summary

Facility	Facilities Operating	Calibration Results	Comments
Crooke Station	Only Well 28	All active facilities were within calibration tolerances	
Cambridge Station	Only Well 38	All active facilities were within calibration tolerances	
Well 40	All	All active facilities were within calibration tolerances	
Zone PRVs	PRV1 & 3 operating, PRV2 sporadic	PRVs 1 & 3 were within calibration tolerances See TM 6 for detailed results for PRVs 2 & 4	No SCADA data for PRV PRV2 data was sporadic

6.4.2   Average Day EPS Calibration Results

Average day calibration was completed for the demand conditions occurring on August 27-28, 2014. **Table 15** and **Table 16** below summarize the MDD calibration results for the Low Zone and High Zone respectively.

Table 15 – Low Zone MDD Calibration Results Summary

Facility	Facilities Operating	Calibration Results	Comments
Walnut Station	All	Well flows were higher than SCADA data Booster pump station discharge pressures were within calibration tolerances Reservoir levels and booster pump station flow fluctuated significantly throughout the calibration	Reservoir and pump variation may be due to several factors including: • Zone-wide diurnal pattern used for the portion of the system being served by Walnut Station • Modeling software limitations regarding pressure setpoints • Influence from other pumping facilities in the vicinity may have affected the performance
John Garthe Station	All	Well flows were within calibration tolerances Reservoir levels were slightly high than SCADA data Booster pump station flows were slightly higher than SCADA data	
East Station	All	All active facilities were within calibration tolerances	

Facility	Facilities Operating	Calibration Results	Comments
West Station	All	All active facilities were within calibration tolerances	
South Station	All	Well flows were slightly less than indicated by SCADA data Reservoir levels were within calibration tolerances but slightly higher than SCADA data Booster pump station flows (pumps from the reservoir) were slightly higher than indicated by SCADA data	Lower well flows improved reservoir levels and booster pump station flows
Low Zone Wells	All	All active facilities were within calibration tolerances	
Elevated Tank		All active facilities were within calibration tolerances	
MWD PRVs	Only SA-1		

Table 16 – High Zone MDD Calibration Results Summary

Facility	Facilities Operating	Calibration Results	Comments
Crooke Station	All	Well discharge pressures and flows were within calibration tolerances	Tank and booster pumps operated for 9 hours on the 2nd day of data collection
Cambridge Station	Only Well 38	All active facilities were within calibration tolerances	
Well 40	All	All active facilities were within calibration tolerances	
Zone PRVs	PRVs 1 & 2	All active facilities were within calibration tolerances	

6.4.3 Calibration Conclusions and Recommendations

In general, the model results matched the field data within calibration tolerances and the model can be used with high confidence for master planning, operational planning, water quality planning, and pumping/energy optimization under varying demand and operating conditions. However, calibration tolerances could not be achieved at all locations. This was due in large part to well pump curve data that could not be verified at several facilities and a lack of available SCADA data for a high number of wells. There is no stated standard within the modeling community regarding when a model is considered fully

calibrated and it is generally understood that calibration is an ongoing process. Model calibration could be improved with additional data. The following are recommendations for future calibration efforts:

- Revise calibration annually or when new demands are added to the system

- Obtain accurate well pump curve data

- Obtain SCADA data for wells currently lacking data

- Obtain SCADA data in 15-minute increments rather than 1-minute increments

7.0 Supplemental Hydraulic Analyses

Using the calibrated steady state and EPS models, IDM performed the following value-added planning and operational analyses:

- Fire flow analysis

- Criticality analysis

- Water quality analysis

- Energy analysis

The results of each value-added analysis are described in the sections below.

7.1 Fire Flow Analysis

IDM utilized the calibrated steady state model under the MDD scenario to perform a system-wide fire flow analysis at each junction representing a fire hydrant. This simulation determined the available fire flow at a residual pressure of 20 psi. Simulation results are shown in **Attachment A**. Available fire flow contours were included to gain an understanding of the fire flow deficiencies within the distribution system under MDD operating conditions. The model results show that there are very few locations that have available fire flows of less than 1,000 gpm. This is a good indication of the overall robustness of the City's distribution system and the ability to handle emergency conditions.

Areas within the distribution system where the available fire flow is below 1,000 gpm should be reviewed on an individual basis as available fire flow can be affected by a pump status, tank water levels, hydrant lead length and diameter, the surrounding piping capacity supplying the particular hydrant, or a combination of these items.

7.2 Criticality Analysis

Using the calibrated steady state model under MDD conditions, IDM performed a valve criticality analysis of the City's system. The criticality analysis was performed to determine the water system vulnerability, and pipelines which have the greatest consequence of failure to customers and operations.

Criticality is a function of the number of customers served, demand, valve location, length of pipe, pressure, pipe velocity, and pipe headloss. A criticality score (or index) was assigned to each pipe segment

based on these criteria. The Criticality Index indicates the severity of a pipe failure to adjacent customers and system operations based on a scale of 0 to 100, with 100 indicating the highest consequence of failure.

Attachment B shows the color-coded Criticality Index for each pipe segment in the system. To further define the portions of the water system with high vulnerability, a criticality surface was developed and overlayed upon the system piping. Using the figure, any pipe segment in question can be reviewed to identify the vulnerability if this segment were to go out of service. This is especially helpful when performing field operations where pipeline shutdowns are required or understanding the impacts of an outage on a critical customer like a medical facility.

7.3   Water Age Analysis

The calibrated 48-hour EPS model was used as the basis for performing a water age analysis of the City's water system. The goal of this analysis was to determine where possible water quality problems may exist. In general, the age of the water within the distribution system is a good indicator of where water quality problems may exist. In general, high water age correlates to low chlorine residual or potential formation of disinfection by-products. Water age analyses were performed using a model analysis period of fourteen days.

7.3.1   Water Age Scenarios

The water age analysis consisted of following scenarios:

Scenario 1: Scenario 1 includes the baseline scenario to determine current system-wide water age at all junctions under existing average day demand conditions. The controls used in the model were similar to the controls observed on the calibration day.

Results for Scenario 1 are shown in **Attachment C (Figure 1)** and indicate that the distribution system overall has low water age. There is only one storage tank that floats on the system, and therefore a majority of the water that enters the distribution system through groundwater wells or MWD connections is used very quickly. However, higher than expected water age was observed in the vicinity of ground level storage reservoirs that were not being utilized regularly. These storage reservoirs include Crooke, Cambridge, Walnut, East, and South.

Scenario 2: Scenario 2 includes operational modifications to Scenario 1 to minimize system-wide water age with focus on areas of higher water age or longer residence time in the City's storage reservoirs. The modified controls are described in the section below. Results are shown in **Attachment C (Figure 2)**.

In general, controls were updated so that each facility operated once per day. In addition, some wells which pumped directly to the distribution system were shut off to facilitate the use of the booster stations to turn over the water in the storage reservoirs. The storage reservoirs were operated at approximately 50% full which helped reduce the average age of the water within each tank.

7.3.2   Recommendations

The following recommendations have been developed based on the results of the water age analysis:

General Recommendations

- Operate tanks at a reduced level when water quality is a concern. Operating all tanks at 50% full helps to measurably reduce the water age in the vicinity of the storage reservoirs.

- Prioritize reservoir turnover by utilizing the booster stations and turn off the system wells, when possible

- Attempt to operate each reservoir booster station every day to turn over the water in the reservoir and promote circulation within the distribution system

Individual Facility Recommendations

- Elevated Storage Tank – When active, Well 31 reduces the ability of the elevated storage tank to supply water to the distribution system such that very little water can exit the tank. To increase turnover in the elevated storage tank, reduce the use of Well 31.

- South Station – When the Walnut booster pumps and Well 37 are in operation the South booster pumps cannot deliver a large supply of water to the system. Reduce the use of Well 37 and utilize the South booster station to increase turnover and improve circulation.

- West Station – there is the potential that the booster station can draw water directly from the wells supplying the tank if the pipeline located to the south of the tank is utilized. This pipeline should be closed to route water through the tank.

- John Garthe Station – Due to the volume of the John Garthe Reservoir, a minimum of two booster pumps need to operate to move water through the reservoir and into the system to reduce water age and improve circulation.

- Walnut Station – Due to its location, the Walnut booster pumps can overpower other facilities. Reduce the number of booster pumps operating at Walnut to prioritize other facilities like South Station.

- East Station – The East reservoir was shown to have water quality issues if filled from the distribution system (as what was occurring during the calibration period). However, if the reservoir is filled using the onsite groundwater well, the water age improves significantly.

- Cambridge Station – For best water quality results, operate the booster pump station for a minimum of two (2) hours per day

- Crooke Station – For best water quality results, operate the booster pump station for a minimum of two (2) hours per day

7.4 Energy Evaluation

The calibrated 48-hour EPS model was used as the basis for performing the energy evaluation of the City's water system. The goal of this analysis was to determine where possible energy savings may exist. In general, the energy use for each station was modeled to determine where possible savings may arise. Energy efficiency data was applied to each pump in the model based on information provided in the manufacturer's pump data sheets. In addition, energy rates were applied for each facility based on recent Southern California Edison billing summaries provided by the City.

This analysis focused on energy use during the maximum day demand calibration period (August 27-28, 2014) and explored methods to reduce energy use over the 48-hour period of operation. The recommendations were then extrapolated to create general principles to reduce energy consumption.

7.4.1   Energy Evaluation Scenarios

Scenario 1: Scenario 1 includes a baseline scenario representing the EPS calibration day. The results of the Scenario 1 analysis determined each station's total energy use and were normalized to be represented as the ratio of cost ($) per million gallons (MG) pumped. This was calculated using each station's contribution to the distribution system and the total cost of the power consumed by the pumps. Other station energy use (i.e. lighting and static power costs) was not considered. The normalized results helped identify the stations that were inefficient in comparison to other stations.

Scenario 2: Scenario 2 focused on updating operational controls to reduce the energy use throughout the entire system by focusing on the station facilities with the highest energy efficiency, while minimizing use of the stations and wells with known lower efficiencies.

7.4.2   Evaluation Results

When comparing the results of Scenario 1 to Scenario 2, some station energy usage increased while other station energy usage decreased based on the modified operational controls. However, the overall total energy cost within the system was shown to decrease. In general, the most inefficient pumps were turned off while also lowering the overall HGL of the entire system by 5 feet (2 psi) by modifying the setpoints of the pumps in operation. **Table 17** below summarizes the overall results of the energy evaluation.

The following items represent the individual facility observations based on the operational control modifications implemented for Scenario 2:

- Elevated Storage Tank – the reduced HGL did not adversely affect the elevated storage tank. The tank water levels fluctuated at a slightly lower level.

- South Station – South Station is the second most inefficient station after East Station. This station was inactive for Scenario 2.

- West Station – West Station is one of the more efficient stations. Utilization of the West Station increased from Scenario 1.

- Walnut Station – Walnut Station is the second most efficient of the City's stations and therefore, the capacity from Walnut Station was maximized for Scenario 2. However, if too much of the supply load is shifted to Walnut Station, it does have an adverse effect on the overall station efficiency as it becomes harder to pump water out of the station. This occurs when the velocity observed in the piping downstream becomes excessively high (above 9 ft/s).

- John Garthe Station – John Garthe Station is less efficient than Walnut Station, however John Garthe Station has energy generation capabilities that were not accounted for in the modeling effort. With energy generation John Garthe becomes the most efficient station. As with Walnut Station, excessive pumping results in a loss of station efficiency as the head required to pump water into the system increases. It was observed that the system-wide reduction in HGL helped the station's overall efficiency.

- East Station – During the calibration day, East Station was filled from the system under low demand periods and discharged back to the system during high demand periods. It was observed that East Station was one of the more inefficient stations in the City's system. When Well 26 is in operation the $/MG was the highest of all the tank stations. Therefore this station was not operated for Scenario 2.

- Well 31 – Of all the groundwater wells pumping directly to the Low Zone, Well 31 was determined to be the least efficient. Therefore, this well was utilized minimally, mostly under high demand periods, during the Scenario 2 evaluation.

- Crooke Station – Well 28 was determined to be much more efficient than the other pumps in the High Zone. Therefore, Well 28 was utilized throughout the duration of the Scenario 2 evaluation.

- Cambridge Station – Well 38 located at Cambridge station was determined to be the least efficient pump within the High Zone. Therefore, this well was utilized minimally, mostly under high demand periods, during the Scenario 2 evaluation.

Table 17 – Overview of System-wide Energy Evaluations

Zone	Station	Peak Cost ($/kWh) [2]	Off-Peak Cost ($/kWh) [3]	Scenario 1 Normalized Cost ($/MG)	Scenario 2 Normalized Cost ($/MG)	Scenario 1 Total Cost ($)	Scenario 2 Total Cost ($)	Cost Reduction (%)
Low Zone	John Garthe	0.06109	0.04164	103.0	84.1	1,449	1,033	
	Walnut	0.06389	0.04300	77.9	72.0	973	1,195	
	East	0.06109	0.04164	32.2	0.0	88	0	
	West	0.06389	0.04300	82.8	84.8	1,318	1,314	
	South	0.07557	0.04891	122.8	0.0	168	0	
	Well 31	0.06109	0.04164	0.0	92.3	0	131	
	Well 35	0.06109	0.04164	84.3	84.7	535	533	
	Well 37	0.06109	0.04164	71.9	70.6	495	497	
	Well 41	0.06216	0.04158	79.6	81.4	706	705	
					Subtotal	5,732	5,408	5.65
High Zone	Crooke	0.06389	0.04300	133.6	103.9	570	623	
	Cambridge	0.09198	0.08063	332.7	263.6	868	99	
	Well 40	0.06216	0.04185	131.8	121.4	973	956	
					Subtotal	2,410	1,679	30.35
					Total	8,143	7,087	12.96

1. East Station's normalized cost is approximately $170/MG when Well 26 is active.

2. Peak rates occur between 8 a.m. and 11 p.m.

3. Off-peak rates occur between 11 p.m. and 8 a.m.

7.4.3   Recommendations

The following recommendations have been developed based on the results of the energy evaluation:

- Reduce the system HGL by 5 feet (2 psi) by modifying pump station setpoints. This did not have an adverse effect on filling the elevated storage tank and helped with lowering system-wide energy usage.

- Utilize the most efficient stations prior to operating the less efficient pumping facilities. **Table 18** below displays the operational priority for utilizing each station in order to reduce system-wide energy use. It may not be feasible to completely follow this priority list due to field conditions, but this table can be used as a reference for moving towards operational efficiency.

