City of Sonoma

Final Water Master Plan Update

GHD | 2235 Mercury Way, Suite 150, Santa Rosa California 95407

11140097 | February 2018

Final Water Master Plan Update

City of Sonoma

Project No. 11140097

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February 2018

Executive Summary

The residents, visitors, and businesses in Sonoma count on the City to deliver high quality, dependable water for drinking, cooking, cleaning dishes, hygiene, landscaping, operating restaurants, hotels, and other businesses, as well as dozens of other uses each and every day. People also count on the City to deliver the water that the Sonoma Valley Fire & Rescue Authority requires to protect the lives, homes, and property of the residents, visitors, and businesses in Sonoma and surrounding area.

The City's original water system was developed by General Vallejo in 1850. The heirs of General Vallejo operated the water system from 1875 to 1925. It was then sold to the Sonoma Water and Irrigation Company in 1926. The City of Sonoma purchased the water system in 1933; the water source came from local production wells. In 1963, the City of Sonoma began purchasing water from the Sonoma County Water Agency (SCWA). In 1970, a Thornsberry Road Area Water Assessment District was formed to fund improvements consisting of water mains and appurtenances in the vicinity of Thornsberry Road and Lovall Valley Road (outside the City limits). The City agreed to provide water services to parcels within this area. This decision was made prior to the City Council action in 1976 establishing a moratorium on water service connections outside of the City limits.

The potable water system is critical infrastructure that provides high quality, dependable water for a variety of community needs, including consumption, irrigation, and fire protection. The Water Master Plan (WMP) report includes an evaluation of City water distribution system infrastructure based on available data and planning information for current and future conditions. Generally, the WMP Update provides the City with a roadmap for the management of its potable water system.

The City of Sonoma retained GHD to update the City's existing 2011 *Water Master Plan* (WMP) by incorporating water system projects that the City has completed since 2011, revising water supply and demand data, and identifying proposed water system improvement projects for inclusion in the City's Capital Improvement Program (CIP). The proposed water system improvement projects identified in this Water Master Plan update are tailored to achieve the following objectives:

1. **Supply Reliability:** Strengthen the City's ability to reliably supply potable water based on current and planned demand.
2. **City Well Resilience:** Protect the City's potable water supply against emergencies, drought, or natural disaster by bolstering potable water supply from City wells.
3. **Public Safety:** Promote public safety by addressing system pressure and fire flow deficiencies.
4. **Cost-Effective Renewal and Replacement:** Minimize life-cycle costs by planning for the cost-effective renewal and replacement of aging water system components.

To achieve the objectives above, and to identify future water system improvement projects, a detailed technical analysis was needed. This WMP provides a description of the technical analysis and the resulting conclusions.

Capital Improvement Projects Completed 2011-2017

The City has completed several Capital Improvement Projects since the completion of the 2011 WMP. In general, these projects, which are listed below, improved water production, distribution, and reliability for the City's water system. Additional information can be found in Chapter 2.

- Zone 1-2 Intertie (2014): Improved pressure within Zone 2 east of the City Limits.
- West Napa Street Water System Replacement (2017): Improved aging water infrastructure in West Napa Street ahead of planned Caltrans improvements.
- Napa Road Waterline Extension Project (2010): Improved fire flow along Napa Road between Broadway and Larkin Drive.
- Zone 3 Expansion (2011): Improved pressure and fire flow demands in the residential area near Well 4.
- Tank Mixing: Improved water quality with the installation of a mixer at the Napa Street Tank in 2015 and in the Norrbom and Thornsberry tanks in 2017.
- East Napa Tank Improvement (2013): Improved the condition of the 2 million gallon East Napa tank by painting its exterior to protect against corrosion.
- Well 2 Improvement (2013): Improved water quality with the installation of a Cl2 tablet feeder.
- Well 8 (2016): Added water production through the conversion and development of a private well to a City well.
- Various Water Service Improvements: Improved the condition and reliability of water services through various repairs and replacement projects since 2011.

Current and Projected Potable Water Supply and Demand

The Sonoma County Water Agency (SCWA) supplies most of the City's potable water via connection to the SCWA's aqueduct and storage system. An agreement between the City and the SCWA establishes a fixed allocation of 3,000 acre feet per year (AF/Y) through 2035. Additional potable water supply is available to the City from its municipal wells. Table ES-1 summarizes the currently available water supply for the City as well as the water supply that could be made available through completion of the water system improvement projects identified in this WMP. Future supply is assumed to have the same total, as it is assumed the SCWA Contractual Entitlement will remain, and the new Well #9 CIP project is recommended for replacement of diminishing well yields in the future.

Table ES-1 Current Water Supply

Potable Water Source	Current (AF/Y)
SCWA Contractual Entitlement[1]	3,000
Well No. 1[2]	130
Well No. 2[2]	15
Well No. 3[2]	14
Well No. 4[2]	33
Well No. 5[3]	0
Well No. 6[2]	56
Well No. 7[4]	0
Well No. 8[2]	119
Total	3,367

1 Amount does not include reduction of 356 AF/Y due to allocation change adopted by SCWA in April, 2006.
2 Assumes wells are run during summer periods only and allows for recovery time.
3 Well No. 5 is on standby due to poor water quality and no sanitary seal.
4 Well No. 7 does not currently have a pump, and is inactive due to poor water quality.

Assuming a capital planning horizon of year 2040, overall demand growth is projected to be relatively flat based on a slight increase in projected population combined with recent decreases in per capita consumption. Due to an unusual drop in per capita demand between 2008 and 2015 caused by water rationing and/or drought conditions, current demand is based on adjusted data for years 2006 through 2008. The City risks underestimating future water demand if non-representative years (drought or water rationing years) are used as a baseline.

The demand projection slowly rises from current demand to a slightly higher future demand (Year 2040). Table ES-2 provides current average daily demand vs. projected daily demand at future. Peaking factors[1] of 2 and 3 were used to estimate peak day demand and peak hour demand, respectively, as described in Section 3 (Demand Analysis). It is important to note that the current available supply is 3,367 AFY or 3.01 mgd (SCWA Contractual Entitlement and total current well yields), which is significantly above both current and future demand.

Table ES-2 Current vs. Future Demand

Current Demand (mgd[1])	Future Demand– Year 2040 (mgd[1])
2.08	2.31

1 mgd = million gallons per day

Model Development and Calibration

The City's water system was modeled using Bentley's WaterCAD v8i software platform. Constructed model elements include pipes, junctions, tanks and pumping stations. Current demands were based on 2006-2008 City billing data. Future demands were based on approved land use documents and

[1] Peaking factors are a multiplier, a flow of 1 million gallons per day (mgd) for average daily flow is assumed to be 2 mgd for peak day demand and 3 mgd for peak hour demand.

demand projections included in the City's 2015 *Urban Water Management Plan* (UWMP). Billing records were geocoded to individual parcels using street address information. Calibration was performed by comparing predicted model pressures in the model to hydrant pressure/flow data (provided by City staff). Additional modifications were applied to the water model by incorporating water system projects completed since the 2011 WMP.

Recommended Capital Improvement Projects

A summary of the water system capital improvement projects that are recommended to address capacity and system deficiencies under existing/future conditions are listed in Table ES-3.

The project for renewal and replacement of existing pipelines is intended to continue beyond the five-year timeframe of projected CIP.

Overall, the City of Sonoma has historically made important investments in its water infrastructure to meet the objectives of supply reliability, resilience, and public safety. The analysis and capital projects in this Master Plan continue this tradition and financial reinvestment.

Table ES-3 Recommended 5-Year Water Capital Improvement Program

	City Objective[2]	FY 18-19	FY 19-20	FY 20-21	FY 21-22	FY 22-23	Totals
Condition Data - Phase 1	4	$18,000					$18,000
Condition Data - Phase 2	4	$115,000	$100,680	$45,000	$45,000	$45,000	$350,680
Renewal and Replacement of Existing Pipelines	1, 4			$1,099,400	$1,099,400	$1,099,400	$3,298,200
Condition Assessment of AC Pipes	1	$23,000					$23,000
Fire Flow Improvements - Upsizing AC Pipe 8" PVC	1, 3	$580,000	$580,000				$1,160,000
Fire Flow Improvements - Upsizing Unknown Pipe to 8" PVC	1, 3		$480,000				$480,000
New Well No. 9	2	$452,058	$289,500	$750,471	$750,471		$2,242,500
Meter System Upgrades	1, 4	$25,000	$75,000	$830,916	$830,916	$830,916	$2,592,748
2020 UWMP and Minor Water Master Plan Update	1, 2			$75,000			$75,000
Totals		**$1,213,058**	**$1,525,180**	**$2,800,787**	**$2,725,787**	**$1,975,316**	**$10,240,128**

[2] City Objectives 1 – 4 are listed in the beginning of this Executive Summary

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List of Acronyms

AACE	Association for the Advancement of Cost Engineering, International
ABAG	Association of Bay Area Governments
AC	asbestos cement
ACP	asbestos cement pipe
AF	acre-feet
AFD	acre-feet per day
AF/Y	acre-feet per year
AMI	Advanced Metering Infrastructure
AMR	Automatic Meter Readin
ASR	Aquifer Storage and Recovery
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
BST	booster pumping station
CDPH	California Department of Public Health
CEQA	California Environmental Quality Act
CIP	Capital Improvement Program
CMMS	Computerized maintenance and monitoring system
DI	Ductile Iron
DWR	Department of Water Resources
EBIT	Earnings Before Interest & Tax
EIR	Environmental Impact Report
ENR CCI	Engineering News Record Construction Cost Index
ft	feet
GIS	Geographic Information System
gpcd	gallons per capita per day
gpd	gallons per day
gpm	gallons per minute
Hp	horsepower
MDM	Meter Data Management
MDR	Metrological Description Ratio
MG	million gallons

mgd	million gallons per day
MOU	Memorandum of Understanding
NPV	Net Present Value
PE	polyethylene
PG&E	Pacific Gas and Electric Company
PRV	pressure reducing valve
psi	pounds per square inch
PVC	polyvinylchloride
RAV	Reasonably Available Volume
R&R	Renewal and Replacement
SCADA	Supervisory Control And Data Acquisition
SCWA	Sonoma County Water Agency
SDC	Sonoma Developmental Center
STL	steel
SVCSD	Sonoma Valley County Sanitation District
TRSY	Total Right or Safe Yield
UNK	unknown
UWMP	Urban Water Management Plan
VOMWD	Valley of the Moon Water District
WAC	Water Advisory Committee
WMP	Water Master Plan
WWTF	Wastewater Treatment Facility

1. Introduction

The City of Sonoma retained GHD to update the City's existing 2011 *Water Master Plan* (WMP) by incorporating water system projects that the City has completed since 2011, revising water supply and demand data, and identifying proposed water system improvement projects for inclusion in the City's Capital Improvement Program (CIP).

The City owns and maintains 54.8 miles of water main, ranging in diameter from 4 to 14-inches. These pipelines connect City water customers and fire hydrants to the City's water supply provided by the Sonoma Aqueduct and City municipal wells. The Sonoma County Water Agency (SCWA) supplies water through the Aqueduct into two tanks totaling 10 million gallons. The City also owns and operates three water storage tanks that are used to maintain sufficient hydraulic performance within the water distribution system. In the event of an emergency which results in a loss of aqueduct water supply, City wells will be the only source of water for the community.

The City currently provides potable water to approximately 4,400 connections within their service area. Historically, most of the City's water has been provided by the SCWA, with the balance provided by City-owned wells. The City limits and additional water service areas are shown in Figure 1-1.

1.1 History of City Water System

The City's original water system was developed by General Vallejo in 1850. The heirs of General Vallejo operated the water system from 1875 to 1925. It was then sold to the Sonoma Water and Irrigation Company in 1926. The City of Sonoma purchased the water system in 1933; the water source came from local production wells. In 1963, the City of Sonoma began purchasing water from the Sonoma County Water Agency (SCWA). In 1970, a Thornsberry Road Area Water Assessment District was formed to fund improvements consisting of water mains and appurtenances in the vicinity of Thornsberry Road and Lovall Valley Road (outside the City limits). The City agreed to provide water services to parcels within this area. This decision was made prior to the City Council action in 1976 establishing a moratorium on water service connections outside of the City limits.

1.2 Purpose

The purpose of this Master Plan is to establish a CIP for the City's water system infrastructure by analyzing water supply vs. current/projected water demands, and entering this information in the water distribution system model to identify operational deficiencies and required improvements. The plan also uses City geographic information system (GIS) records to identify water system components that are at a higher risk for failure due to age and condition (i.e., asbestos cement pipe), with the purpose of identifying renewal and replacement strategies for those assets. Specifically, the Plan identifies the following existing infrastructure:

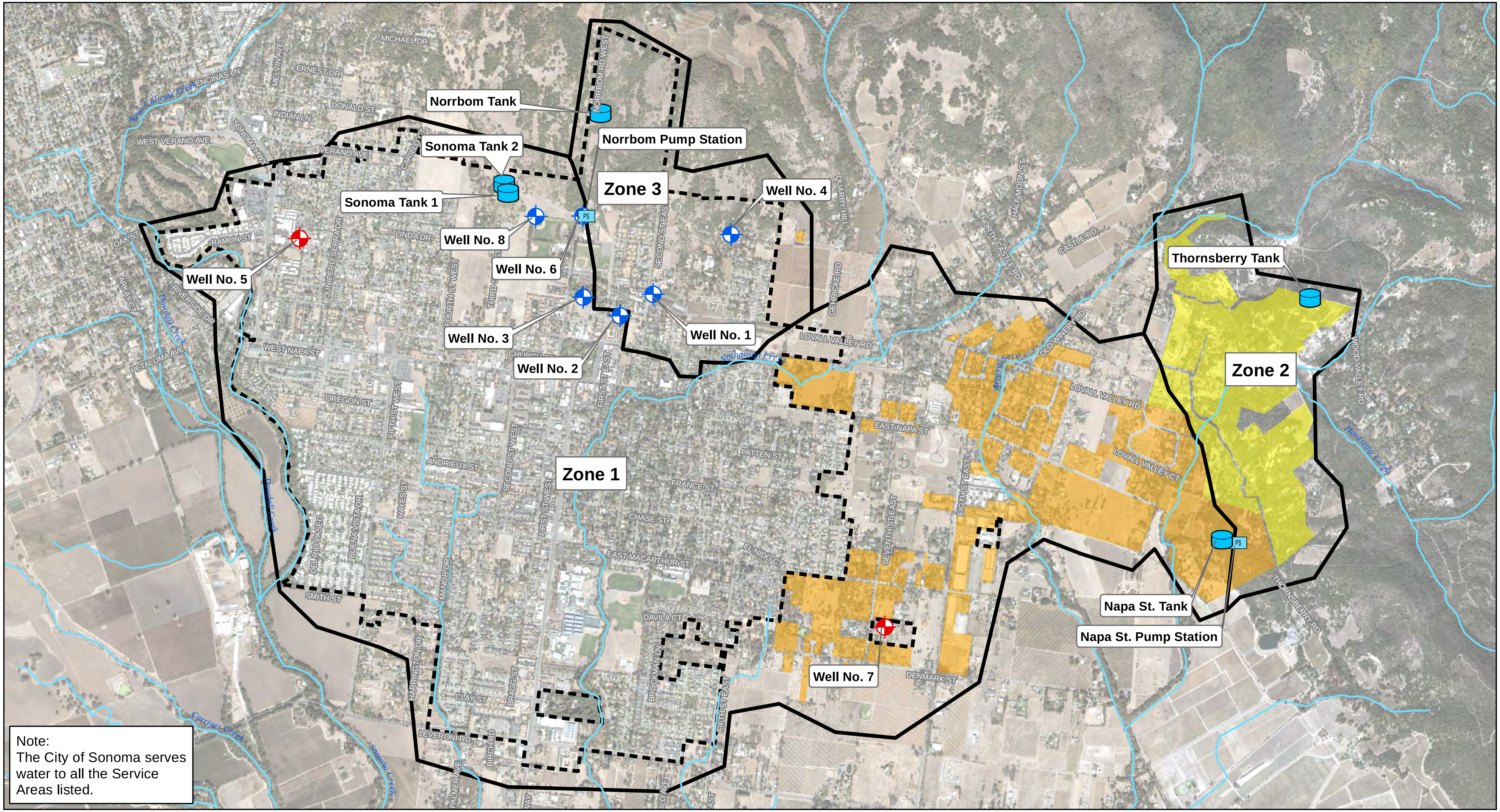
- Storage tanks;
- Distribution piping arrangement; and
- Water supplies.

This document also includes:

- Estimates of current and future demands;
- Analysis of supply capacity;
- Analysis of delivery pressures;
- Analysis of storage; and a
- Capital improvement program.

1.3 Objectives and Scope

The objective of the work is to define water system improvements necessary to ensure a reliable and efficient water system by documenting and analyzing key elements of the City's existing potable water facilities, including renewal and replacement of aging pipelines and wells.



Paper Size ANSI B

0 500 1,000 1,500

Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California II FIPS 0402 Feet

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- Tank
- Pump Station
- Production Well
- Non-Production Well
- Mains
- Creeks
- Pressure Zones
- City Limits
- Outside Service Area
- Thornsberry A.D. Service Area

City of Sonoma
Water Master Plan Update

Job Number	11140097
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City of Sonoma
Service Area

Figure 1-1

\\ghdnet\ghd\US\Santa Rosa\Projects\111\11140097 Sonoma Water Master Plan Update\08-GIS\Maps\Deliverables\FINAL\1-1 City of Sonoma Service Area.mxd

Data source: Sonoma Veg Mapping, Imagery, 2013; City of Sonoma GIS, Water Utility, Roads and Streams, 2010; GHD, Water Demands, 2017. Created by:lphilbert

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2. Summary of Existing Potable Water Facilities

2.1 Existing Storage Facilities

Each of the three zones in the City's distribution system is served by a City-owned storage tank. A summary of the City's tanks is provided in Table 2-1 below.

Table 2-1 Existing City-Owned Storage Facilities

Tank Name	Capacity [MG[1]]	Overflow Elevation [ft]	Floor Elevation [ft]	Year Built	Type	Zone Served
Napa Street	2.0	230	198	1990	Welded steel	1
Thornsberry	0.5	547.7	517.7	1971	Welded steel	1 & 2
Norrbom	3.0	314.5	285	2002	Welded steel	1 & 3

[1]MG = million gallons

In addition to the three tanks listed above, the City owns an existing 50,000-gallon wood-stave tank that was constructed in 1984. However, this tank has essentially been abandoned because it is lower (overflow elevation of 233') than the normal hydraulic grade line for Zone 1 (230' – 260'), and would require a dedicated booster pump to move water from the tank back into the distribution system.

The Norrbom tank serves both Zone 1 and 3 through pressure reducing valves. The Thornsberry tank serves Zone 1 through a pressure reducing valve. A tank mixer was installed at the Napa Street Tank in 2015 and in the Norrbom and Thornsberry tanks in 2017. The Napa Street Tank had the exterior painted in 2013 for condition improvements.

Since the 2011 Water Master Plan, two new projects were implemented that affect the pressure zones. The Zone 1-2 intertie is a new 8-inch pipeline intertie (along Lovall Valley Road) connecting Zone 2 (higher pressure system) to Zone 1 (lower pressure system). This intertie increases pressures in Zone 1 during periods of high demand, as well as improved water quality resulting from greater turnover in the Napa St. and Thornsberry storage tanks. Zone 3 was expanded by installing a 10-inch check valve on Fourth Street East and selectively installing/opening/closing specific isolation valves in the Zone 1 system. The purpose of the Zone 3 expansion project was to meet pressure and fire flow demands in residential area near Well No. 4.

2.2 Distribution system

The water system consists of three pressure zones that are each served by one or more storage tanks. Most of the system is contained within Zone 1, which operates at a hydraulic grade between elevations 260' – 212'. Potable water from SCWA is delivered to two SCWA tanks located in the northwest corner of the distribution system, which feeds Zone 1 via a 16-inch aqueduct. The distribution system is shown on Figure 2-1. City maintained water mains are asbestos-cement (AC), polyvinylchloride (PVC), polyethylene (PE), Ductile Iron (DI), and Steel (STL) with sizes that range between 4-inches and14-inches. Tables 2-2 and 2-3 below provide a breakdown of the different pipe sizes by diameter and material, respectively. Approximately half of the water system pipelines are AC pipe.

There have been two improvement projects for the water distribution system since the previous master plan.

The West Napa Street Water System Replacement Project was completed in 2017 and improved aging water infrastructure along West Napa Street ahead of planned Caltrans street improvements. The existing ACP water main along West Napa Street between Sonoma Highway and approximately Fifth Street West was replaced with a new water main, along with new water main connections at intersecting streets. The project also included the replacement of various water services between Sonoma Highway and First Street West, and the installation of fire hydrants to improve fire protection infrastructure in the project area.

The Napa Road Waterline Extension Project was completed in 2010 and improved fire flow in the project area along Napa Road between Broadway and Larkin Drive.

Additionally, the City has replaced water service lines in several areas. In 2013, the City replaced water service lines at Maxwell Village Shopping Center. In 2017, the City replaced the service lines at El Nido Court, Aureo Court, and part of Avenue Del Oro. The service lines along West Napa Street were also replaced as part of the West Napa Street Water System Replacement Project.

Table 2-2 Pipe Diameter Summary

Nominal Diameter [inches]	Total Length [ft]
4	3,643
6	49,671
8	159,655
10	40,898
12	27,812
14	7,910

Table 2-3 Pipe Material Summary

Nominal Diameter [inches]	Total Length [ft]
Asbestos-Cement (AC)	136,275
Ductile Iron (DI)	4,068
Polyethylene (PE)	50
Polyvinylchloride (PVC)	116,956
Steel (STL)	1,251

Nominal Diameter [inches]	Total Length [ft]
Unknown (UNK)	30,668

Current Meter System

The City currently operates a system of 4,378 mechanical water meters. The meters are mostly Neptune T-10 meters that have a rotating disc-measuring chamber and a Metrological Description Ratio (MDR) of approximately 1:50 within a ±2% accuracy envelope. An MDR describes the flow range capability of a water meter as a ratio of the permanent flowrate divided by the minimum flow rate. This ratio helps illustrate the degree with which the meter can accurately measure both high and low flows. Meters with smaller MDRs and narrower accuracy envelopes minimize apparent losses, which typically occur when the meter is reading low flows (e.g. leaks). A MDR of 1:50 is considered low. Internationally most metering technologies can achieve 1:150. The modern solid state digital electronics can achieve higher than 1:500.

The City's fleet of mechanical meters are read using an automatic meter reading (AMR) system that remotely reads meters with a drive-by system consisting of 900i Encoder electronics attached to the existing mechanical meters. The existing system is a hybrid-mechanical metering system.

A summary of the City's existing meter fleet is provided in Table 2-4.

Table 2-4 Existing Water Meter Fleet

Description	Number of Meters	Percentage
Single family residential	3,330	76.1
Multifamily residential	253	5.8
Commercial / Municipal	361	8.2
Irrigation	284	6.5
Fire service	150	3.4
Total	4,378	100

2.3 Water Supplies

Most of the City's water is supplied from the SCWA via two storage tanks. The tanks, totaling 10 million gallons of capacity, are located in the northwest corner of the City. Water surface elevations in the tanks can range between elevation 211.6' (floor elevation) to 260.6' (overflow elevation). SCWA typically regulates the level in the tanks to an average of 30-ft in the winter, and 44-ft in the summer.