Table 18 – Priority of Facility Operation to Conserve Energy

Zone	Station	Operational Priority
Low Zone	John Garthe	1
	Walnut	2
	Well 37	3
	West	4
	Well 41	5
	Well 35	6
	Well 31	7
	South	8
	East	9
High Zone	Crooke	1
	Well 40	2
	Cambridge	3

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APPENDIX B
Power Outage Analysis
TM#3

TO:	Rudolfo Rosas, P.E., City of Santa Ana
	Brian Ige, City of Santa Ana
FROM:	Kevin Trott, P.E., IDModeling, Inc.
	Leslie Farnsworth-Lee, P.E., IDModeling, Inc.
CC:	Tom Epperson, P.E., TetraTech
	Jason Pierce, P.E., IDModeling, Inc.
DATE:	February 2, 2016

1.0   Introduction

IDModeling (IDM) has developed this technical memorandum to report on the results of an area-wide power outage (7 days of outage) for the City of Santa Ana (City). The City determined the need to evaluate the possibility of an area-wide power outage which affects all City-owned facilities serving potable water to its customers. It was determined that the only source of supply would be from the Metropolitan Water District (MWD) source connections during this outage scenario. An average day demand scenario was analyzed to determine if the City can serve its customers exclusively from MWD sources. This document will provide the setup and results of the power outage scenario and any recommendations required to adequately serve the City during this emergency situation.

> **Section 1.0** – Introduction
> **Section 2.0** – Scenario Setup and Results
> **Section 3.0 –** Conclusions and Recommendations

2.0   Scenario Setup and Results

To test the feasibility of serving the City from MWD connections, all well facilities were assumed to be off and all booster stations were inactive. If an area-wide power outage occurs, the City will most likely take measures to reduce demands within the system. Therefore, an average day demand was assumed as a reasonable demand if a power outage occurred during the summer months. The total demand for the system was assumed to be 32.6 mgd. In addition, the 48-hour average day diurnal pattern currently in the model was used for this evaluation. The maximum peaking factor for the system under average day conditions is 1.52, which corresponds to 49.5 MGD that must be served from the MWD connections. **Table 1** presents the MWD connection capacity and the increase in capacity required to meet average day demands.

Table 1 – Comparison of MWD Capacity and Average Day Demands

MWD Connection	Name	Location	Normal Operating Capacity (gpm)	Available Capacity (gpm)	Required Capacity to Meet Demands (gpm)
SA-1	Bristol	2315 N. Bristol St. Santa Ana, CA 92706	5.2	6.5	5.8
SA-2	First	Bristol St. & First St.	0.0	9.7	0.0
SA-3	McFadden	1300 w Mc Fadden Santa Ana, CA 92704	5.2	6.5	5.8
SA-4	Warner	1299 W. Warner Ave, Santa Ana, CA 92707	4.8	6.5	5.8
SA-5	Alton	Bristol St. & Alton Ave.	4.8	12.9	11.5
SA-6	Santa Clara	2301 N. Tustin Ave. SA, CA 92705	7.8	12.9	11.5
SA-7	Red Hill	2215 Ritchey St., Santa Ana, CA 92705	4.8	32.3	9.8
		Total	32.6	87.3	50.1
	Peak Hour of Average Day Demand		49.5	49.5	49.5
	Shortage		-16.9	37.8	0.6

As shown in **Table 1**, the normal operating flow from the MEWD connections was not adequate to meet the City's total average day demands. Since additional flow is available at each turnout, flows were increased, in some cases up to the maximum available flow.

In addition to increasing the flowrate from the connections, the pressure also needs to be increased. During the calibration, it was assumed that the HGL at the MWD connections ranges from 250 – 280 feet based on an instantaneous SCADA screenshot of pressures at each of the turnouts, as provided by the City. The downstream pressure was not provided during the calibration as many of the connections were not active during the calibration period. However, the City operators provided operating information for each connection. Many of the connections only operate when the downstream pressure is below 45 psi. This may be acceptable during normal operations, but the pressure must be increased to serve the entire

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City from MWD connections during an emergency. In order to maintain appropriate water levels in the City's elevated storage tank, the turnout must provide flow at a hydraulic grade line of 280 feet (Low Zone). Without a hydraulic grade line of 280 feet, the elevated storage tank would operate at an unacceptably low level and low pressure problems observed near the Interstate 5 freeway would be compounded.

Table 2 provides the required HGL to maintain adequate water levels within the elevated storage tank.

Table 2 – HGL Required at MWD Connections

MWD Connection	Name	Normal Operating HGL (feet)	Required Operating HGL (feet)	Normal Operating Pressure (psi)	Required Operating Pressure (psi)
SA-1	Bristol	261.0	268	61	64
SA-2	First	257.7	267	67	71
SA-3	McFadden	259.7	279	80	89
SA-4	Warner	260.0	276	93	100
SA-5	Alton	259.0	277	98	105
SA-6	Santa Clara	365.0	365	75	75
SA-7	Red Hill	260.0	280	82	91

Figure 1 below presents the minimum pressures and maximum velocities observed during the power outage scenario.
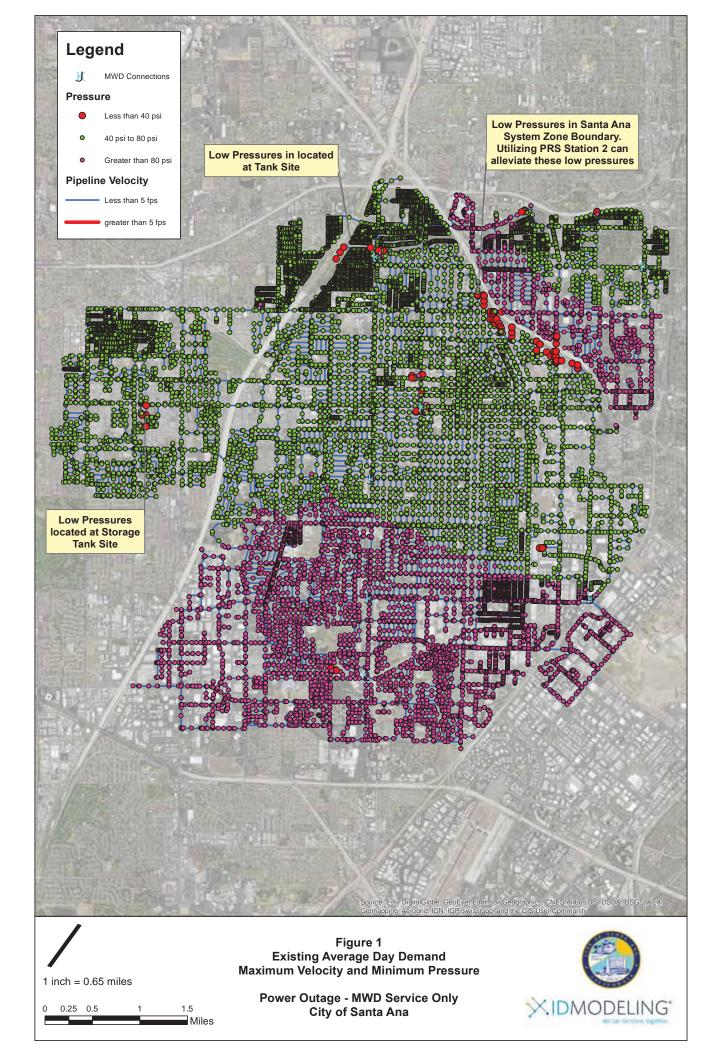
3.0   Conclusions and Recommendations

There is adequate capacity to serve the City under average day demand purely from MWD connections. However, there is some concern as to the HGL provided at the MWD connections. To serve the entire service area from MWD connections, these setpoints must be increased. In order to keep the elevated storage tank at an appropriate water level, the MWD connections must provide water with the hydraulic grade lines of presented in **Table 2**.

To plan for an area-wide power outage, it is recommended that the following items be completed:

- Verify the design capacity of the MWD connections

- Verify the HGL on the upstream side of the MWD connections (must be greater than 280 feet)

- Create new setpoints for the control valve at the turnouts. Setpoints should be similar to the setpoints provided in **Table 2**

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Legend

⨆ MWD Connections

Pressure
- 🔴 Less than 40 psi
- 🟢 40 psi to 80 psi
- 🟣 Greater than 80 psi

Pipeline Velocity
- —— Less than 5 fps
- —— greater than 5 fps

Low Pressures in located at Tank Site

Low Pressures in Santa Ana System Zone Boundary. Utilizing PRS Station 2 can alleviate these low pressures

Low Pressures located at Storage Tank Site

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

1 inch = 0.65 miles

0   0.25   0.5   1   1.5
Miles

Figure 1
Existing Average Day Demand
Maximum Velocity and Minimum Pressure

Power Outage - MWD Service Only
City of Santa Ana

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APPENDIX C
Master Plan Hydraulic Analysis
Technical Memorandum

TO:	Rudolfo Rosas, P.E., City of Santa Ana
	Tom Epperson, P.E., TetraTech
FROM:	Kevin Trott, P.E., IDModeling, Inc.
	Eric Michel, IDModeling, Inc.
CC:	Brian Ige, City of Santa Ana
	Paul Hauffen, IDModeling, Inc.
DATE:	April 30, 2017

1   Introduction

IDModeling (IDM) has developed this Technical Memorandum (TM) to document the hydraulic analysis associated with the City of Santa Ana's (City) 2016 Water Master Plan. This TM builds upon previous analyses detailed in the City's *Water System Computer Modeling Project* (IDM, 2015), the *Fuller Site Analysis* (IDM, 2016), and the *Power Outage Analysis* (IDM, 2016) projects (Attachment A) to serve as the capstone project for the City's 2016 Water Master Plan.

The following tasks are documented in this TM:

- Create future demands for near-term and buildout analysis

- Analyze the existing, near-term and future systems for deficiencies

- Analyze the ability of the City to serve the future system without imported water

- Analyze the ability of the system to provide fire flows under future demand conditions

- Identify whether any facilities require replacement

This TM will serve as documentation of the tasks discussed above and includes the following sections and attachments:

Section 1 – Introduction
Section 2 – Demand Allocation
Section 3 – System Performance Criteria
Section 4 – System Analysis under Normal Operations
Section 5 – Water Supply Analysis
Section 6 – Capital Improvement Program
Section 7 – Valve Replacement Program

Appendix A – Referenced Technical Memoranda
Appendix B – Hydraulic Evaluation Supplemental Information
Appendix C – Mapbook, CIP, and Valve Criticality Supplemental Information

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2   Demand Allocation

Demands were allocated for three time horizons: existing (years 2012-2019), near-term (Years 2020-2025), and buildout (years 2040 and beyond). For each timeframe, the average day demand (ADD), maximum day demand (MDD), and peak hour demand (PHD) was determined. MDD was calculated by scaling ADD according to the previously determined max day demand peaking factor (1.35), and PHD was calculated by scaling ADD to the previously determined peak hour demand peaking factor (1.95). Peaking factors and calculated values for each of the nine demand sets are listed in **Table 1**.

Table 1 - Demand Allocations and Peaking Factors

Time Horizon	Average Day Demand (mgd)	Max Day Peaking Factor	Maximum Day Demand (mgd)	Peak Hour Peaking Factor	Peak Hour Demand (mgd)
Existing	33.5	1.35	45.2	1.95	65.3
Near-Term	34.9	1.35	47.1	1.95	68.0
Buildout	35.5	1.35	47.9	1.95	69.1

2.1   Existing Demands

Existing system demands were previously allocated as component of the *Water System Computer Model Project*. Because the *Water System Computer Model Project* was started prior to the completion of the City's *2015 Urban Water Management Plan* (Appendix A), demand data was calculated based upon the City's 2012-2013 demand data (the most recent available at the time). Table 2 shows demand projections as listed by *Table 4-2 Retail* of the City's 2015 Urban Water Management Plan (UWMP) and the *Water System Computer Model Project*, as well as near-term and buildout demands utilized in this TM.

Table 2 - Comparison of Demands by Data Source

Demand Source	2015	Existing	2020	Near-Term	2025	2030	2035	2040 / Buildout
UWMP (AFY)	36,655	-	36,678	-	39,397	39,669	39,658	39,716
UWMP (mgd)	32.7	-	32.7	-	35.2	35.4	35.4	35.5
Water System Computer Model Project	-	33.5	-	-	-	-	-	-
Master Plan Hydraulic Analysis TM	-	33.5	-	34.9	-	-	-	35.5
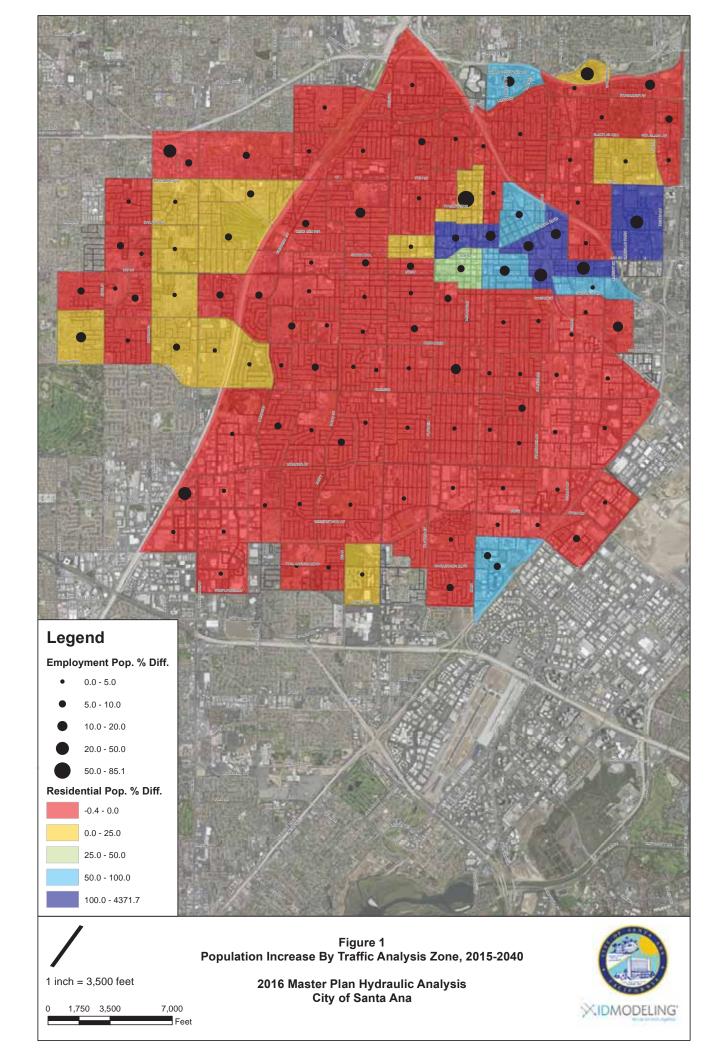
2.2   Near-Term Demand Allocation

To allocate near-term demands, existing system demands were scaled upwards according to projected population change by geographic area, with a total system demand of 34.9 mgd. Geographic areas were delineated by a combination of Traffic Analysis Zones (TAZ) defined by the City's Sewer Master Plan and specific project areas provided by the City's planning department. The additional demand is mainly concentrated in the areas where specific planning processes are already identified with many these projects affecting the downtown area.