In addition to the SCWA connection, the City also owns eight potable water wells. A summary of the well information is provided in Table 2-5 below.

Table 2-5 Well Summary

Well No.	Nominal Capacity [gpm]	Current Status
1	350	Active
2	165	Active since 2012. Improved water quality with the installation of a Cl_2 tablet feeder
3	150	Active
4	90	Not operating in the last 2 years due to positive bacti samples.
5	0	Inactive emergency standby, poor water quality, no sanitary seal (standby capacity of 175 gpm[1])
6	150	Not operating in over a year because of positive bacti samples.
7	0	Inactive, poor water quality, unfinished permitting, no pump
8	320	Active

1. gpm = gallons per minute.

Well 8, completed in 2016, was installed as a CIP to the previous Water Master Plan. This well, located at the Field of Dreams Baseball Field (See Figure 2-1), was installed to provide increased groundwater water supply and system redundancy in the event an existing well must be taken out of service.

The total estimated capacity of the City's wells is approximately 1,225 gpm. The capacity of Well No. 5 is not included in this total estimate because this well is only used for emergency standby purposes. In addition, for conservative planning of available well supply, the total estimated capacity does not include the capacity of the largest single unit (Well No. 1). This results in a firm-capacity of the well system of 875 gpm.

Except for Well No. 4, the above-grade equipment at each of the well sites is in good condition. The chlorination equipment at Well No. 4 is non-operational due to parts being scavenged for repairs at other City owned chlorination systems.

The wells are started and stopped manually by the water operations staff.

Paper Size 22" x 34" (ANSI D)

0 400 800 1,200 1,600

Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California II FIPS 0402 Feet

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Tank	PRV	**Water Pipe Material & Size**	
Pump Station	Normally Closed Zone Valve	AC	PVC
Production Well	Motor Operated Valve	DI	STL
Non-Production Well	Check Valve	PE	Unknown
Creeks	Contours	Pressure Zones	City Limits

Note: Zoom in to view additional details.

City of Sonoma
Water Master Plan Update

Job Number 11140097
Revision 1
Date 10 Jan 2018

Distribution System Overview

Figure 2-1

\\ghdnet\ghd\US\Santa Rosa\Projects\111\11140097 Sonoma Water Master Plan Update\08-GIS\Maps\Deliverables\FINAL\2-1 Distribution System Overview.mxd

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:afisher2

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3. Demand Analysis

This section presents analyses of current and future (2040) potable water demand conditions, which are used to establish the standards for the adequacy of the City's potable water infrastructure.

3.1 Current Conditions

Public water system statistics for 2006, 2007, and 2008 were used to establish the current average daily demand. This is because water demand data from more recent years reflect lower water usage due to water rationing and/or drought conditions. The City risks underestimating future water demand if non-representative years (drought or water rationing years) are used as a baseline. Potable water demand data for 2010 to 2016 was obtained from the City's water billing records, which represent retail deliveries (demand) to City water customers. This data confirmed low demands compared to 2006-2008 conditions.

Maximum-day demands were estimated by applying a peaking factor of 2.0 to the average daily demands derived from the annual demand data available. This peaking factor[3] was established in a previous study that was published in 1999[4], and was based on an analysis of Wholesale water delivery (demand) recorded at the SCWA turnouts. A summary of the historical demand data is presented in Table 3-1. A map showing the spatial distribution of demand by parcel is provided in Figure 3-4, which is located at the end of this section.

Table 3-1 Summary of Historical Demands

	2006	2007	2008	Average 2006-2008
SCWA [mgd]	2.01	2.00	2.03	2.01
Wells [mgd]	0.06	0.06	0.09	0.07
Average Daily Demand [mgd]	**2.07**	**2.06**	**2.12**	**2.08**
SCWA	97%	97%	96%	97%
Wells	3%	3%	4%	3%
Estimated Peak Day Demand [mgd]	**4.14**	**4.13**	**4.24**	**4.17**

Annual potable water demand did not change significantly between 1997 and 2008. The average daily demand was 2.01 mgd in 1996 and 2.14 mgd in 1997[5]. The demand per capita decreased during the same period, from 216 gallons per capita per day (gpcd) in 1997 to 187 gpcd in 2008, a 14% reduction[6]. Increase in demand may be attributed to an increase in population. The increase was limited due to the reduction in per capita demand, which may be attributed to increased water conservation practices.

[3] Peaking factors are a multiplier, a flow of 1 million gallons per day (mgd) for average daily flow is assumed to be 2 mgd for peak day demand and 3 mgd for peak hour demand.

[4] Water System Improvement Plan, Brelje and Race, January, 1999.

[5] Water System Improvement Plan, Brelje and Race, January, 1999.

[6] Per capita demands were obtained by dividing the total water consumption, including non-residential uses, by the population.

Potable water demand data for 2006 - 2008 was obtained from the City's billing records. The zoning for each billing record was obtained by geocoding each record to the Assessor's Parcel Map using GIS software. The land-use designation for each parcel was obtained from the City's General Plan land-use map. This process allows unit-demand factors to be calculated for each zoning designation based on actual demand data as summarized in Table 3-2 below.

Table 3-2 Unit-Demand Factors for 2006 – 2008 (inside City limits)

Land Use / Zoning	Normalized Unit Flow (gallons per day / acre)
hillside residential	368
rural residential	3,271
Sonoma residential	6,697
low-density residential	902
medium-density residential	1,042
high-density residential	1,301
housing opportunity	3,465
mobile home	228
commercial	1,557
gateway commercial	2,712
mixed use	1,961
public facility	255
park	401
agriculture	2,620
wine production	164

Average daily demand for connections outside the City limits was 115,600 gpd for 2006 - 2008. Dividing the daily consumption by 796 people (population estimate for the time period) yields an average demand of 145 gpcd.

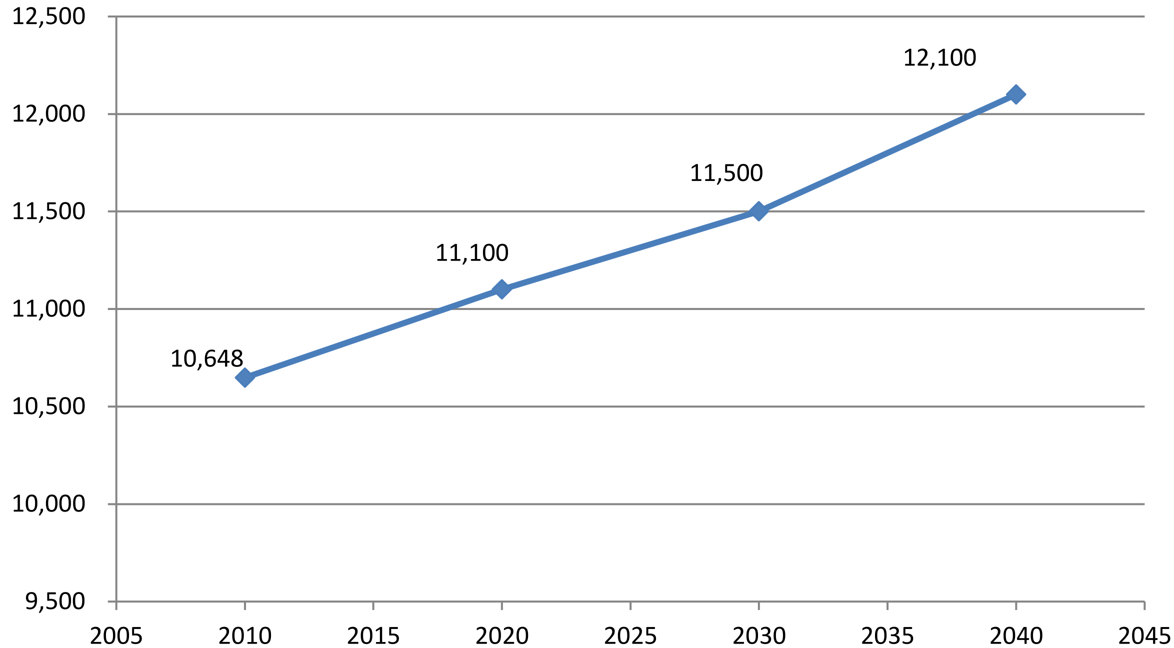
Average daily demand for connections inside the City limits was 1,964,400 gpd for 2006 - 2008. Dividing the daily consumption by 10,496 people (population estimate for the time period) yields an average demand of 187 gpcd.

3.2 Potable Water Demand at Future (2040)

The planning horizon for this study ends at the year 2040, with population projection data given by the Association of Bay Area Governments (ABAG). This data was referenced by the 2015 UWMP and the City's 2015-2023 Housing Element. For planning purposes, it is important to note the population projection data has undergone CEQA review as part of the CEQA document prepared for the Housing Element[7]. Results are shown in Figure 3-1 below.

[7] City of Sonoma 2015-2023 Housing Element. City of Sonoma. March 2015

Figure 3-1 Housing Element Population Projections[8]



The 2015 UWMP projects gallons per capita per day (gpcd) demand out until 2040 based on water conservation measures in Appendix D[9]. The City's projected gpcd demand are presented in Figure 3-2 up to 2040, with a limit of 173 gpcd, based on the SB X7-7 Target goal stated in Table ES-4 of the 2015 UWMP Appendix D. The UWMP Appendix D also describes 4 programs of conservation measures that project lower gpcd, but for the purposes of conservative planning estimates, these projections are not shown.

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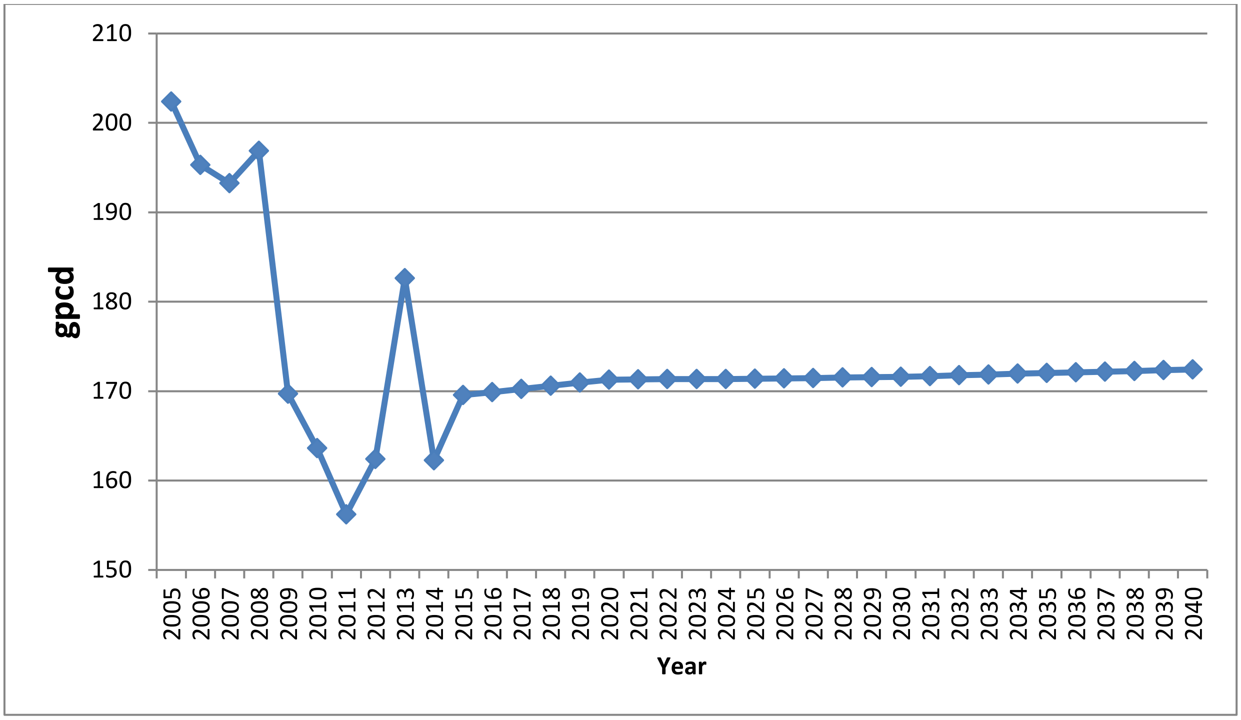
[8] Association of Bay Area Governments (ABAG). Plan Bay Area Projections, December 2013. Online: http://abag.ca.gov/planning/housing/projections13.html