2.3   Buildout Demand Allocation

To allocate buildout demands, existing system demands were further scaled upwards according to projected population change by geographic area, with a total system demand of 35.5 mgd. This value was chosen to match the year 2040 demand projection listed in the 2015 UWMP. Like near-term demands, the additional demand is mainly concentrated in the downtown area, with projected relative population increases by TAZ shown in **Figure 1** below.

Legend

Employment Pop. % Diff.

- · 0.0 - 5.0
- • 5.0 - 10.0
- ● 10.0 - 20.0
- ● 20.0 - 50.0
- ● 50.0 - 85.1

Residential Pop. % Diff.

🟥	-0.4 - 0.0
🟨	0.0 - 25.0
🟩	25.0 - 50.0
🟦	50.0 - 100.0
🟪	100.0 - 4371.7

Figure 1
Population Increase By Traffic Analysis Zone, 2015-2040

2016 Master Plan Hydraulic Analysis
City of Santa Ana

1 inch = 3,500 feet

0   1,750   3,500   7,000
|————————————| Feet

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3 System Performance Criteria

Water system performance criteria represent design and operating guidelines for a distribution system. Performance criteria are often referred to as "design criteria" within water Master Plan documents. These criteria identify critical conditions that are desired to be met for the system. They include operating criteria such as maximum and minimum system pressures and maximum pipeline headloss and velocity, as well as key conditions for pump and tank operation.

The established performance criteria were grouped into the following categories:

- Storage Reservoirs

- System Pressures

- Pipelines

- Pump Stations/Wells/Turnouts

- Time-of-Use Criteria

- Fire Flow Operations

A tabular breakdown of these criteria can be found in **Table 3** below.

Table 3 – System Performance Criteria

	Existing City Criteria	Source	Sample Performance Criteria
Storage Reservoirs			
Total Storage			Total Storage Volume = Operational + Emergency + Fire Flow
Emergency Storage Credit		Check AWWA, DWR regulations	Credit given to wells with backup power to Emergency Storage
Fire Flow Storage		AWWA M32 Manual of Water Supply Practices	Fire flow storage per zone equals the highest required fire flow per zone at its necessary designation. For example, 5,000 gpm for 5 hours is 1.5 MG of fire storage required.
Minimum Storage Level			Recommend minimum tank levels are based on fire storage plus emergency storage.
Water Age			Maximum water age of 160 hours within reservoir.
Storage Turnover Criteria			Tanks should turnover at least once per week.
System Pressure			
Normal Operation: Minimum Pressure Criteria Normal Operation: Maximum Pressure Criteria	40 psi during peak hour normal operation for each customer 100 psi	California Law Section 64602	Maintain 40 psi minimum normal operating pressure at customer locations Maintain pressures at customer locations within 40-100 psi
Pipelines			
Normal Operation: Velocity Criteria		AWWA M32 Manual of Water Supply Practices	**Allowable Velocity Normal Operation:** Maintain velocities during peak demands under 5 fps
Normal Operation: Headloss Criteria		AWWA M32 Manual of Water Supply Practices	**Allowable Headloss per 1000 ft:** Transmission piping (16 inch or greater) - 3 ft of headloss per 1000 ft Distribution piping (less than 16 inch) - 10 ft headloss per 1000 ft
Pump Stations/Wells/ Turnouts			

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	Existing City Criteria	Source	Sample Performance Criteria
Firm Capacity			Assume the largest pump at a facility is on standby
Well Operation: Allowable Percentage for Groundwater Production			70% groundwater - 30% water imported from MWD
Time-of-Use (TOU) Requirements			
Well and Boosters on TOU	**Mid-Peak Rate:** 8 am-Noon - Weekdays except holidays **On-Peak Rate:** Noon-6 pm - Weekdays except holidays **Mid-Peak Rate:** 6 pm-11 pm - Weekdays except holidays **Off-Peak Rate:** 11 pm-8 am - Weekdays and all day on weekends including holidays	Rate Schedule TOU Scan Document	**Mid-Peak Rate:** 8 am-Noon - Weekdays except holidays **On-Peak Rate:** Noon-6 pm - Weekdays except holidays **Mid-Peak Rate:** 6 pm-11 pm - Weekdays except holidays **Off-Peak Rate:** 11 pm-8 am - Weekdays and all day on weekends including holidays
Fire Flow Operations			
Fire Flow: Flow Requirements			Assign fire flow requirements based on land use.
Fire Flow: Minimum Pressure	Minimum 25 psi	Section 64602 of California law requires customers have at least 20 psi at all times. Orange County Fire Marshal	Maintain 20 psi at all customer locations during a fire event Maintain 25 psi at the fire flow location.
Fire Flow: Maximum Pipe Velocity			Maximum Goal Velocity - No more than 10 fps. These pipes generally cause most of the headloss during a fire event.
Fire Flow: Model Boundary Conditions			Assume Tanks at Minimum Levels Assume Max Day Assume a conservative turnout and pumps (well and booster) operation

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4 System Analysis under Normal Operations

This section summarizes the results of evaluating the system under current normal operating conditions. Current normal operation includes importing water from Metropolitan Water District (MWD) as well as operating many of the City's wells. Specifically, this analysis included MWD connections SA-6 in the High Zone and SA-1 and DA-7 in the Low Zone. A water supply analysis evaluating the system without importing any water from MWD is presented in Section 5.

4.1 Scenario Setup

The analyses under normal operating conditions were performed using steady-state modeling for the existing, near-term and buildout timeframes. Modeled scenarios included peak hour and maximum day plus fire flow demand conditions. Fire flow modeling was performed using the automated fire flow function to determine the available fire flow that provides a residual pressure of 20 psi at all hydrants. The fire flow scenarios were run on nodes representing fire hydrants located in a street. Nodes that did not correspond to fire hydrants or fire hydrants located on private property were not included in the analysis.

4.2 Existing System Results

Results from the existing system analysis for each scenario are presented below.

4.2.1 Peak Hour Demands

Figure 2 below presents the results for peak hour demand conditions. Observations are listed below:

- Distribution system pressures ranged from 38 to 107 psi.

- Pressure less than 20 psi were reported at nodes near tanks and along well transmission lines that feed the tanks. These locations are not demand nodes, and therefore pressure do not violate minimum pressure performance criteria.

- Pressures greater than 120 psi were reported at the discharge side of pump stations. High pressures are expected at these locations and are not a concern. These locations are not demand nodes, and therefore pressure do not violate maximum pressure performance criteria.

- Pressures ranging from 38 psi to just less than 40 psi were reported in the northeastern portion of the High Zone on the south side of Interstate 5 between East 17th and East 1st Streets.

- In general, pipeline velocities were less than 7 fps.

4.2.2 Maximum Day plus Fire Flow Demands

Figure 3 below presents the results for maximum day plus fire flow demand conditions. Observations are listed below:

- Available fire flows ranged from a low of 740 gpm to greater than 5,500 gpm, and 55 percent of the hydrants tested had an available fire flow of 5,000 gpm or greater. It is assumed that multiple hydrants will be used to meet large fire flow demand.

- The lowest available fire flows were located on single-feed pipelines or 4-inch diameter loops. Additionally, the single-feed pipelines with low fire flows were 6-inch diameter.

Legend

Minimum Pressure

!	Less Than 20 psi
!	20 - 40 psi
!	40 - 80 psi
!	80 - 100 psi
!	100 - 120 psi
●	Greater Than 120 psi

Maximum Velocity

——	Less Than 3 fps
——	3 - 5 fps
——	5 - 7 fps
——	7 - 10 fps
——	Greater Than 10 fps

1 inch = 3,500 feet

0   1,750   3,500   7,000
Feet

Figure 2
Existing System Peak Hour Demand

2016 Master Plan Hydraulic Analysis
City of Santa Ana

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Legend

Hydrant Flow

●	Below 500 gpm
●	500 - 1000 gpm
●	1000 - 1500 gpm
●	1500 - 2000 gpm
●	2000 - 2500 gpm
●	2500 - 3000 gpm
●	3000 - 3500 gpm
●	3500 - 4000 gpm
●	4000 - 4500 gpm
●	4500 - 5000 gpm
●	5000 - 5500 gpm

Fire Flow Contours

——	500
——	1000
——	1500
——	2000
——	2500
——	3000
——	3500
——	4000
——	4500
——	5000
——	5500

Notes:

1. The City's hydraulic model includes fire hydrants and hydrant lateral piping. The nodes shown on this map are fire hydrants in the system. Available fire flows are based on a residual pressure of 20 psi.

2. Contours are only valid within the existing potable system network.

3. Available fire flows are based upon typical operating conditions under maximum day demand. Varying system conditions may affect the available fire flow. These conditions include, but are not limited to system demands, tank levels, control valve settings, and pump status.

4. Predicted available hydrant fire flows should only be considered accurate witin +/- 500 gpm.

Figure 3
Existing System Max Day Demand + Fire Flow

2016 Master Plan Hydraulic Analysis
City of Santa Ana

1 inch = 3,500 feet

0	1,750	3,500	7,000

Feet

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4.3   Near-Term System Results

Results from the near-term system analysis for each scenario are presented below.

4.3.1   Peak Hour Demands

Figure 4 below presents the results for peak hour demand conditions. Observations are listed below:

- Distribution system pressures ranged from 38 to 107 psi.

- Pressure less than 20 psi were reported at tanks and along well transmission lines that feed the tanks. These locations are not demand nodes, and therefore pressure do not violate minimum pressure performance criteria.
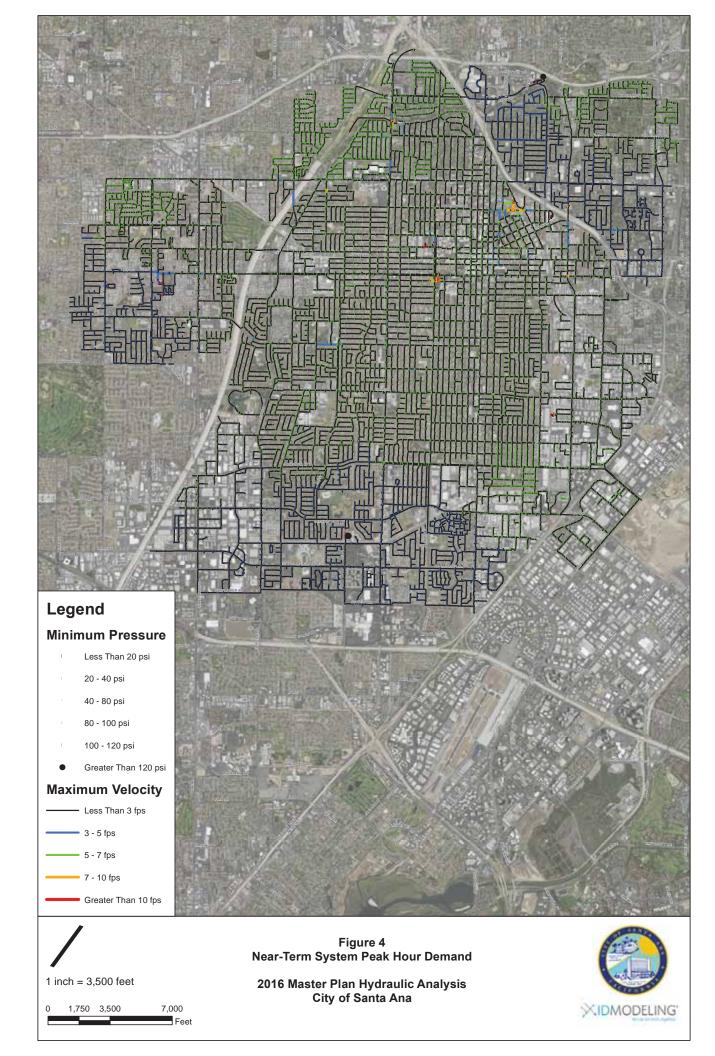
- Pressures greater than 120 psi were reported at the discharge of pump stations. These locations are not demand nodes, and therefore pressure do not violate maximum pressure performance criteria.

- Pressures ranging from 38 psi to just less than 40 psi were reported in the northeastern portion of the High Zone on the south side of Interstate 5 between East 17th and East 1st Streets.

- In general, pipeline velocities were less than 7 fps.
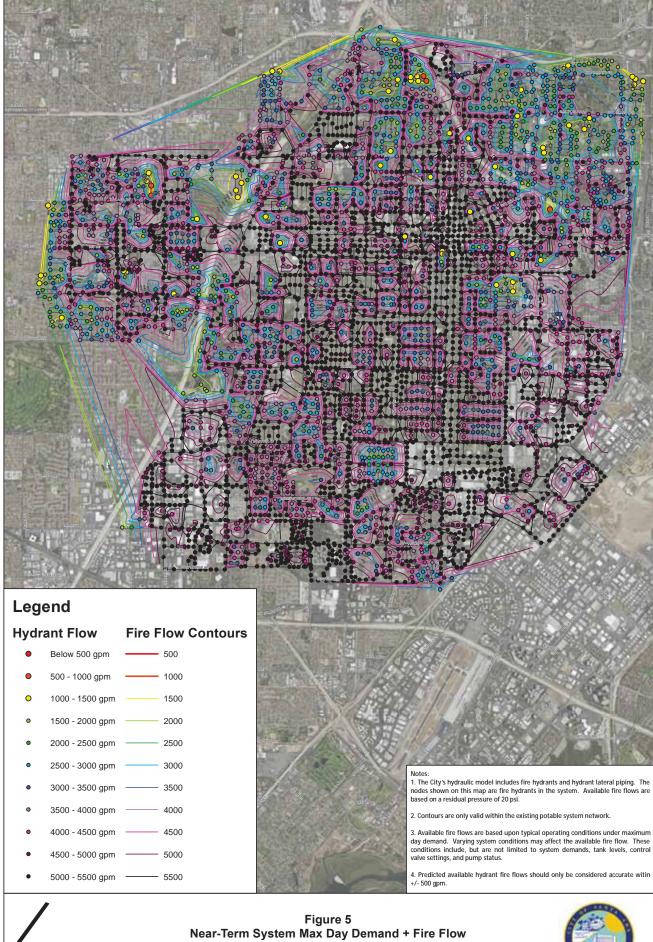
4.3.2   Maximum Day plus Fire Flow Demands

Figure 5 below presents the results for maximum day plus fire flow demand conditions. Observations are listed below:

- Available fire flows ranged from a low of 739 gpm to greater than 5,500 gpm, and 43 percent of the hydrants tested had an available fire flow of 5,000 gpm or greater. It is assumed that multiple hydrants will be used to meet large fire flow demand.

- The lowest available fire flows were located on single-feed pipelines or 4-inch diameter loops. Additionally, the single-feed pipelines with low fire flows were 6-inch diameter.

Legend

Minimum Pressure

!	Less Than 20 psi
!	20 - 40 psi
!	40 - 80 psi
!	80 - 100 psi
!	100 - 120 psi
●	Greater Than 120 psi

Maximum Velocity

——	Less Than 3 fps
——	3 - 5 fps
——	5 - 7 fps
——	7 - 10 fps
——	Greater Than 10 fps

Figure 4
Near-Term System Peak Hour Demand

2016 Master Plan Hydraulic Analysis
City of Santa Ana

1 inch = 3,500 feet

0   1,750   3,500   7,000
Feet

IDMODELING

Legend

Hydrant Flow

- ● Below 500 gpm
- ● 500 - 1000 gpm
- ● 1000 - 1500 gpm
- ● 1500 - 2000 gpm
- ● 2000 - 2500 gpm
- ● 2500 - 3000 gpm
- ● 3000 - 3500 gpm
- ● 3500 - 4000 gpm
- ● 4000 - 4500 gpm
- ● 4500 - 5000 gpm
- ● 5000 - 5500 gpm

Fire Flow Contours

- —— 500
- —— 1000
- —— 1500
- —— 2000
- —— 2500
- —— 3000
- —— 3500
- —— 4000
- —— 4500
- —— 5000
- —— 5500

Notes:
1. The City's hydraulic model includes fire hydrants and hydrant lateral piping. The nodes shown on this map are fire hydrants in the system. Available fire flows are based on a residual pressure of 20 psi.

2. Contours are only valid within the existing potable system network.

3. Available fire flows are based upon typical operating conditions under maximum day demand. Varying system conditions may affect the available fire flow. These conditions include, but are not limited to system demands, tank levels, control valve settings, and pump status.

4. Predicted available hydrant fire flows should only be considered accurate witin +/- 500 gpm.

1 inch = 3,500 feet

0	1,750	3,500		7,000

Feet

Figure 5
Near-Term System Max Day Demand + Fire Flow

2016 Master Plan Hydraulic Analysis
City of Santa Ana

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4.4   Buildout System Results

Results from the buildout system analysis for each scenario are presented below.

4.4.1   Peak Hour Demands

Figure 6 below presents the results for peak hour demand conditions. Observations are listed below:
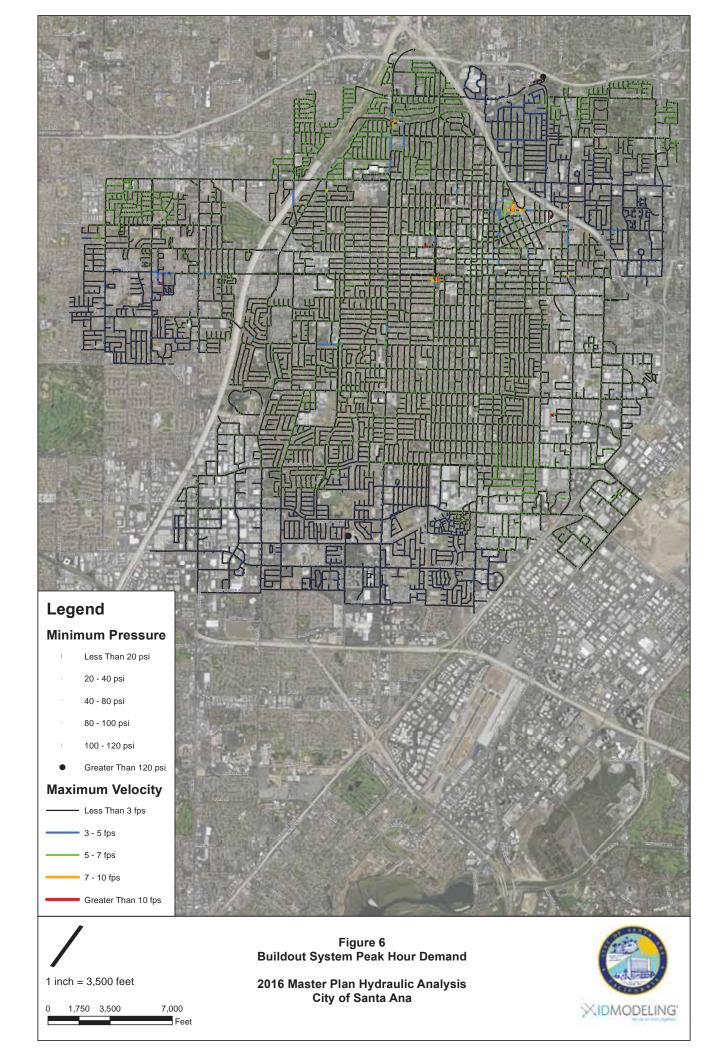
- Distribution system pressures ranged between 40 psi and 100 psi.

- Pressures less than 40psi were reported at tanks and along well transmission lines that feed the tanks. These locations are not demand nodes, and therefore pressure do not violate minimum pressure performance criteria.

- In general, pipeline velocities were less than 7 fps.
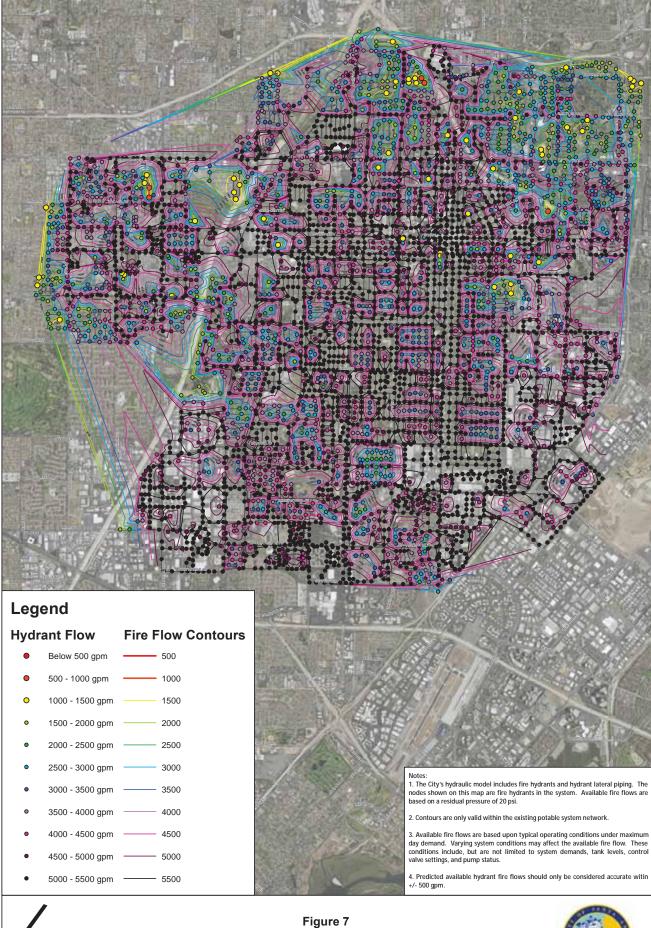
4.4.2   Maximum Day plus Fire Flow Demands

Figure 7 below presents the results for maximum day plus fire flow demand conditions. Observations are listed below:
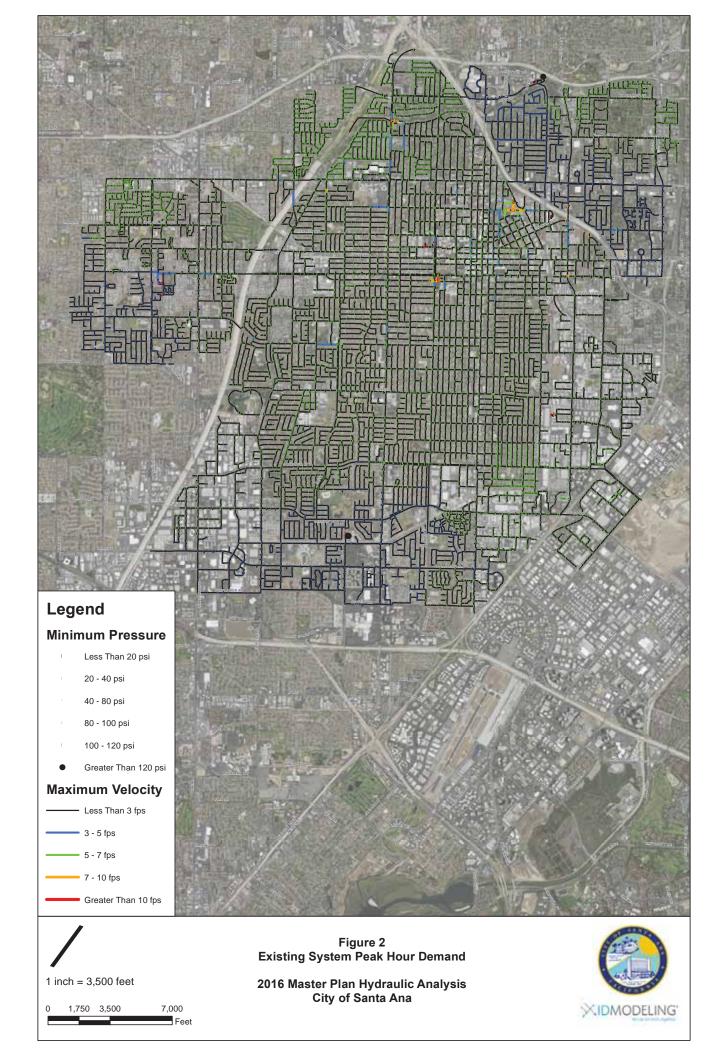
- Available fire flows ranged from a low of 739 gpm to greater than 5,500 gpm, and 55 percent of the hydrants tested had an available fire flow of 5,000 gpm or greater. It is assumed that multiple hydrants will be used to meet large fire flow demand.
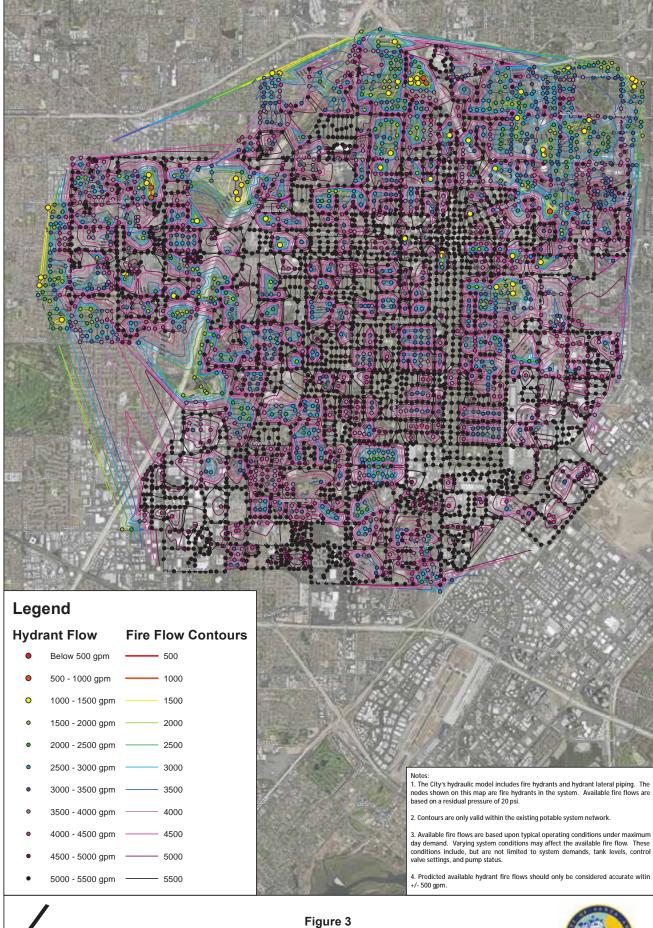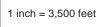
- The lowest available fire flows were located on single-feed pipelines or 4-inch diameter loops. Additionally, the single-feed pipelines with low fire flows were 6-inch diameter.

Legend

Minimum Pressure

Symbol	
!	Less Than 20 psi
!	20 - 40 psi
!	40 - 80 psi
!	80 - 100 psi
!	100 - 120 psi
●	Greater Than 120 psi

Maximum Velocity

——	Less Than 3 fps
——	3 - 5 fps
——	5 - 7 fps
——	7 - 10 fps
——	Greater Than 10 fps

1 inch = 3,500 feet

0   1,750   3,500   7,000
Feet

Figure 6
Buildout System Peak Hour Demand

2016 Master Plan Hydraulic Analysis
City of Santa Ana

IDMODELING

Legend

Hydrant Flow

- 🔴 Below 500 gpm
- 🟠 500 - 1000 gpm
- 🟡 1000 - 1500 gpm
- 🟢 1500 - 2000 gpm
- 🟢 2000 - 2500 gpm
- 🔵 2500 - 3000 gpm
- 🔵 3000 - 3500 gpm
- 🟣 3500 - 4000 gpm
- 🟣 4000 - 4500 gpm
- 🟣 4500 - 5000 gpm
- ⚫ 5000 - 5500 gpm

Fire Flow Contours

- —— 500
- —— 1000
- —— 1500
- —— 2000
- —— 2500
- —— 3000
- —— 3500
- —— 4000
- —— 4500
- —— 5000
- —— 5500

Notes:
1. The City's hydraulic model includes fire hydrants and hydrant lateral piping. The nodes shown on this map are fire hydrants in the system. Available fire flows are based on a residual pressure of 20 psi.