[9] City of Sonoma 2015 Urban Water Management Plan Water Demand Analysis and Water Conservation Measures Update. Maddaus Water Management Inc. July 2015

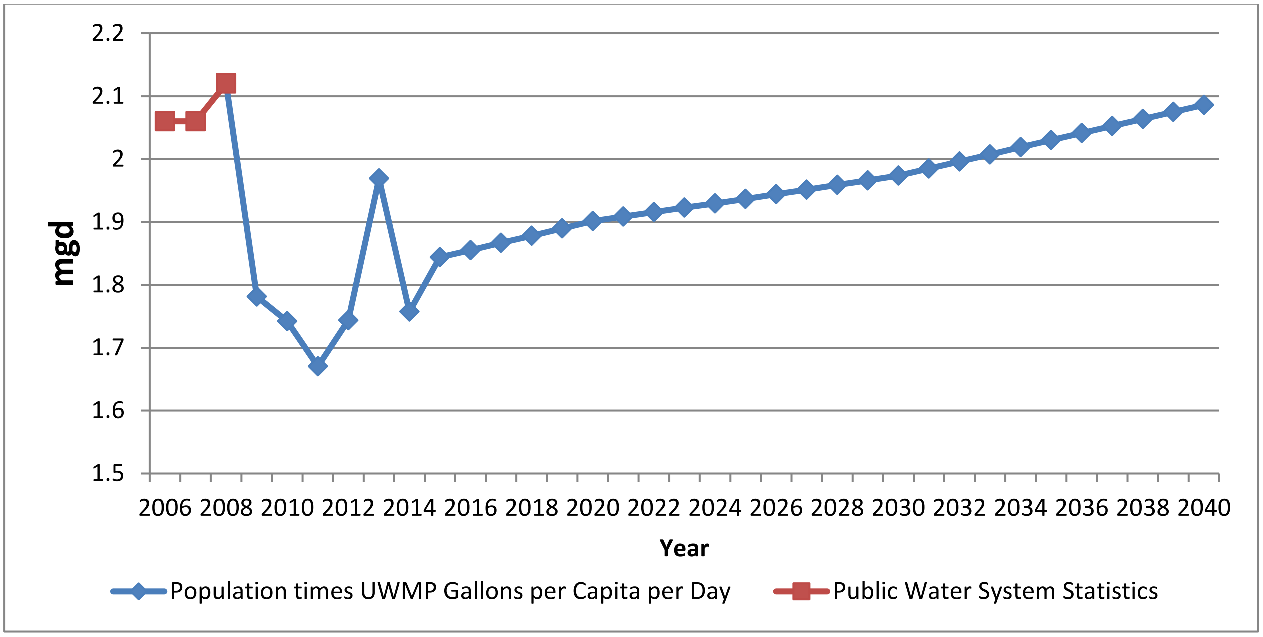
Figure 3-2 Water Conservation Program Savings Projections – SB X7-7[10]



Given population projections from Figure 3-1, and per capita demand from Figure 3-2, Figure 3-3 shows the average daily demand projections for the City solely based on population projections multiplied by gallons per capita demand.

[10] From the 2015 UWMP Appendix D. City of Sonoma 2015 Urban Water Management Plan Water Demand Analysis and Water Conservation Measures Update. Maddaus Water Management Inc. FINAL. July 1, 2015.

Figure 3-3 Population multiplied by Per Capita Demand, compared to Table 3-1



From Figure 3-3, conservative average daily demand for 2040 is projected at 2.09 mgd. For chosen current conditions, the average daily demand for 2006 – 2008 was found to be 2.08 (See Table 3-1). Since there is only 0.01 mgd difference between these two conditions, it was determined that in areas of the City where there is no planned development, the future water demand is equal to the chosen current water demand. In areas of potential development, the projected water demand of these developments would be added onto the current demand, only at the individual areas where development may occur.

For the purpose of identifying potential future operational deficiencies, the City provided a list of proposed development projects that would increase demand on the system by approximately 0.23 mgd. The demands for each project are incorporated into the 2040 model in order to assess the impacts on specific segments of the water system. From this analysis projected demand increases are mostly due to development, and the average day demand in the year 2040 is projected to be approximately 2.31 mgd (2.08 mgd + 0.23 mgd).

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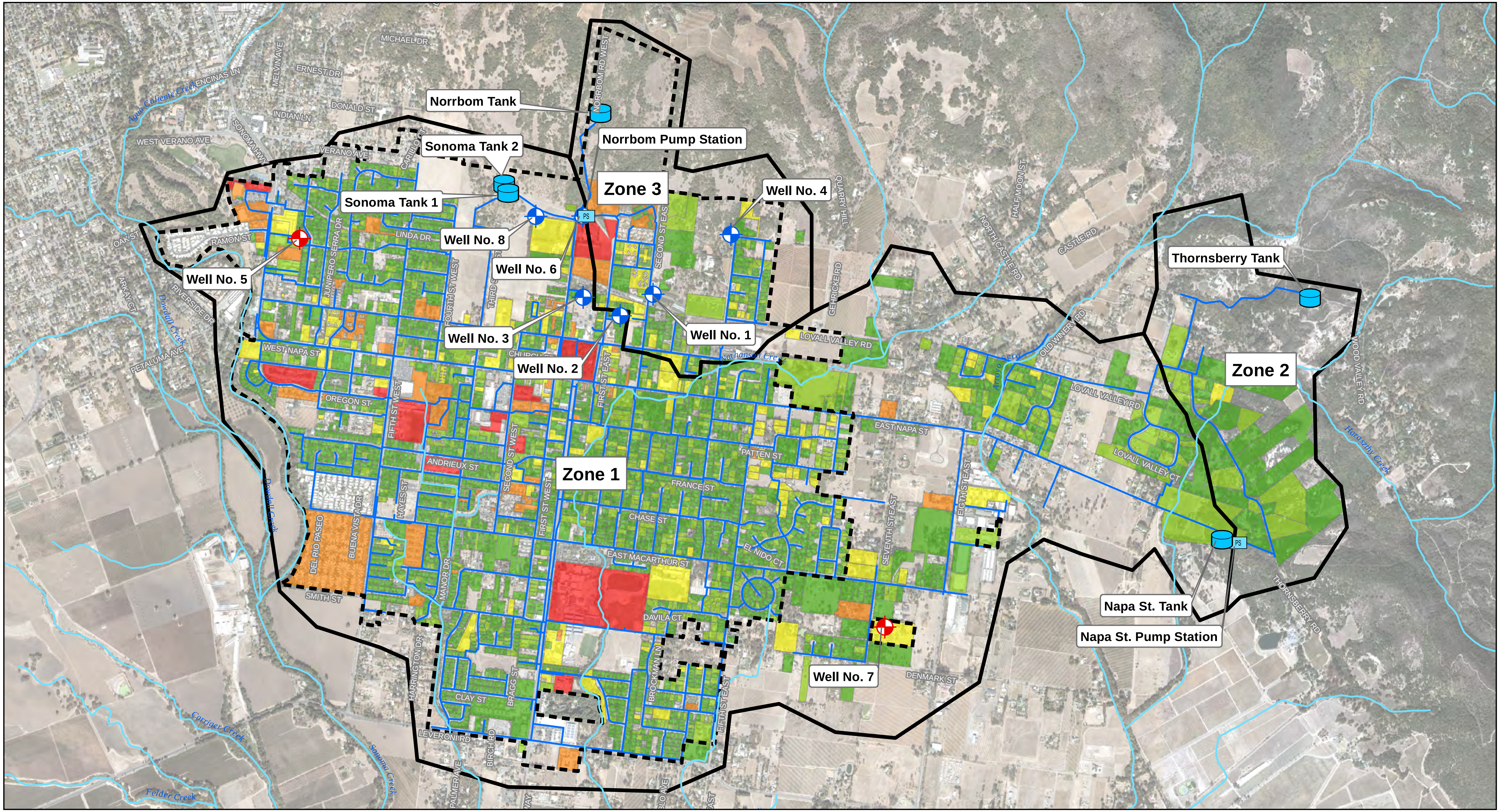

Paper Size ANSI B

0 500 1,000 1,500

Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California II FIPS 0402 Feet

N

- Tank
- PS Pump Station
- Production Well
- Non-Production Well
- Creeks
- Pressure Zones
- City Limits
- Mains

Parcel Demand (gallons per day)

- < 500
- 500 - 1,000
- 1,000 - 2,500
- 2,500 - 10,000
- > 10,000

GHD

City of Sonoma
Water Master Plan Update

2015 Potable Water Demands

Job Number	11140097
Revision	1
Date	24 Jan 2018

Figure 3-4

\\ghdnet\ghd\US\Santa Rosa\Projects\111\11140097 Sonoma Water Master Plan Update\08-GIS\Maps\Deliverables\FINAL\3-4 2015 Potable Water Demands.mxd

Data source: Sonoma Veg Mapping, Imagery, 2013; City of Sonoma GIS, Water Utility, Roads and Streams, 2010; GHD, Water Demands, 2017. Created by:lphilbert

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4. Water Supply Analysis

The water supply planning projections are evaluated in five-year increments beginning with the existing supply in year 2015 and continuing with projected supplies through year 2040. This is consistent with the planning horizon for the City's 2015 UWMP. This section was prepared in coordination with water supply documents being prepared for the City (namely the 2015 UWMP and those mentioned in the footnotes).

The City's primary water supply (approximately 95 percent) is purchased from SCWA. The majority of the SCWA water supply is comprised of surface water from the Russian River and a small contributing source is derived from groundwater wells owned by SCWA and located outside of the City's groundwater basin. In addition to the City's primary water supply (SCWA water), the City uses local groundwater supply from six municipal wells located within City limits (local supply wells). The water supply master agreement with SCWA and other water contractors was executed in 1974. Prior to 1963 when the City first connected to the SCWA water supply, the City used local groundwater as the primary water supply for the City's demands. These local supply wells provided the City with up to 600 AF/Y of water. Local supply wells currently provide the City with 374 AF/Y.

The City's current water strategy is to meet the water demands using purchased SCWA water and use local groundwater supplies to supplement water demand needs during peak periods and also during periods of drought and/or SCWA water shortages and shortfalls. The City's local groundwater supply is a key element of its drought contingency plan and it is expected to remain as such throughout the planning horizon of the 2015 UWMP. Local groundwater wells are also essential for supplying water during an emergency condition, such as an interruption in supply from SCWA.

4.1 Summary of Current and Planned Water Supply Sources

Figure 4-1 shows the general location of the City's SCWA turnout, the six active local supply wells, and the possible connection point from the Sonoma Valley County Sanitation District (SVCSD) for recycled water. The projected water year supply for each source is shown in Table 4-1, and is separated by Reasonably Available Volume (RAV) and Total Right or Safe Yield (TRSY). RAV is considered to be water usage for essentials such as washing and drinking, closely equivalent to water use in winter months. TRSY is the amount contracted through SCWA (Total Right) or the limit of groundwater pumping for sustainability (Safe Yield) as determined by the Sonoma Valley Groundwater Management Plan.

Table 4-1 Current and Planned Water Supplies – AF/Y

Water Supply Sources	2015		2020		2025		2030		2035		2040	
	Actual Volume	TRSY (b)	RAV (a)	TRSY (b)	RAV (a)	TRSY (b)	RAV (a)	TRSY (b)	RAV (a)	TRSY (b)	RAV (a)	TRSY (b)
SCWA Contractual Entitlement (c)	1,588	3,000	1,924	3,000	2,015	3,000	2,088	3,000	2,217	3,000	2,262	3,000
Local Supply Wells (d)	174	238	250	238	195	238	143	238	50	238	50	238
Recycled Water (e)			55		55		55		55		55	
Total	1,762	3,238	2,229	3,238	2,265	3,238	2,286	3,238	2,322	3,238	2,367	3,238

Notes:

a) Reasonably Available Volume

b) Total Right or Safe Yield

c) The City's entitlement under its current water supply agreement with SCWA is 3,000 acre-feet per year (AF/Y). However, due to SCWA's recent action of failing to meet its long term contractual obligation by dropping its petition to increase its water diversion permit from its current 75,000 AF/Y to 101,000 AF/Y. The City's planned SCWA water supply assumes a resultant reduction of 356 AF/Y based on the allocation methodology adopted by the SCWA Board on April 4, 2006.

d) The decline in projected groundwater volume may be accounted for by long-term groundwater-level declines, which, according to the Sonoma Valley Groundwater Management Program Five-Year Review and Update Final Report, are present in the wells southeast of the City of Sonoma.

e) Recycled Water will be distributed to the City of Sonoma beginning in 2016 via a new recycled water pipeline. Approximately 50 AF will be delivered to the Sonoma Valley Unified School District, and another 5 AF to the City's park on Engler Street.

The methodology used for demand projections for 2020 through 2040 are based on normal water use characteristics. In 2015, water use was not representative of a normal year due to drought conditions, implementation of water shortage response plans, economic recession, increases in residential and commercial vacancy, and decreases in tourism. If these conditions are experienced in future years, actual water supply use may be lower than demand projections for 2020 through 2040.

4.2 SCWA Water Supply Source

4.2.1 Description of SCWA Water Supply and Transmission System

Water is delivered to the City from a turnout located at the Sonoma Tank, which is off of First Street West in the northern end of the City. The SCWA transmission system prior to this turnout is described below.

The SCWA aqueduct system is a surface water supply from the natural flow of the Russian River, water stored in winter for later release from Lake Sonoma, and water stored in winter and other times of the year for later release from Lake Mendocino. Lake Sonoma is created by Warm Springs Dam and Coyote Dam creates Lake Mendocino. These dams are federal projects under the jurisdiction of the U.S. Army Corps of Engineers. The SCWA contracts with the Corps for water stored and released from the water supply pool of each dam. The water supply pool of Lake Sonoma is 212,000 AF and Lake Mendocino is 111,000 AF. Figure 4-2 shows a general location map of the SCWA system.

Lake Mendocino also benefits from water released into Potter Valley by Pacific Gas and Electric Company (PG&E). PG&E operates a hydropower generation station at the head of Potter Valley. Water for the power station is diverted through a tunnel from the South Fork of the Eel River via the Cape Horn Dam regulation facility. Power production is optimized by the storage of water in Lake Pillsbury (created by Scott Dam) on the South Fork of the Eel River. The water storage capacity of Lake Pillsbury is 86,400 AF. The Eel River facilities are all owned by PG&E. After a long drawn out re-licensing process, a new license for operation was obtained from the Federal Energy and Regulatory Commission. Conditions of the new license require PG&E to divert about 30 percent less water.

Using the natural channel of Dry Creek and the Russian River, SCWA diverts water from the river near Wohler Bridge via six Ranney Collectors. Each collector is fitted with a motor housing about 40 ft above streambed that pumps water into the aqueduct system. The collectors extract water from a depth of about 90 ft through an array of perforated laterals extending 140 ft horizontally in a spoke-like pattern from the bottom of each well. Water reaching the collector has therefore percolated through about 90 ft of natural sand and gravel making up the streambed of the river. The water is highly polished (has exceptionally low turbidity) and only needs the addition of chlorine to meet California Department of Public Health (CDPH) water quality criteria for a potable supply. In order to minimize corrosion, aqueduct water pH is balanced by the addition of sodium hydroxide. A system of aqueducts, booster pumps and tanks then distribute the water to the various Water Contractors. The system was designed and planned to meet peak day demands of its customers.

The existing Sonoma Aqueduct Facilities serving the City of Sonoma and Valley of the Moon Water District (VOMWD) are listed in Table 4-2 and shown in Figure 4-3. The main booster pumping station (BST) for the Sonoma Aqueduct is called the Sonoma BST and is located on the east side of Spring Lake (see Figure 4-3). Another booster pumping station is located near Glen Ellen called the Eldridge BST. Practice has shown this station to be of little use in increasing flow to the terminal end of the aqueduct, and it is generally left off-line. Finished water storage in above ground water tanks is located near Oakmont - Annadel No. 1, and Annadel No. 2 (the latter is also known as Los Guilicos Tank), Eldridge, and Sonoma near First Street West where the aqueduct terminates in two tanks having total storage of 10 MG. It is important to note that nearly all of the capacity of the Sonoma tanks is available to the City, given the location of VOMWD's upstream demands and turnouts from the Sonoma Aqueduct. This increases "local" storage directly available to the City's distribution system to a total of about 15.5 million gallons or 3,557 gallons per active connection. This exceeds the typical storage per connection commonly found in most municipal distribution systems.

Table 4-2 Sonoma Aqueduct Facilities

Description	Install Date	Size	Length (feet)
Aqueducts (Diameter, inches)			
Santa Rosa Aqueduct: Ralphine Tank to Sonoma Booster Station [(a)]	1959	27 in.	2,183
Sonoma Aqueduct: Sonoma Booster Station to Eldridge Tanks [(b)]	1963	20 in.	57,300
Sonoma Aqueduct Reach 2: Eldridge Tanks to Sonoma Tanks [(c)]	1963	16 in.	31,225
Oakmont Pipeline: Sonoma Booster Station to Oakmont [(d)]	1989	24 in.	27,607
Eldridge-Madrone Pipeline: Eldridge to Madrone Road [(e)]	2006	27 in.	8,623
Tanks (Million Gallons, MG)			
Oakmont Tank (Annadel No. 1)	1963	2.5 MG	
Los Guillicos Tank (Annadel No. 2)	1994	3.0 MG	
Eldridge Tank 1 (Sonoma Valley Park)	1963	2.0 MG	N/A
Eldridge Tank 2 (Sonoma Valley Park)	1973	6.0 MG	
Sonoma Tank 1 (First Street West, Sonoma)	1963	2.0 MG	
Sonoma Tank 2 (First Street West, Sonoma)	1993	8.0 MG	
Booster Pumps (Horsepower, Hp)			
Sonoma No. 1 (3 pumps)		900 Hp	N/A
Sonoma No. 2 (1 pump)		250 Hp	
Eldridge		75 Hp	

Notes:
(a) Owned and operated by SCWA, constructed initially by City of Santa Rosa. Restructured Agreement defines this segment and the 20-inch segment as Reach 1.
(b) The Sonoma Booster Station is located on the east side of Spring Lake.
(c) There are segments of this aqueduct where the coating is 1-inch thick. These segments are covered with a 1/8-inch coal tar coating.
(d) The Oakmont pipeline is the first parallel segment of the Aqueduct system serving the City of Sonoma.
(e) The Eldridge-Madrone pipeline is the second parallel segment of the Aqueduct system serving the City of Sonoma.

4.2.2 SCWA Water Supply Agreement

The SCWA water supply is provided for under the terms of the Restructured Water Supply Agreement dated June 23, 2006. A copy of the agreement is available at the City Public Works Department. The Restructured Agreement and the Eleventh Amended Agreement were based on the SCWA providing a water supply of 139.9 mgd during the average day of the peak month of the year. The agreements were also based on a plan whereby the SCWA would petition and obtain diversion rights from the Russian River from existing rights of 75,000 AF/Y to a total of 101,000 AF/Y. The eight signatories to the Restructured Agreement with the SCWA comprise the “Water Contractors” and are shown in Table 4-3 along with other SCWA customers. This table also includes the average daily rate of flow during any month (for an “all customer” total of 139.9 mgd) as well as the voting weight under the terms of the Restructured Agreement.

Table 4-3 Water Contractors and Customers of the SCWA Restructured Agreement

Customer of SCWA	Avg. Daily Rate of Flow During any month, mgd	Voting Weight (Percent)
Water Contractors		
Cotati	*3.8*	2.80
Petaluma	*21.8*	16.30
Rohnert Park	*15*	11.20
Santa Rosa	*56.6*	42.40
Sonoma	*6.3*	4.70
Windsor	*1.5*	1.10
North Marin Water District	*19.9*	14.90
Valley of the Moon Water District	*8.5*	6.40
Total – Water Contractors	**133.4**	**100.00**
Other Agency Customers	2.7	--
Marin Municipal Water District	3.8	--
Surplus Customers	0	--
Total – All Customers	**139.9**	**--**

Note: A detailed description of the voting power of each Water Contractor and how voting weight is determined can be found in the Restructured Agreement.

A brief description and chronology of the most current agreements are shown in Table 4-4.

Table 4-4 SCWA Water Supply Agreements Summary

Date	Agreement	Key Provisions	Status
6/23/06	Restructured Agreement	Same provisions as Eleventh Amended Agreement and allocated up to 3,000 AF/Y and 6.3 mgd peak month average daily rate; new elements include water conservation requirements, watershed planning and restoration; new governance for Water Advisory Committee (WAC)	In effect until 1/30/40
8/24/05	Extended Temporary Impairment MOU	Due to SCWA system constraints; limited the City's average day peak month flow rate from 2006 to 2008.	Expired 9/30/08
3/31/01	Temporary Impairment MOU	Due to SCWA system constraints; limited the City's average day peak month flow rate from 2006 to 2008.	Expired 9/30/05
1/26/01	Eleventh Amended Agreement	Allocated up to 3,000 AF/Y and a maximum delivery of 6.3 mgd peak month average daily rate; provided for transmission system cost allocation	Terminated and replaced with Restructured Agreement

4.3 Groundwater Supply Source

The City has eight local supply wells (Wells No. 1-8). In recent years, four wells have been used to supplement the aqueduct supply from SCWA (Wells No. 1, 2, 3, and 8) as shown in Table 4-5 (City Well Capacity) below.

Drawdown pumping tests and well analyses were conducted for Wells No. 1, 3, 4 and 6 in 2009 where the pumping capacity for each well was evaluated. The evaluation was conducted to identify pumping rate constraints on each well. These constraints considered the well construction, pumping equipment and well interference between the City's active supply wells. Based on historical groundwater elevation data, the aquifer recharges fully during the winter months and historic operation of the City's supply wells has not caused a condition of sustained aquifer overdraft. In the future it is expected that the increased frequency of use of the City's supply wells could result in localized depression of the groundwater elevation in the pumping area during the four month pumping season but water levels should recover during the winter months.

In normal and wet years, the total volume of pumping is expected to be small, on the order of 60 to 90 AF/Y. During periods of drought or under conditions where SCWA is unable to meet their water deliveries, higher pumping rates from the City's supply wells is planned. The 2015 UWMP presents 174 AF of groundwater entering the distribution system in the year 2015, a drought year. Some of the City's wells are located relatively close together and if they are pumped simultaneously then they extract groundwater from the same portion of the aquifer which induces larger depressions in groundwater elevation. In order to efficiently extract groundwater from the aquifer, it is best to stagger the operation of adjacent wells to provide for appropriate aquifer recovery and avoid pumping interference effects. The pump flow rate and maximum accumulative pumping rates for the 4-month high demand season is summarized in Table 4-5.