2. Contours are only valid within the existing potable system network.

3. Available fire flows are based upon typical operating conditions under maximum day demand. Varying system conditions may affect the available fire flow. These conditions include, but are not limited to system demands, tank levels, control valve settings, and pump status.

4. Predicted available hydrant fire flows should only be considered accurate witin +/- 500 gpm.

Figure 7
Buildout System Max Day Demand + Fire Flow

2016 Master Plan Hydraulic Analysis
City of Santa Ana

1 inch = 3,500 feet

0   1,750   3,500   7,000
                                    Feet

XIDMODELING

5 Water Supply Analysis

Due to persistent drought conditions, the City wishes to evaluate the feasibility of serving the entire system without importing water and using only groundwater wells. The analysis was performed during existing, near-term and buildout MDD conditions with the goal of determining required infrastructure improvements such as rehabilitation of existing wells or drilling of new groundwater wells.

The results are summarized in tables that present the well design capacity and the system firm capacity for the Low Zone and High Zone. The system firm capacity is defined as the capacity with the largest well out of service, and the "out of service" well is indicated in each table.

5.1 Well Inspection Results

Tetra Tech performed well inspections on all wells as part of this Project. The results indicated that the Crooke Wells (Wells 27 and 28 in the tables presented below) that feed the High Zone are in need of rehabilitation, and Well 27 is currently not in service. The analyses presented below assume that the well rehabilitation will be performed and that both Crooke wells are able to perform at their design capacity.

5.2 Existing System Analysis

Table 4 and **Table 5** summarize the results of the water supply analysis for the existing system. The results show excess capacities of 23.5 and 3.8 mgd for the Low and High zones, respectively. This result indicates that the rehabilitated well system has adequate capacity to supply the entire existing system during MDD conditions.

Table 4 – Existing System Low Zone Water Supply Results

Well Number	Location	Discharge Location	Design Capacity (mgd)	Firm Capacity (mgd)
16	1011 W. 6th St	Walnut	2.88	2.88
18	2401 N. Bristol St	Garthe	2.88	2.88
20	4426 W. 1st St	West	4.32	4.32
21	4426 W. 1st St	West	4.32	4.32
24	1800 W. 22nd St	Garthe	2.59	2.59
26	1730 S. Santa Fe	East	3.60	3.60
29	S/E First St. and Flower St	Walnut	3.60	3.60
30	4426 W. 1st St	West	4.32	4.32
31	1815 E. Chestnut St	Low Zone (system)	4.32	4.32
32	2801 N. Westwood	Low Zone (system)	4.00	4.00
33	917 W. Walnut St	Walnut	4.03	4.03
34	1727 W. Alton Ave	South	3.60	3.60
35	1718 N. Sydney Pl	Low Zone (system)	4.32	4.32
36	2415 N Bristol St	Garthe	5.18	--
37	2007 W. McFadden	Low Zone (system)	4.32	4.32
39	2315 N. Bristol St	Garthe	4.32	4.32

Well Number	Location	Discharge Location	Design Capacity (mgd)	Firm Capacity (mgd)
41	907 3/4 N Flower St	Low Zone (system)	4.32	4.32
Low Zone Total Capacity			66.93	61.74
Low Zone Maximum Day Demand			--	38.26
Capacity - Demand			--	23.48

Table 5 – Existing System High Zone Water Supply Results

Well Number	Location	Discharge Location	Design Capacity (mgd)	Firm Capacity (mgd)
27	730 E. Memory Ln	Crooke	3.60	3.60
28	730 E. Memory Ln	High Zone (system - Crooke)	3.60	3.60
38	2736 N. Cambridge St	High Zone (system - Cambridge)	3.60	3.60
40	1301 North Mabury St	High Zone	3.71	--
High Zone Total Capacity			--	10.80
High Zone Maximum Day Demand			--	6.97
Capacity - Demand			--	3.83

5.3 Near-Term System Analysis

Table 6 and **Table 7** summarize the results of the water supply analysis for the existing system. The results show excess capacities of 22.6 and 2.8 mgd for the Low and High zones, respectively. This result indicates that the rehabilitated well system has adequate capacity to supply the entire near-term system during MDD conditions.

Table 6 – Near-Term System Low Zone Water Supply Results

Well Number	Location	Discharge Location	Design Capacity (mgd)	Firm Capacity (mgd)
16	1011 W. 6th St	Walnut	2.88	2.88
18	2401 N. Bristol St	Garthe	2.88	2.88
20	4426 W. 1st St	West	4.32	4.32
21	4426 W. 1st St	West	4.32	4.32
24	1800 W. 22nd St	Garthe	2.59	2.59
26	1730 S. Santa Fe	East	3.60	3.60
29	S/E First St. and Flower St	Walnut	3.60	3.60
30	4426 W. 1st St	West	4.32	4.32
31	1815 E. Chestnut St	Low Zone (system)	4.32	4.32
32	2801 N. Westwood	Low Zone (system)	4.00	4.00
33	917 W. Walnut St	Walnut	4.03	4.03
34	1727 W. Alton Ave	South	3.60	3.60

Well Number	Location	Discharge Location	Design Capacity (mgd)	Firm Capacity (mgd)
35	1718 N. Sydney Pl	Low Zone (system)	4.32	4.32
36	2415 N Bristol St	Garthe	5.18	--
37	2007 W. McFadden	Low Zone (system)	4.32	4.32
39	2315 N. Bristol St	Garthe	4.32	4.32
41	907 3/4 N Flower St	Low Zone (system)	4.32	4.32
Low Zone Total Capacity			66.93	61.74
Low Zone Maximum Day Demand			--	39.15
Capacity - Demand			--	22.60

Table 7 - Near-Term System High Zone Water Supply Results

Well Number	Location	Discharge Location	Design Capacity (mgd)	Firm Capacity (mgd)
27	730 E. Memory Ln	Crooke	3.60	3.60
28	730 E. Memory Ln	High Zone (system - Crooke)	3.60	3.60
38	2736 N. Cambridge St	High Zone (system - Cambridge)	3.60	3.60
40	1301 North Mabury St	High Zone	3.71	--
High Zone Total Capacity			--	10.80
High Zone Maximum Day Demand			--	7.96
Capacity - Demand				2.84

5.4 Buildout System Analysis

Table 8 and **Table 9** summarize the results of the water supply analysis for the existing system. The results show excess capacities of 22.0 and 2.7 mgd for the Low and High zones, respectively. This result indicates that the rehabilitated well system has adequate capacity to supply the entire system during buildout MDD conditions.

Table 8 – Buildout System Low Zone Water Supply Results

Well Number	Location	Discharge Location	Design Capacity (mgd)	Firm Capacity (mgd)
16	1011 W. 6th St	Walnut	2.88	2.88
18	2401 N. Bristol St	Garthe	2.88	2.88
20	4426 W. 1st St	West	4.32	4.32
21	4426 W. 1st St	West	4.32	4.32
24	1800 W. 22nd St	Garthe	2.59	2.59
26	1730 S. Santa Fe	East	3.60	3.60
29	S/E First St. and Flower St	Walnut	3.60	3.60
30	4426 W. 1st St	West	4.32	4.32
31	1815 E. Chestnut St	Low Zone (system)	4.32	4.32

Well Number	Location	Discharge Location	Design Capacity (mgd)	Firm Capacity (mgd)
32	2801 N. Westwood	Low Zone (system)	4.00	4.00
33	917 W. Walnut St	Walnut	4.03	4.03
34	1727 W. Alton Ave	South	3.60	3.60
35	1718 N. Sydney Pl	Low Zone (system)	4.32	4.32
36	2415 N Bristol St	Garthe	5.18	--
37	2007 W. McFadden	Low Zone (system)	4.32	4.32
39	2315 N. Bristol St	Garthe	4.32	4.32
41	907 3/4 N Flower St	Low Zone (system)	4.32	4.32
Low Zone Total Capacity			66.93	61.74
Low Zone Maximum Day Demand			--	39.77
Capacity - Demand			--	21.97

Table 9 – Buildout System High Zone Water Supply Results

Well Number	Location	Discharge Location	Design Capacity (mgd)	Firm Capacity (mgd)
27	730 E. Memory Ln	Crooke	3.60	3.60
28	730 E. Memory Ln	High Zone (system - Crooke)	3.60	3.60
38	2736 N. Cambridge St	High Zone (system - Cambridge)	3.60	3.60
40	1301 North Mabury St	High Zone	3.71	--
High Zone Total Capacity			--	10.80
High Zone Maximum Day Demand			--	8.09
Capacity - Demand			--	2.71

6   Valve Replacement Program

As a component of the *Water System Computer Modeling Project*, a pipeline criticality analysis was conducted to determine areas vulnerable to service interruption in the event of a pipeline break or other outage event. Building upon this study, a criticality analysis of water distribution system valves was performed to assist in prioritization for the City's valve replacement program.

6.1   Criticality Determination Process

Because condition assessment data was not available, valve criticality was determined through a spatial association with calculated pipeline criticality. Pipeline criticality was determined by first subdividing the City's entire system into isolated areas of contiguous service bounded by isolation valves. Pipelines associated with production (e.g. mains directly connected to wells and storage tanks) were excluded.
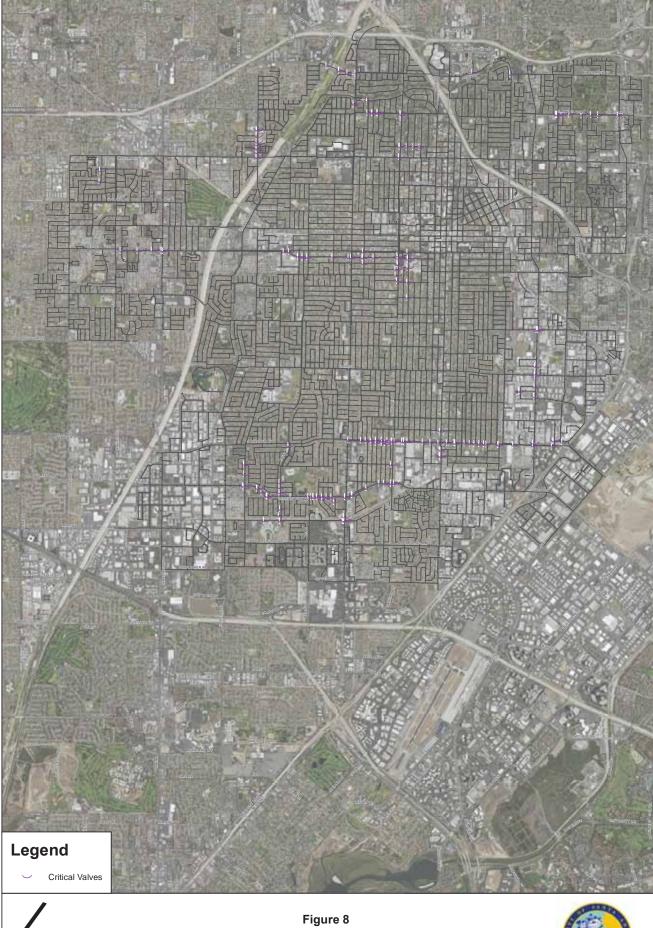
Each contiguous service area was then assigned a value for the number of customers within the area and number of isolation valves contained by the area, which were then combined and normalized to create an overall segment criticality score. This pipeline criticality score was then assigned to all corresponding valves, with valves flagged as abandoned, air, blow-off, check, reclaimed, hydrant, or fire service excluded. Valves were then ranked by criticality, with statistical analysis conducted to determine the natural break points in the criticality ranking. The top cluster corresponding to a valve criticality value of 85 and higher was selected for inclusion in the City's valve CIP list, which was cross referenced with the pipeline CIP list (Section 7, below), and all overlapping valves were removed.
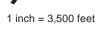
Additional prioritization of valves on the valve CIP list was not conducted, as it is recommended that the City conduct a condition assessment prior to any additional valve replacement prioritization analysis.

6.2   Documentation

Figure 8 shows the location of each critical valve. A complete list of all valves determined to be critical can be found in Appendix C5. Additionally, Figures A1-D6 in Appendix C1 show more detailed locations of each critical valve.

Legend

⌣ Critical Valves

Figure 8
Critical Valve Overview

2016 Master Plan Hydraulic Analysis
City of Santa Ana

1 inch = 3,500 feet

0   1,750   3,500   7,000
▬▬▬▬▬▬▬▬▬▬▬▬▬▬ Feet

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7 Capital Improvement Program

As a component of the Master Plan, an analysis of water distribution system pipelines and facilities was performed to assist in prioritization for the City's Capital Improvement Program. In addition to fire flow and peak hour demand deficiencies as determined by the existing, near-term, and buildout timeframe hydraulic analyses, a risk assessment was conducted on existing pipelines to determine the likelihood of failure (LOF) and consequence of failure (COF) on a per segment basis.

7.1 Likelihood of Failure Criteria

Individual scoring criteria and weights for a likelihood of failure analysis were determined through a statistical analysis of the City's historical leak repair records. Although a comprehensive examination was not possible due to the limited sample size of the data, multiple statistically significant trends were discovered. In conjunction with results of current failure analysis studies and supplemental leak data from other Southern California utilities, these trends were utilized to create LOF scoring criteria, as shown in **Table 10**, below.

Figure 9, **Figure 10**, and **Figure 11** below show water system pipeline age, pipeline material, and number of recorded leaks per pipeline segment, respectively.