Two changes occurred in 2010 to increase the pumping rate from the City's supply wells. Well No. 1 received a new pump and well rehabilitation in May of 2010. Well No. 2 will be used on a limited basis for peak flow demand. Well No. 2 normal pumping rate is assumed to be the capacity of the pump because no long-term pumping tests have been completed[11], and it is assumed that the well can operate for short periods of time without restriction. As noted in Table 4-5, Wells No. 2 and No. 3 are best operated when Well No. 1 is off to avoid large and local groundwater depressions.

The total normal pumping rate of the existing active municipal wells is 367 AF/Y, and was calculated based on efficiently extracting groundwater from the aquifer using the City's existing local supply wells. Because of well interference (overlapping radii of influence from wells located near each other), an estimated pumping schedule that includes rotating operation to allow for resting of the wells and water level recovery was created (Table 4-5). This pumping schedule cycles through the wells every 6 weeks. The annual value for "maximum well pumping" is this six week schedule of operation implemented continuously for the four month pumping season of peak use.

[11] On May 31st, 2012, a basic pump test resulted in 167 gpm.

Table 4-5 City Well Capacity

Well Identification	Pump Flow Rate into Distribution (gpm) [1]	Maximum 4-Month Well Pumping Rate With Well Resting Periods(AF/Y) [2] [3]	Well Installation Date	Notes
No. 1, Second Street East	350	130	1959 Rehabilitated in 2010	Well No. 1 should not be run with Wells Nos. 2 and 3.
No. 2, Mission Terrace	165	15	1944, Active since 2012	Well No. 2 should not be run with Wells Nos. 1 and 3.
No. 3, Depot Park	150	14	1947; Relined in 2001	Well No. 3 originally yielded 200 gpm, and had a 25 Hp pump installed in 2012, which can be ramped up to 175 gpm if needed. Well No. 3 should not be run with Wells Nos. 1 and 2.
No. 4, Brazil/Fourth Street East	90 (when operational, see notes column)	33	1959; Relined in 2001	Has not been operating in the last two years (as of this writing) due to positive bacti samples. When operational, runs between 80 gpm and 100 gpm due to screens being exposed.
No. 5, Sonoma Bowl Well	0	0	1960	Inactive emergency standby, poor water quality, no sanitary seal (standby capacity of 175 gpm)
No. 6, First Street West, near Veteran's Building	150 (when operational, see notes column)	56	1956; relined in 1999	Has not been in over a year because of positive bacti samples. When operational, should not be run longer than 2 weeks at a time.
No. 7, Seventh Street East at Community Garden	0	0	2002	No pump currently in well, 100 gpm test flow, inactive due to poor water quality.
No. 8, Field of Dreams Well	320	119	2015	Drilled in 1993 and taken over by the City in 2015.
Totals	**1,225 gpm**	**367 [1]**		

Footnotes:

1 The wells should not be relied upon for more than 367 AF/Y for a 4-month pumping season.

2 Pumping rate is predicated on the assumption the wells will only be run during the summer season (June-Sept) and not year-round thus providing adequate recovery time for groundwater recharge during the rainy season.

3 Drawdown studies indicate that Wells Nos. 1, 2 and 3 should not be operated at the same time in order to avoid large interference between the three wells. Efficient operation of the system requires rest periods for wells during the pumping season to allow for groundwater recharge.

4 Currently Well No. 6 has undergone an Aquifer Storage Recover Pilot Test, and is estimated to have a long-term injection capacity of approximately 73 AF of surplus water over a six month injection season.

There are a number of operational adjustments that will efficiently extract the groundwater. The sample operational schedule below can be varied. This example accommodates the operational constraints of the individual wells to avoid large localized groundwater depressions in the well caused by overlapping radii of pumping influence. The daily average shown below is between 2.21 acre feet per day (AFD) and 4.02 AFD, but the average is 2.91 AFD. Under normal operation all the wells should not be used at the same time to avoid drawing the groundwater level down below the screen of the well or to levels for which the pump is not designed to operate. Table 4-6 below indicates a sample of the well output for peak seasonal use for 18 weeks during a drought or condition of limited SCWA deliveries.

Table 4-6 Sustainable Maximum Use of Municipal Wells Sample Schedule in AF/Week for Seasonal Peak Use

Active Well No.	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Total for 6 Weeks	Total for 4 Month Peak Seasonal Use (18 weeks)
	Acre-Feet per Week						AF/6 weeks	AF/Y
Well 1	10.83	10.83		10.83	10.83		43.31	130
Well 2						5.10	5.10	15
Well 3			4.64				4.64	14
Well 4		2.78	2.78		2.78	2.78	11.14	33
Well 6	4.64	4.64		4.64	4.64		18.56	56
Well 8		9.90	9.90		9.90	9.90	39.60	119
Totals	**15.47**	**28.15**	**17.32**	**15.47**	**28.15**	**17.79**	**122.35**	**367**
Daily Average (AFD)	2.21	4.02	2.47	2.21	4.02	2.54	Daily Average = 2.91	
Daily Average (mgd)	0.72	1.31	0.81	0.72	1.31	0.83	Daily Average = 0.95	

Note: Weekly Acre Foot Calculations are based on =GPM*60*24*7 and converted to AF.

In the case of an emergency event, where the City of Sonoma could be completely cut off from SCWA deliveries, it is important to compare City demands to the sustainable maximum use of municipal wells. Demands were analyzed from the Department of Water Resources Public Water System Statistics for the years 2014 to 2016. Total water deliveries were reported per month, and it is a conservative assumption that the minimum monthly flow for these years would be the demand in the event of an emergency. In January 2016, DWR reported 0.76 mgd. While this demand is slightly higher than the minimum supply of 0.72 mgd in Table 4-6, in actuality the demand in a state of emergency would be in a state of demand hardening, much less than the minimum monthly flow for 2014 – 2016 when there was no emergency. In addition, loss of aqueduct water supply in the event of an emergency would most likely last for one or two weeks, during which the City operators could run the wells at a daily average flow between 0.81 mgd to 1.31 mgd. A one to two-week duration is a reasonable time for an interim emergency aqueduct water supply to be provided until a permanent solution can be achieved. Section 8 includes CIP items that will enable the wells to supply enough flow in the future during a possible state of emergency.

Based on the recommendation of Winzler and Kelly Engineers (now GHD Inc.), the City moved forward with siting studies for construction of several new wells and a plan for replacement of some of the existing wells that are over 50 years old[12]. The purpose of these studies, delivered in 2010, are to supplement water demands during water shortages frequently encountered due to environmental constraints with the SCWA water supply.

An equipment summary was provided listing priorities of well improvements. The order of priority, from first to last, is Well No. 3, 1, 6, then 4. It was recommended to replace Well No. 3 (0-5 years / 2010-2015) because space is available and historical yield and specific capacity were high. Replacing Well No. 3 is a CIP item further discussed in Section 8. It was found that replacing Well No. 1 (5-15 years / 2015-2025) should be done due to old age and yield decline with continued use. Well No. 6 should be replaced (10-20 years / 2020-2030). It is also recommended to relocate the air release valve for Well No. 1 to above grade. Well No. 4 is recommended for replacement (10-20 years / 2020-2030) because yield was originally only moderate and a new well may yield 200 gpm. However, this portion of the aquifer may not be pumped by other municipal wells and therefore, could represent underutilized source water.

In the siting evaluation, it was also recommended that a new well be installed in the eastern portion of the Study Area (Well No. 8). This was also recommended as CIP No. 6 in the 2011 WMP. In June 2013, as a follow up to the 2010 siting evaluation, a well pump testing report was done for the City of Sonoma at Well No. 8, also called the Field of Dreams Well (FOD Well), an underutilized private irrigation well used for several ball fields on a long term lease to the Field of Dreams Association. Well No. 8 was taken over by the City in 2015. Although a flow rate of 425 gpm was achieved during the test, a flow rate of approximately 320 gpm was currently reported from City staff.

For planning purposes, in 2011 it was assumed from a water supply analysis[13] that there would be three new wells (Well Nos. 8, 9, and 10). Each well would theoretically yield the average amount available from the existing active wells in 2010, which was approximately 60 AF/Y per well or 180 AF/Y total (each well operating at approximately 140 gpm for the 18 week pumping peak season). Some of the existing supply wells were operating at pumping rates that are lower than when they were first installed. This reduction is due to age and modifications that were made to the wells in order to extend the operational life of the wells. These modifications resulted in a reduction of the pumping efficiency of the well and a lower total extraction rate. These trends are currently happening and are of a concern for future yields, which is why the addition of Well #9 to the City system is a CIP item, further discussed in Section 8.

Aquifer Storage and Recovery (ASR), also known as groundwater banking, would also increase the availability of groundwater for the City. ASR accelerates the recovery of groundwater in storage and allows for greater surety of supply when natural recharge is insufficient or too slow to fully recharge

[12] Expansion of City Groundwater Sources. Hydrogeologic Siting Evaluation for a Focused Area in Northwestern Sonoma. City Project #1006. Prepared by Winzler and Kelly on behalf of the City of Sonoma. October 2010. W&K Job Number 02418-10010-32102.

[13] Technical Memorandum No. 6. Sonoma Water Master Plan – Water Supply Analysis. Prepared by Winzler & Kelly on behalf of the City of Sonoma. July 2010. W&K Job Number 02418-10-019

the aquifer during the rainy season. This process allows for the extraction of groundwater during peak season demand and the recharge of the aquifer when water is available during the rainy season.

The Sonoma Well No. 6 undertook an ASR pilot testing program in 2015[14]. Conclusions were that less than 20 AF of potable surface water from the SCWA network would be recharged into the shallow and upper portions of the Intermediate Aquifer zone, through Well No. 6, at rates of up to a maximum of 90 gpm during the six month testing period of November 2015 through April 2016. At the time of this writing, the feasibility and cost of groundwater banking was unknown, and being investigated.

4.4 Sonoma Development Center Water Supply Source

The Sonoma Development Center Water Supply Source is a water supply project that provides increased reliability of customer service to all parties. The project utilizes surplus capacity in the VOMWD and Sonoma Developmental Center (SDC) water systems, captures, and makes beneficial use of off-peak water (wintertime water) available in the Russian River and off-peak capacity available in SCWA's Water Supply and Transmission System. This project increases the water supply to the City of Sonoma during water shortages, and, during critical hot spells, increases flows available in the south end of the Sonoma Aqueduct that serve VOMWD's Aqueduct Zone customers and SCWA's Sonoma tanks, and reduces competition among SCWA's Water Contractors for summertime deliveries from the Russian River. Implementation of the plan would require an agreement between the SDC, VOMWD, and City of Sonoma and the cooperation of the SCWA pursuant to provisions contained in the existing Restructured Agreement for Water Supply. Specifically, the following water system components having surplus capacity would be optimized:

SCWA System:

- Surplus water available for diversion from the Russian River in the off-peak period (February through April).
- Surplus off-peak capacity in the SCWA Water Supply and Transmission System from the intakes at the Russian River near Wohler Bridge to the metered turnout from the Sonoma Aqueduct serving SDC.

SDC System:

- Storage space in local lakes that does not fill with water in dry years.
- Surplus treatment plant capacity.

VOMWD System:

- Surplus transmission capacity available in VOM's Arnold Drive Pipeline, which parallels the Sonoma Aqueduct from Glen Ellen south to the southern terminus of Madrone Road.

At this time, the City has not been actively engaged in this project with SDC and VOMWD, and it is anticipated the discussions will become more formal and frequent. Because there has not been a

[14] Aquifer Storage and Recovery Pilot Test Work Plan Sonoma Well #6, Prepared by GEI on behalf of the Sonoma County Water Agency, Activity No. 101630, August 6, 2015

letter of understanding or even an informal agreement amongst the parties at the time of the writing of this document, this water supply source is not included in Table 4-1.