Table 10 – Likelihood of Failure Scoring Criteria

	Min Value	Max Value	Individual Weight	Group Weight
Age	1	20	15%	
	21	40	18%	
	41	60	20%	5%
	61	80	22%	
	81	100	25%	

	Value (Type)		Individual Weight	Group Weight
Material	AC		15%	
	CI		45%	
	CMLC		4%	35%
	CYL		5%	
	DI		25%	
	PVC		6%	

	Modifier	Value	Individual Weight	Group Weight
# of Existing Leaks	Equal to	0	0%	
		1	30%	35%
	Greater than or Equal to	2	70%	

	Value (inches)		Individual Weight	Group Weight
Diameter	6		55%	5%
	Other		45%	

	Value (fps)		Individual Weight	Group Weight
Velocity	1		1%	
	4		4%	20%
	7		35%	
	10		60%	

Legend

Pipe Age (Years)

——	0 - 20
——	21 - 40
——	41 - 60
——	61 - 80
——	81 - 100

Figure 9
Pipeline Age

2016 Master Plan Hydraulic Analysis
City of Santa Ana

1 inch = 3,500 feet

0	1,750	3,500	7,000

Feet

Legend

Pipe Material

——	Other
——	AC
——	CI
——	CMLC
——	CYL
——	DI
——	PVC

1 inch = 3,500 feet

0	1,750	3,500	7,000

Feet
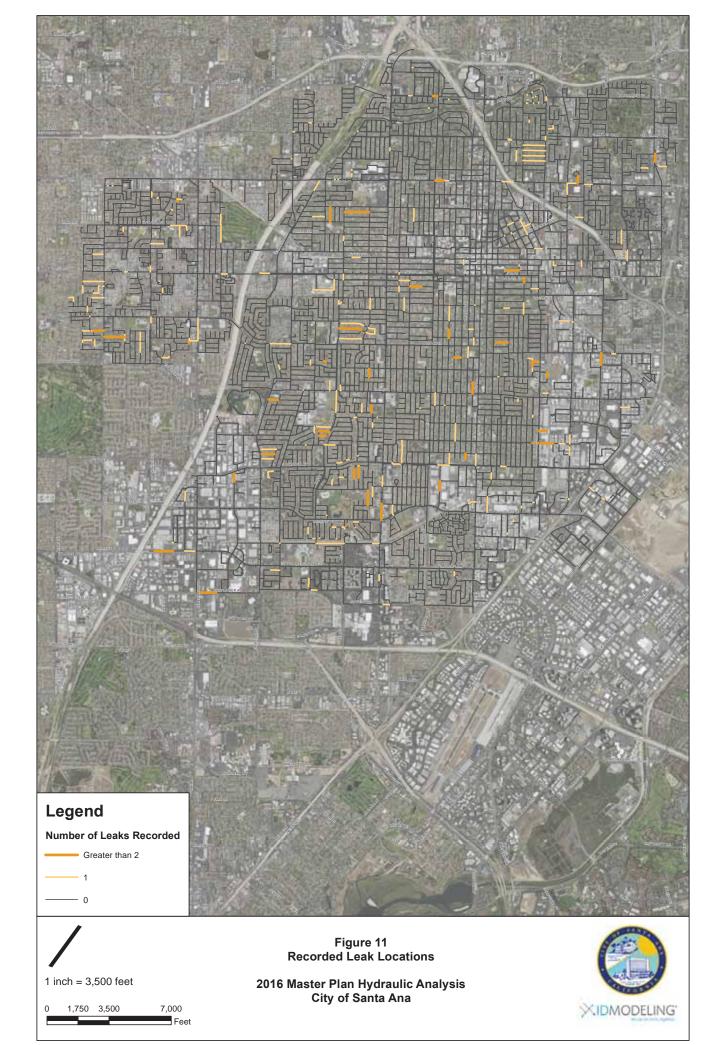
Figure 10
Pipeline Material

2016 Master Plan Hydraulic Analysis
City of Santa Ana

IDMODELING

Legend

Number of Leaks Recorded

- ▬▬ Greater than 2
- ▬▬ 1
- ─── 0

Figure 11
Recorded Leak Locations

2016 Master Plan Hydraulic Analysis
City of Santa Ana

1 inch = 3,500 feet

0	1,750	3,500		7,000

Feet

IDMODELING

7.2   Consequence of Failure Criteria
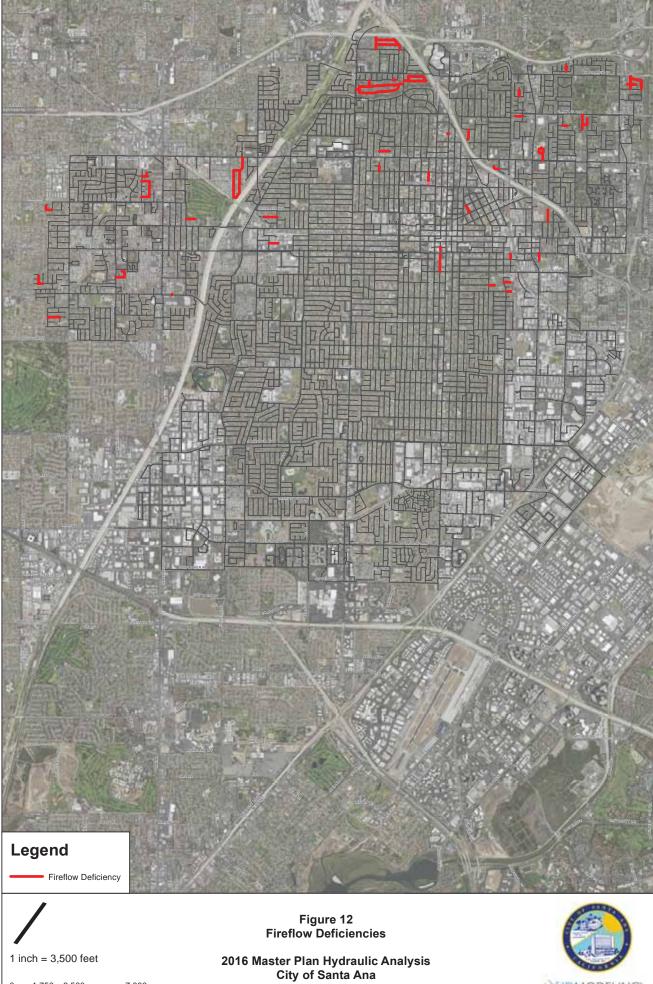
Individual scoring criteria and weights for a consequence of failure analysis was determined by three factors: flow deficiency as determined through MDD+FF (Section 4), modeled flow volume during an ADD normal operation scenario, and relative pipeline criticality (Section 6). A breakdown of COF scoring criteria is shown in **Table 11**, below.

Figure 12 and **Figure 13** below show calculated fire flow deficiencies (Section 5), and pipeline criticalities (Section 6) respectively.

Table 11 - Consequences of Failure Scoring Criteria
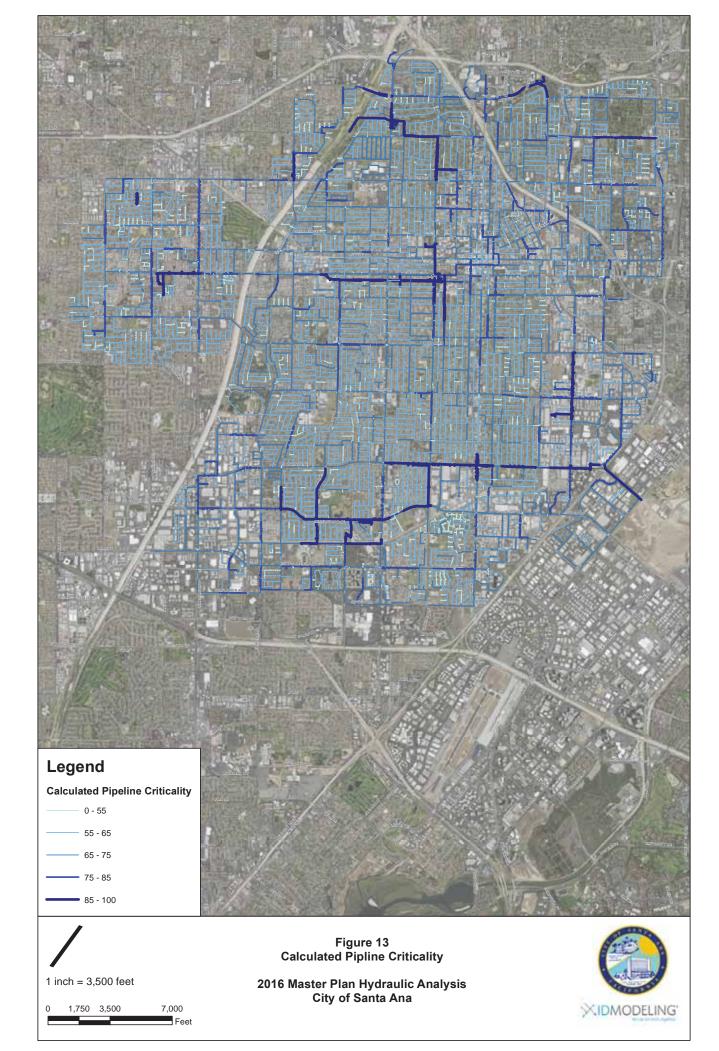
Flow Deficiency	Value	Individual Weight	Group Weight
	No	0%	50%
	Yes	100%	

Flow (gpm)	Value	Individual Weight	Group Weight
	25	5%	
	150	7%	
	500	13%	20%
	1000	25%	
	5000	50%	

Valve Criticality Score	Value	Individual Weight	Group Weight
	80	5%	
	85	15%	
	90	20%	30%
	95	25%	
	100	35%	

Legend

— Fireflow Deficiency

Figure 12
Fireflow Deficiencies

2016 Master Plan Hydraulic Analysis
City of Santa Ana

1 inch = 3,500 feet

0   1,750   3,500   7,000
                                  Feet

IDMODELING

Legend

Calculated Pipeline Criticality

——	0 - 55
——	55 - 65
——	65 - 75
——	75 - 85
——	85 - 100

**Figure 13
Calculated Pipeline Criticality**

**2016 Master Plan Hydraulic Analysis
City of Santa Ana**

1 inch = 3,500 feet

0	1,750	3,500	7,000

Feet

IDMODELING

7.3   Existing System Risk Assessment

Utilizing the above criteria, likelihood of failure and consequence of failure scores were determined for each pipeline on a segment-by-segment basis for the existing system timeframe. **Figure 14** and **Figure 15** below show the calculated scores for likelihood of failure and consequence of failure, respectively.

Legend

Likelihood of Failure Score

—— 0 - 25

—— 26 - 40

—— 41 - 100

1 inch = 3,500 feet

0   1,750   3,500   7,000
Feet

Figure 14
Existing System Likelihood of Failure

2016 Master Plan Hydraulic Analysis
City of Santa Ana

IDMODELING

Legend

Consequence of Failure Score

—— 0 - 8

—— 9 - 49

—— 50 - 100

Figure 15
Existing System Consequence of Failure

2016 Master Plan Hydraulic Analysis
City of Santa Ana

1 inch = 3,500 feet

0   1,750   3,500   7,000
|_____|_____|_____| Feet

IDMODELING

7.4　Near-Term System Risk Assessment

Utilizing the above criteria, likelihood of failure and consequence of failure scores were determined for each pipeline on a segment-by-segment basis for the near-term system timeframe. **Figure 16** and **Figure 17** below show the calculated scores for likelihood of failure and consequence of failure, respectively.

Legend

Consequence of Failure Score

——	0 - 25
——	26 - 40
——	41 - 100

1 inch = 3,500 feet

0	1,750	3,500	7,000

Feet

Figure 16
Near-Term System Likelihood of Failure

2016 Master Plan Hydraulic Analysis
City of Santa Ana

IDMODELING

Legend

Consequence of Failure Score

— 0 - 8

— 9 - 49

— 50 - 100

Figure 17
Near-Term System Consequence of Failure

2016 Master Plan Hydraulic Analysis
City of Santa Ana

1 inch = 3,500 feet

0   1,750   3,500   7,000
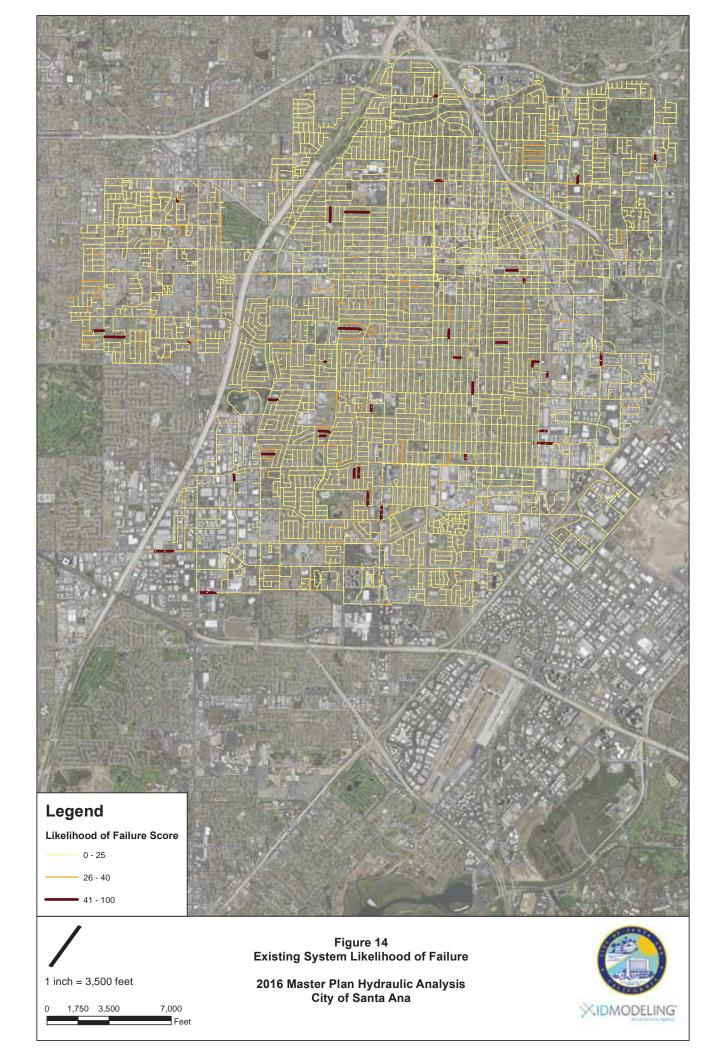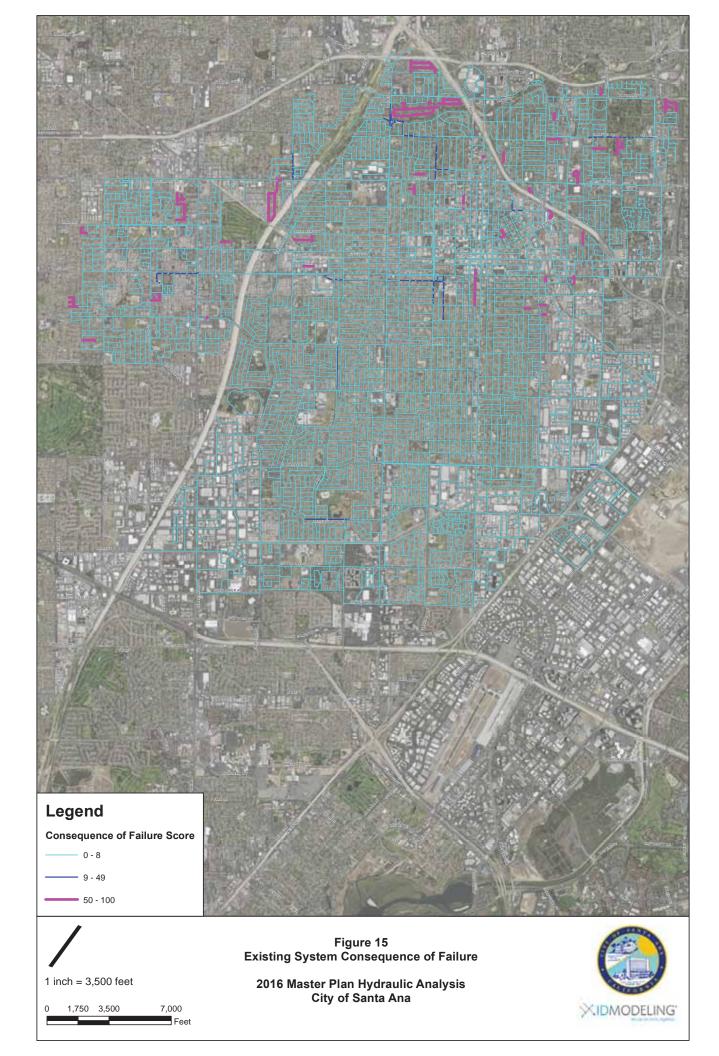   Feet

IDMODELING
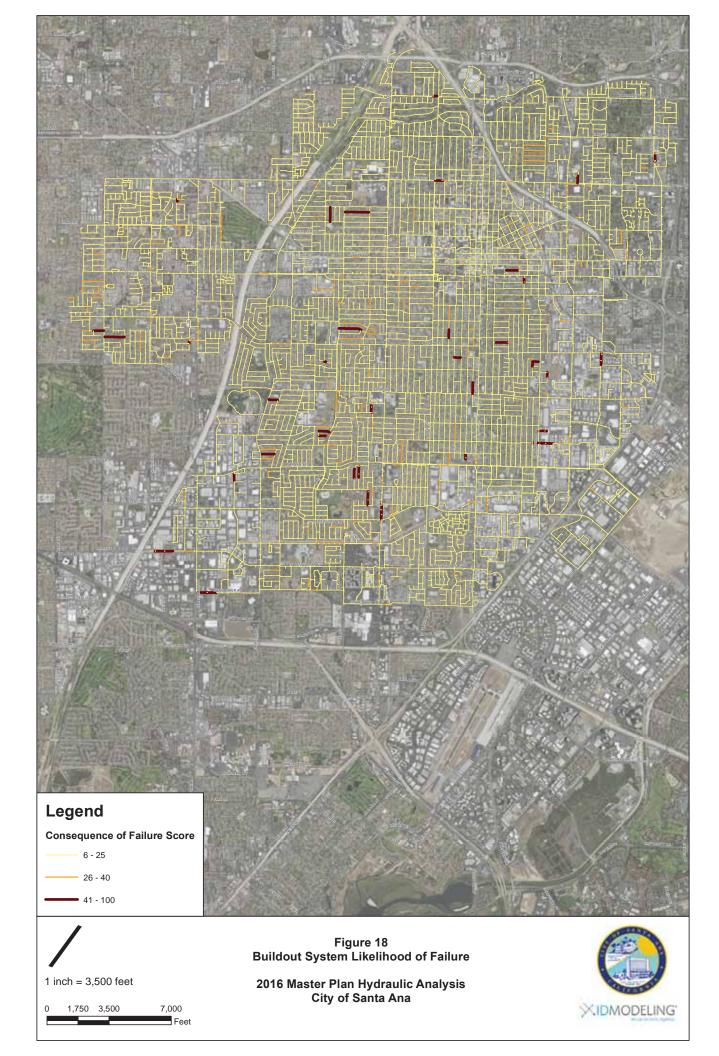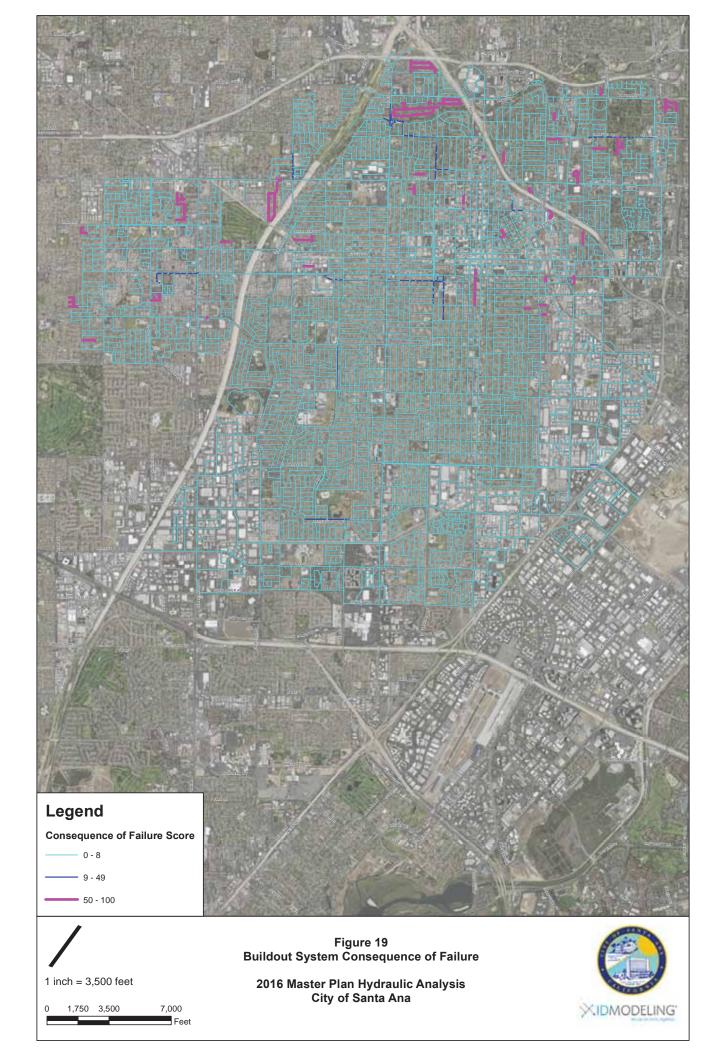
7.5 Buildout System Risk Assessment

Utilizing the above criteria, likelihood of failure and consequence of failure scores were determined for each pipeline on a segment-by-segment basis for the buildout system timeframe. **Figure 18** and **Figure 19** below show the calculated scores for likelihood of failure and consequence of failure, respectively.
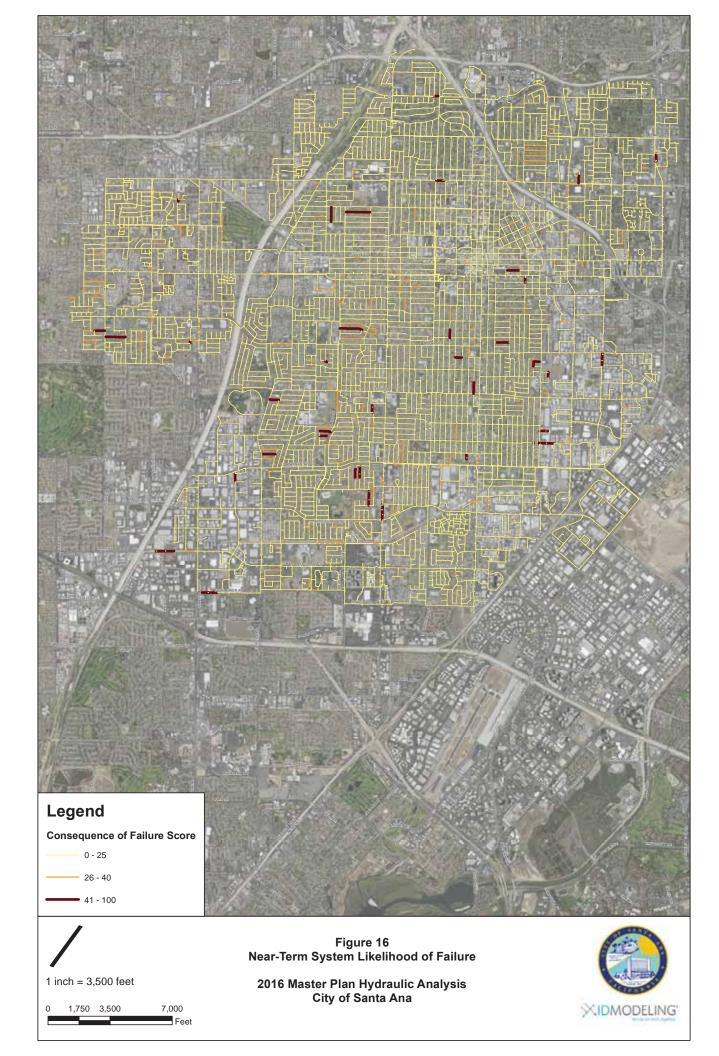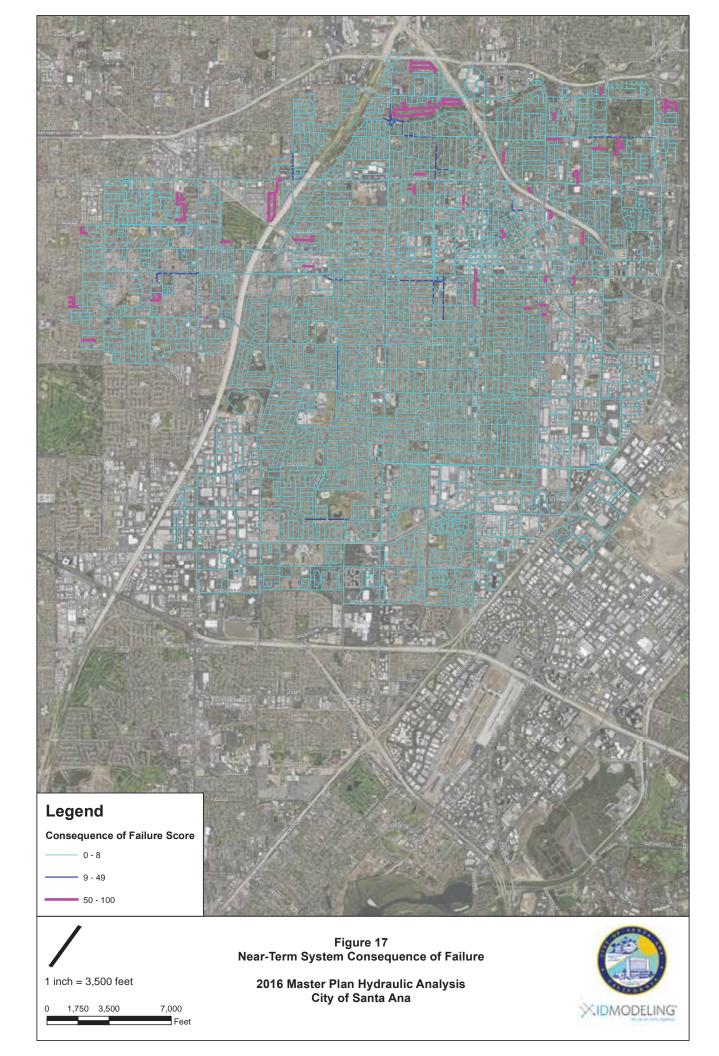
Legend