4.5 Recycled Water Supply Source

In 2005, the SCWA, on behalf of the Sonoma Valley County Sanitation District (SVCSD), VOMWD and City of Sonoma, prepared a feasibility study on use of recycled water for valley vineyards, dairies, pastures, wetland restoration sites and urban irrigation sites[15], and shortly thereafter, an Environmental Impact Report (EIR)[16]. The reports showed that a recycled water project could increase use of recycled water from the "no project" level of 1,000 to 1,200 AF/Y (primarily irrigation of pasture and use in wetland restoration) to 2,750 AF/Y. The primary users would be agriculture, but the project would include pipeline segments that would also distribute water to urban irrigation sites in the City and VOMWD service areas. The feasibility study identified 86 AF/Y for the City and 60 AF/Y for VOMWD or 146 AF/Y of potential potable water offset. This represents 3% and 2% respectively of the City and VOM's large irrigation customer demand. Increased recycled water use envisioned in the project EIR was 1,500 AF/Y. Recycled water use by large customers in the City and VOMWD make up 10% of this amount. Therefore, implementation of the project depended on the support of agriculture, mainly vineyards. Some controversy surrounds the use of recycled water on vineyards, notwithstanding that clear authorization to do so is provided by CDPH standards.

Subsequently, additional studies have been undertaken as part of a regional effort under the auspices of the North Bay Water Reuse Authority in concert with the US Bureau of Reclamation. Several phases were studied and a final EIR was completed in November 2009[17]. Phase 1 studies identified 1,972 AF/Y for the lower Sonoma Valley area. Out of that total, the City's potential recycled water use is estimated at 130 AF/Y with the City establishing a maximum amount of 80 AF/Y with the full project beyond the planning horizon of this document.

The SVCSD has constructed a recycled water pipeline from the District's wastewater facility (WWTF) on Eight Street East up to the intersection of Fifth Street East at Denmark Street. Approximately 50 AF is delivered to the Sonoma Valley Unified School District and another 5 AF will be delivered to the City of Sonoma park on Engler Street. A further study, substantially complete at the time of this WMP, analyzes the cost feasibility of extending the recycled water from the intersection of Fifth Street East and Denmark Street to the north towards various parks and fields. This Recycled Water Feasibility Analysis has determined an unfavorable cost/benefit ratio for this extension.

[15] Sonoma Valley Recycled Water Feasibility Study, Prepared by SCWA on Behalf of Sonoma Valley County Sanitation District, Valley of the Moon Water District, and City of Sonoma, December 2005

[16] Sonoma Valley Recycled Water Project Draft EIR, Prepared for Sonoma County Valley Sanitation District, September 2006

[17] North Bay Water Recycling Program, EIR/EIS, SCH# 2008072098, November 2009

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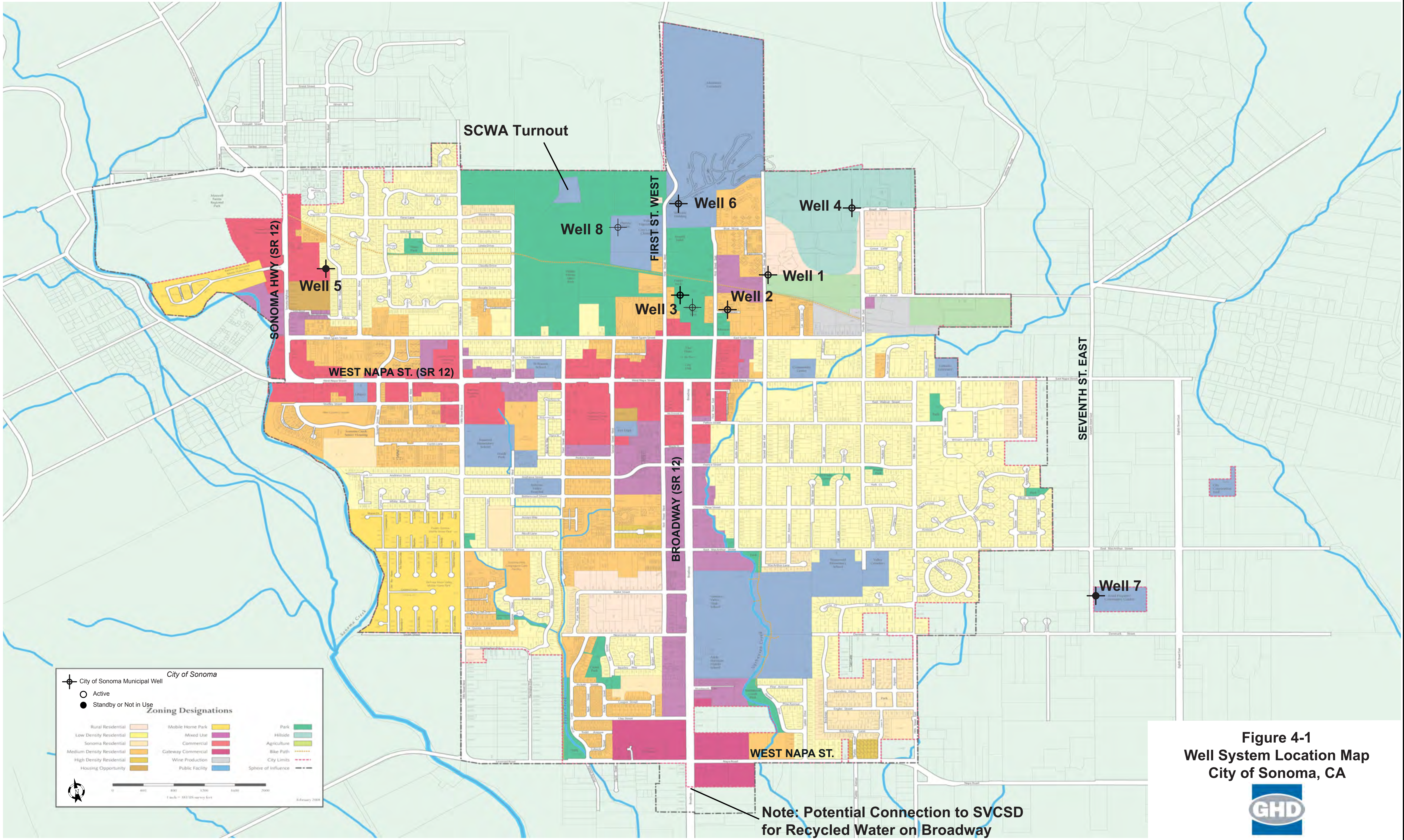

Figure 4-1
Well System Location Map
City of Sonoma, CA

J:\02418 - Sonoma\02418-10-010 Well Field Syst Plan & Expan\Figures\Well Location Map.indd

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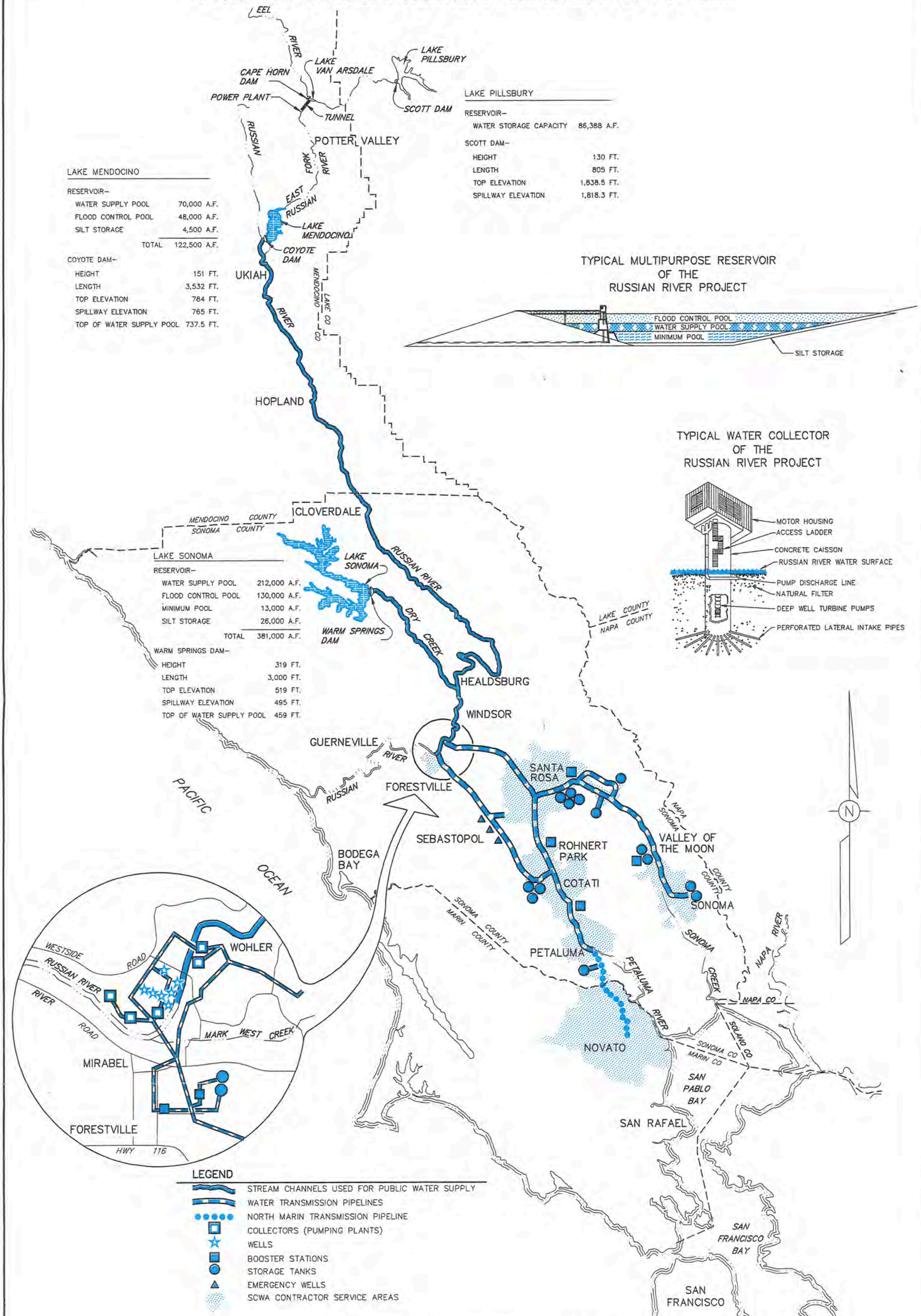
\WATER TRANMISS\ 'NERAL\WATSY-17 SEPT 9, 1998