Consequence of Failure Score

- 6 - 25
- 26 - 40
- 41 - 100

1 inch = 3,500 feet

0   1,750   3,500   7,000
⊢————⊢————⊢——————————⊢ Feet

**Figure 18
Buildout System Likelihood of Failure**

**2016 Master Plan Hydraulic Analysis
City of Santa Ana**

IDMODELING

Legend

Consequence of Failure Score

— 0 - 8

— 9 - 49

— 50 - 100

Figure 19
Buildout System Consequence of Failure

2016 Master Plan Hydraulic Analysis
City of Santa Ana

1 inch = 3,500 feet

0   1,750   3,500   7,000
⊢——————⊣——————⊣——————————————⊣ Feet

IDMODELING

7.6   Capital Improvement Program Project Selection

After determining likelihood of failure scores and consequence of failure scores for each of the three timeframes, the final per segment risk analysis score was determined by taking the product of the LOF and COF scores. **Figure 20**, **Figure 2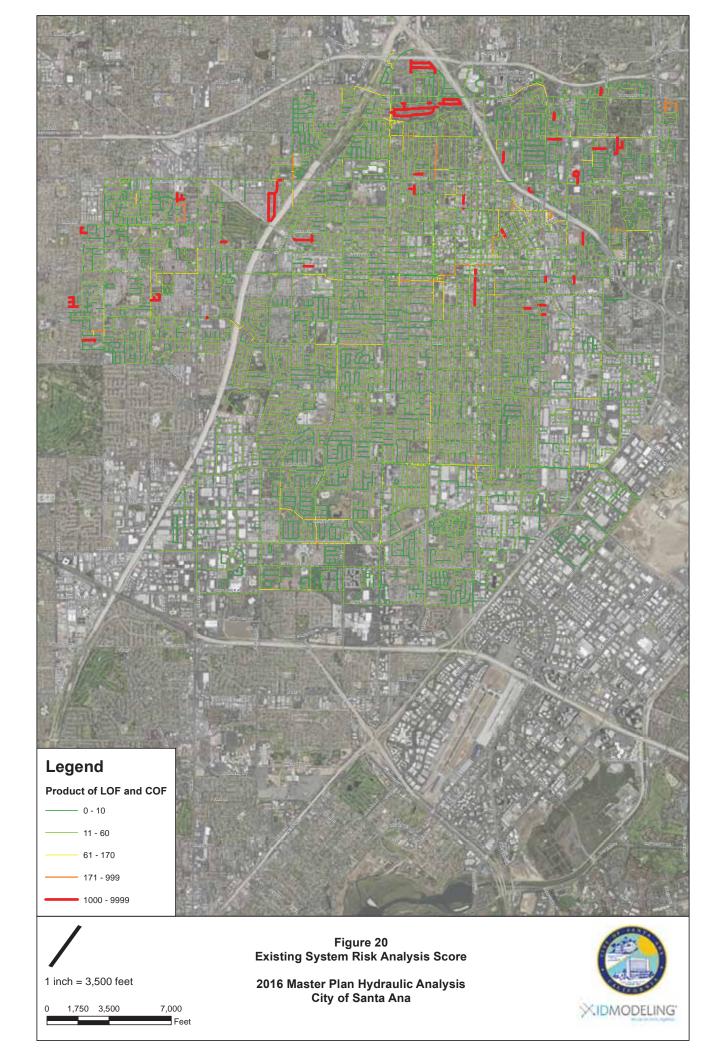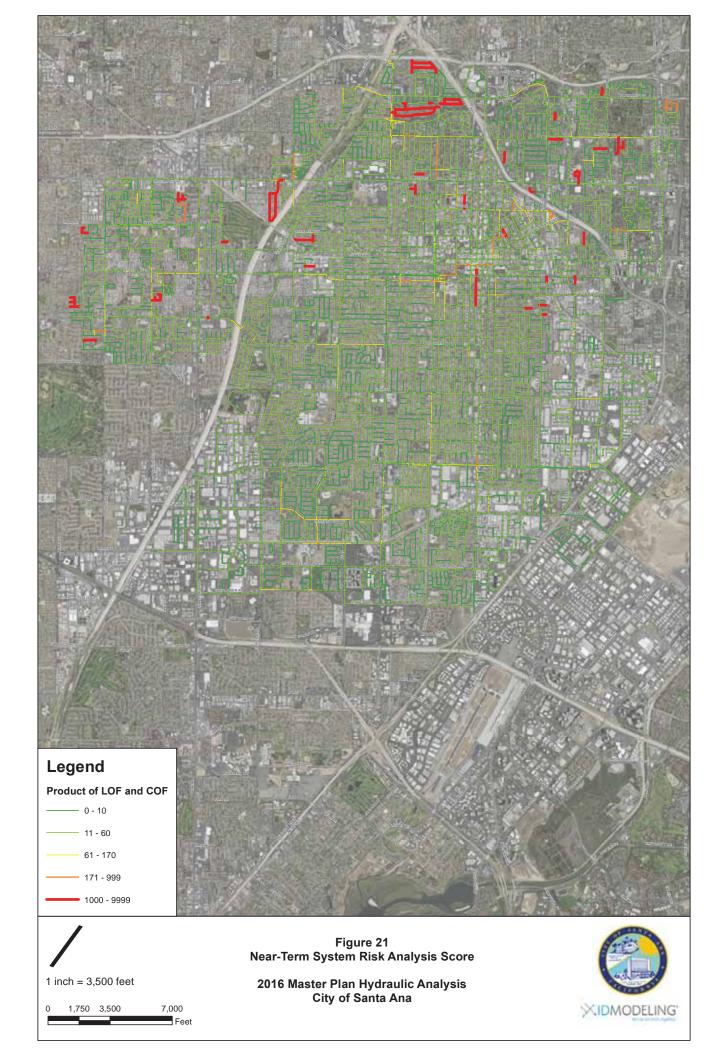1**, and **Figure 22** below show the final risk analysis (RA) scores for the existing, near-term, and buildout timeframes, respectively. As shown, per segment RA scores are similar for each timeframe.
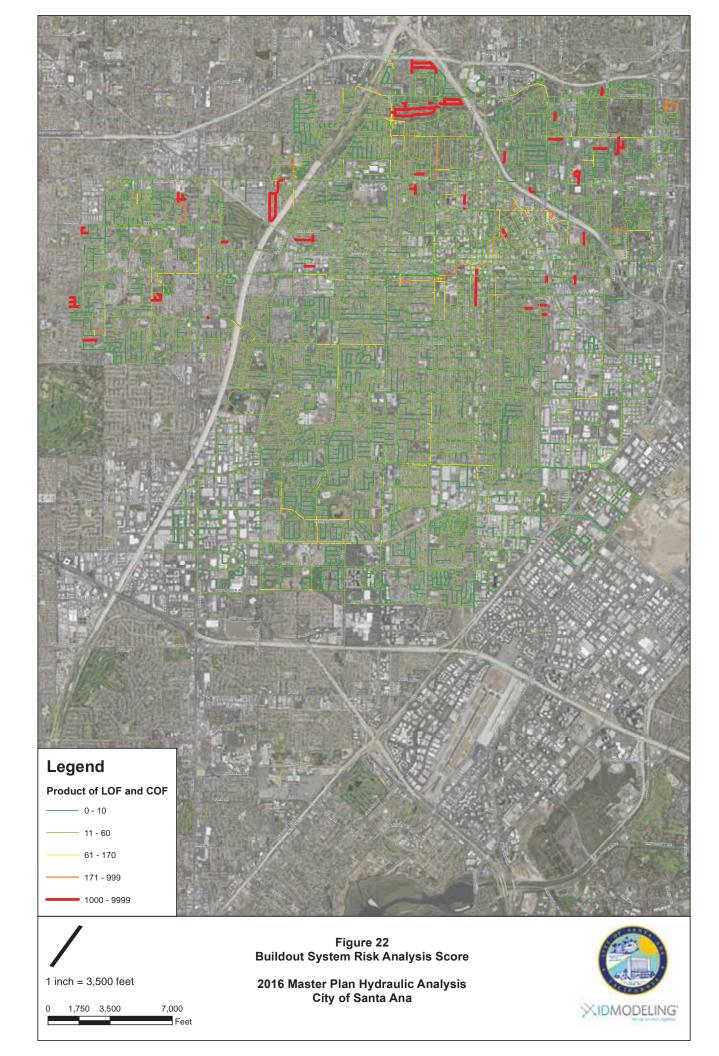
CIP projects were then created for each timeframe by determining natural breaks in each dataset, selecting segments in the top cluster, and combining them into groups geographically. Unsurprisingly, CIP projects for the existing, near-term, and buildout timeframes were identical. **Figure 23** below shows CIP projects for all timeframes.
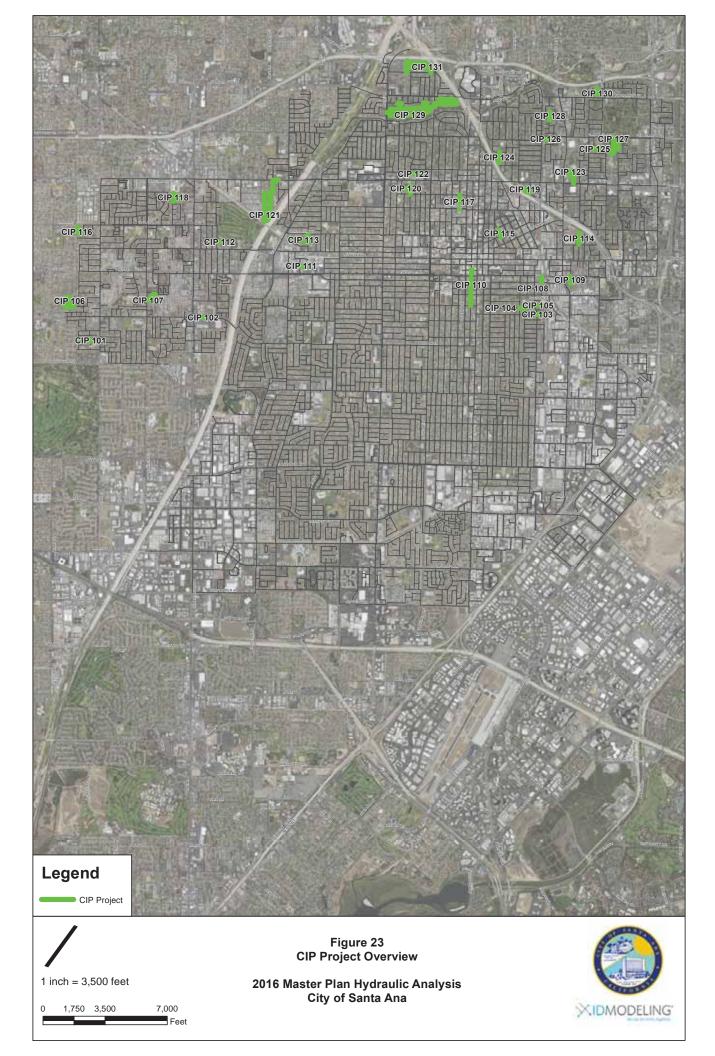
Prioritization of CIP projects for each timeframe was determined by creating a prioritization score equivalent to the sum of the highest single risk analysis score of segments in the project and the average risk analysis score of all segments in the project. Priority rankings for each CIP project are listed in Appendices C2, C3, and C4, respectively.

Legend

Product of LOF and COF

——	0 - 10
——	11 - 60
——	61 - 170
——	171 - 999
——	1000 - 9999

**Figure 20
Existing System Risk Analysis Score**

**2016 Master Plan Hydraulic Analysis
City of Santa Ana**

1 inch = 3,500 feet

0	1,750	3,500	7,000

Feet

IDMODELING

Legend

Product of LOF and COF

— 0 - 10
— 11 - 60
— 61 - 170
— 171 - 999
— 1000 - 9999

1 inch = 3,500 feet

0   1,750   3,500   7,000
Feet

Figure 21
Near-Term System Risk Analysis Score

2016 Master Plan Hydraulic Analysis
City of Santa Ana

IDMODELING

Legend

Product of LOF and COF

——	0 - 10
——	11 - 60
——	61 - 170
——	171 - 999
——	1000 - 9999

Figure 22
Buildout System Risk Analysis Score

2016 Master Plan Hydraulic Analysis
City of Santa Ana

1 inch = 3,500 feet

0	1,750	3,500	7,000

Feet

IDMODELING

Legend

CIP Project

Figure 23
CIP Project Overview

2016 Master Plan Hydraulic Analysis
City of Santa Ana

1 inch = 3,500 feet

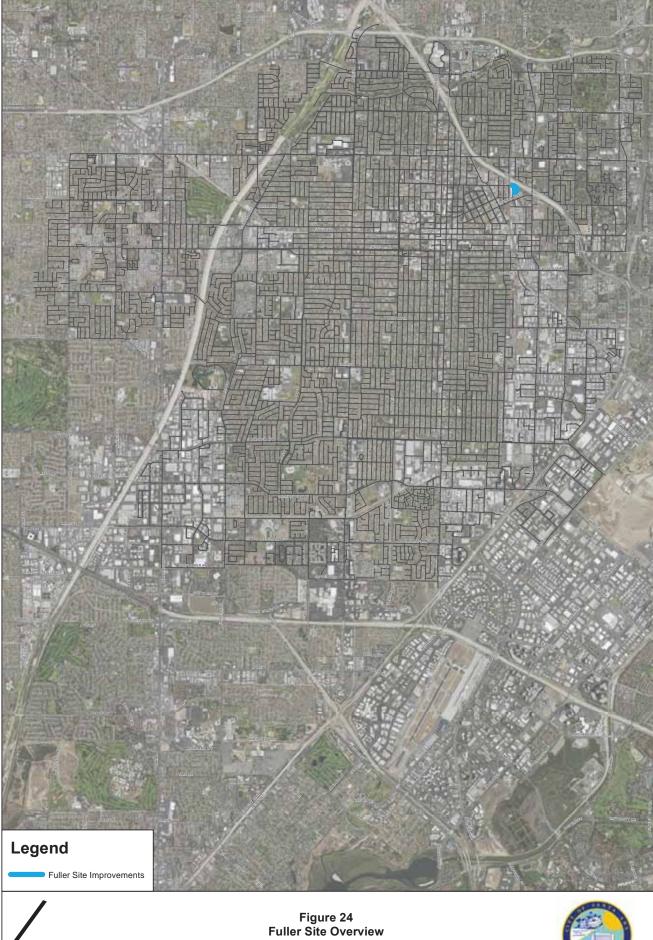0   1,750   3,500   7,000
Feet

IDMODELING

7.7   Facilities Analysis

In conjunction with Tetra Tech's on-site visits of the City's pumping facilities, it was determined that the pumps currently utilized in the City's facilities will be sufficient up to Buildout conditions. As described in more detail in the *Fuller Site Analysis* (Appendix A), a study to determine the effects of building a production site at Fuller Site was conducted, with pipeline upgrades shown on **Figure 24**, below.

Legend

━━━ Fuller Site Improvements

Figure 24
Fuller Site Overview

2016 Master Plan Hydraulic Analysis
City of Santa Ana

1 inch = 3,500 feet

| 0 | 1,750 | 3,500 | 7,000 |

Feet

IDMODELING
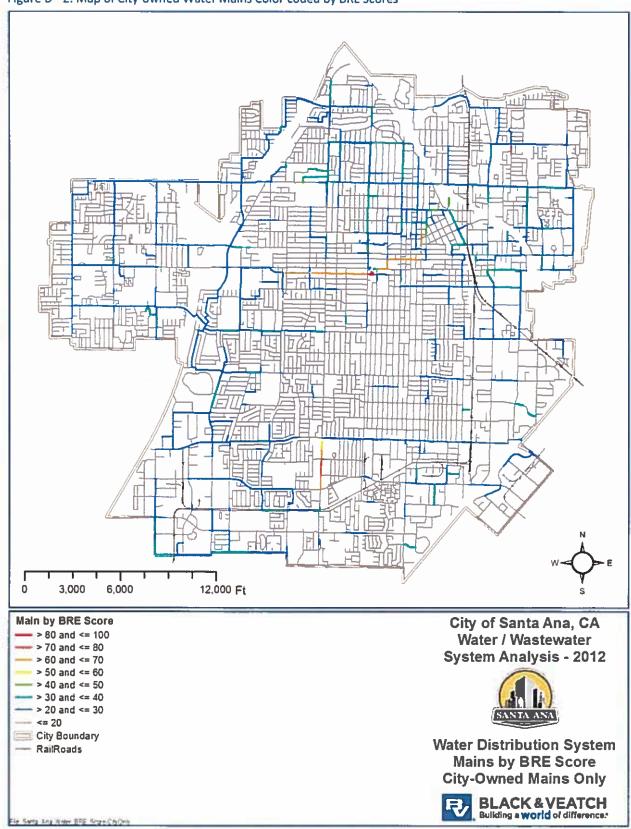
APPENDIX D
Map of Water Main – BRE Score
Black & Veatch

Figure D - 2: Map of City-owned Water Mains Color coded by BRE Scores

Main by BRE Score
- > 80 and <= 100
- > 70 and <= 80
- > 60 and <= 70
- > 50 and <= 60
- > 40 and <= 50
- > 30 and <= 40
- > 20 and <= 30
- <= 20
- City Boundary
- RailRoads

City of Santa Ana, CA
Water / Wastewater
System Analysis - 2012

Water Distribution System
Mains by BRE Score
City-Owned Mains Only

BLACK & VEATCH
Building a **world** of difference.

2017 WATER MASTER PLAN

MASTER PLAN

City of Santa Ana

TETRA TECH