THE RUSSIAN RIVER WATER SYSTEM



GENERAL LOCATION MAP

1998

PREPARED BY THE

SONOMA COUNTY WATER AGENCY

2150 WEST COLLEGE AVENUE
SANTA ROSA, CALIFORNIA

Figure 4-2

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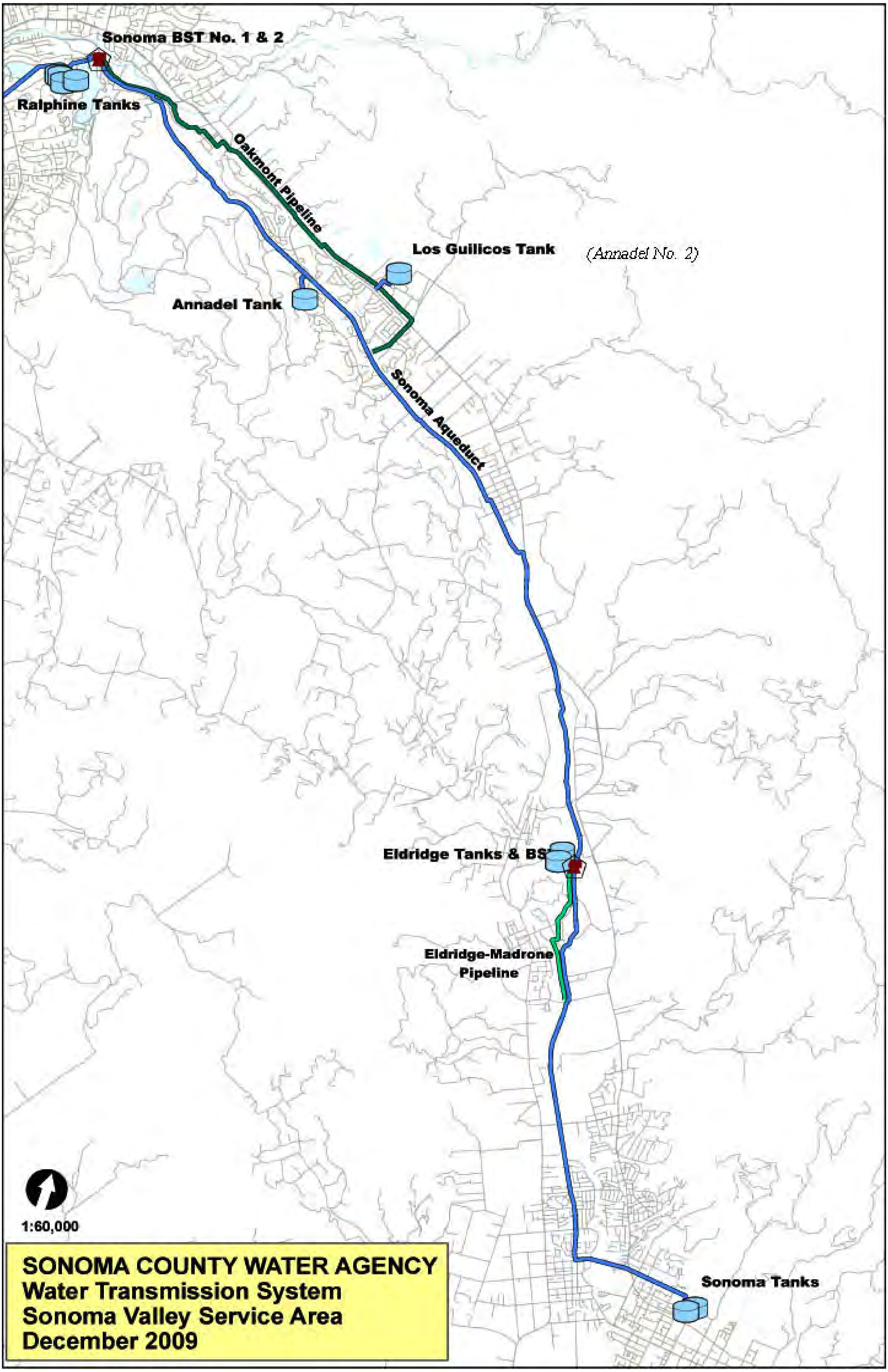

FIGURE 4-3
SONOMA AQUEDUCT FACILITIES

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5. Hydraulic Model Calibration

The purpose of this section is to explain how the hydraulic model was developed for the City's potable water distribution system, and present a summary of the calibration results. The model was developed utilizing Bentley's WaterCAD v8i software platform, and was calibrated by comparing modeled predictions of pressures with field measurements taken by City staff. These results are summarized in the following sections.

5.1 Model Development

The City provided a GIS data set that mapped all known water mains within the City's potable water service area, including pipelines and other improvements for the water distribution system since the 2011 WMP. This data set was imported into the hydraulic model. Tank and pump station piping was modified according to field notes gathered by GHD and City staff. The hydraulic model was then used to compare static and residual pressures within the model to a series of fire hydrant test flow data provided by the City.

Once model elements such as pipes, junctions, tanks, and pump stations were entered into the hydraulic model, junction demands were entered based on adjusted potable water demand data from 2006, 2007 and 2008. As mentioned in Section 3.1, this data provided a more conservative baseline for future conditions, since recent drought years have caused demands to be unusually low. Individual billing records were geocoded to individual parcels using street addresses. Three years of billing data were then aggregated for each parcel and assigned to a node in the computational model. All parcels were increased so the current total demand matched the UWMP per capita demand (gpcd) and population predictions at 2.08 mgd. Future conditions added water demand associated with planned development, resulting in a future demand of 2.31 mgd.

5.2 Model Calibration

Model calibration was achieved using fire hydrant test flow data provided by the City. A total of eight test data sheets were utilized in the calibration of Zone 1. Seven tests occurred for the 2011 WMP. An additional test (Hydrant Flow Test No. 8) was performed after the Capital Improvement Projects had occurred, and the updated model was compared to the hydrant test, confirming that the model is still well calibrated. Flow test data was not available for Zones 2 and 3. However, these zones comprise less than 6% of the City's total water demand. Figure 5-1 shows the location of the hydrants used in the model calibration.

Table 5-1 provides a summary of observed static and residual pressures at the test hydrants along with the corresponding hydraulic model static and residual pressures. The hydrant flow test numbers in the table also correspond to Figure 5-1.

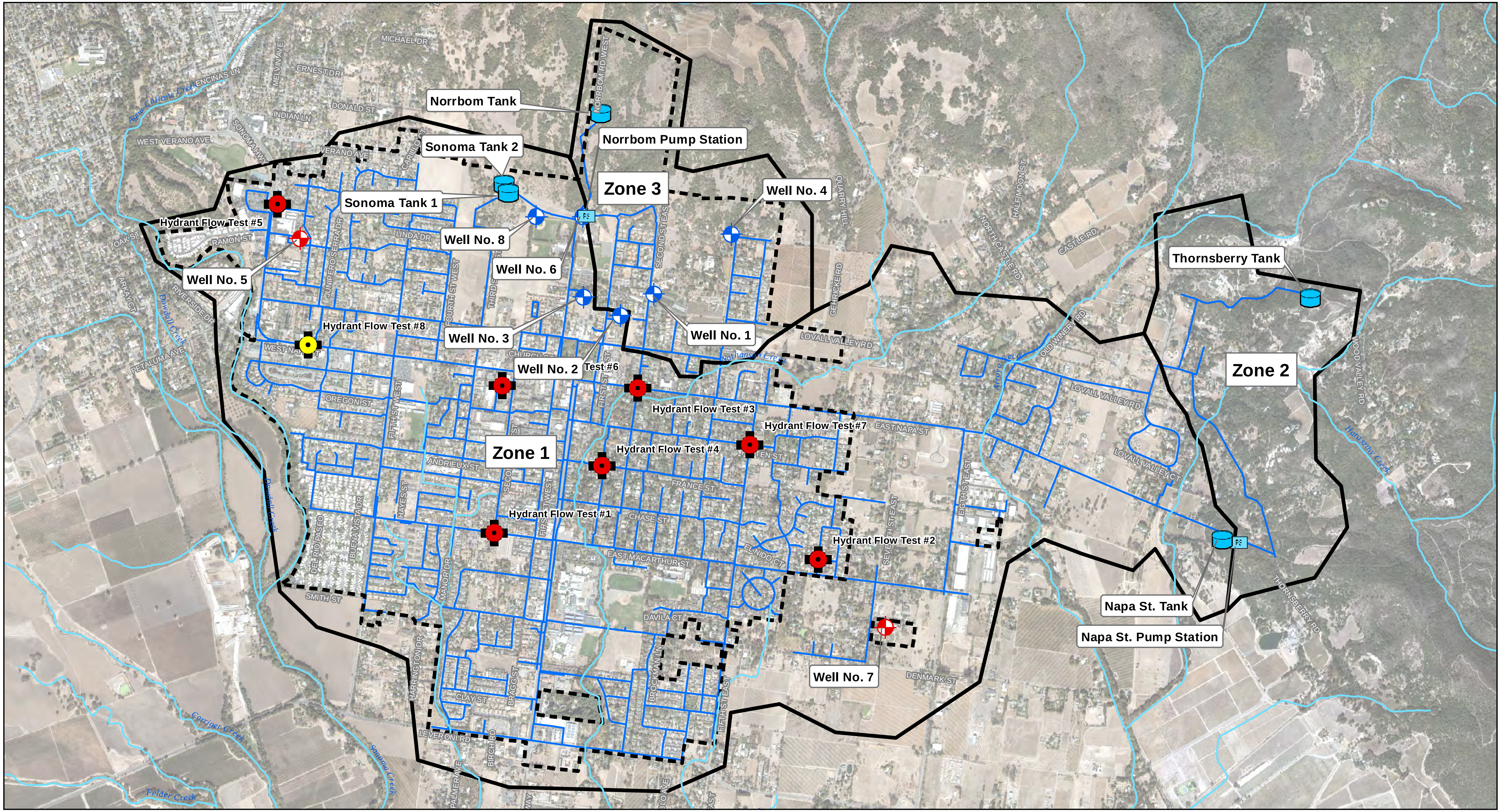
Table 5-1 Summary of Hydraulic Model Calibration Results

Hydrant Flow Test No.	Hydrant Location	Model Junction ID No.	Recorded Flow (gpm)	Recorded Static Pressure (psi)	Recorded Residual Pressure (psi)	Tank Level (ft)	Model Static Pressure (psi)	Model Residual Pressure (psi)
1	West MacArthur & 2nd St W	J-389	1111.5	80	78	40.4	77.5	74
2	862 Towne St	J-569	1101	74	64	39	71.4	65.4
3	2nd St E & E Napa St	J-874	1020	76	71	42.5	69.5	66.8
4	693 Austin Ave	J-331	1020	70	67	30	70	67.9
5	19190 Sonoma Hwy	J-1134	925	64	60	48[1]	63	59.1
6	201 W Napa St	J-1792	1020	75	70	48[1]	75.1	71.9
7	492 Patten St	J-1095	1075	68	65	48[1]	68.3	63.6
8	772 W. Napa St.	J-1711	990	65	62	32.25	65	61.2

[1]Unknown tank levels were assumed to be at 48 feet elevation.

The calibration results shown above deviated between -6% and +3% when comparing model residual pressures to recorded residual pressures at the fire hydrants. This is considered to be a suitable calibration given the accuracy of the hydraulic model and the pressure gages used during the flow testing. Hazen-Williams roughness coefficients were uniformly adjusted to attain calibration with the flow test data, and a roughness coefficient of C=130 was used to achieve the results shown in the table above.

The calibrated hydraulic model is acceptable for use in evaluating the City's sources of supply, storage, and distribution piping under current and future conditions.



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Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California II FIPS 0402 Feet

N

Tank	Mains
Pump Station	Creeks
Production Well	Pressure Zones
Non-Production Well	City Limits

Fire Hydrant Test Location

- 2011 Master Plan
- 2017 Master Plan

GHD

City of Sonoma
Water Master Plan Update

Job Number	11140097
Revision	1
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Fire Hydrant Test Locations

Figure 5-1

\\ghdnet\ghd\US\Santa Rosa\Projects\111\11140097 Sonoma Water Master Plan Update\08-GIS\Maps\Deliverables\FINAL\5-1 Fire Hydrant Test Locations.mxd

Data source: Sonoma Veg Mapping, Imagery, 2013; City of Sonoma GIS, Water Utility, Roads and Streams, 2010; GHD, Water Demands, 2017. Created by:afisher2

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6. System Performance Summary

The purpose of this section is to summarize the analyses run to evaluate the City's water system including sources of supply, storage, and distribution piping. The analyses were run to identify bottlenecks and pressure deficiencies within the City's water system. A total of four demand scenarios were analyzed using the calibrated hydraulic model:

1. Current (2015) peak hour,
2. Future (2040) peak hour,
3. Current (2015) maximum day with fire flow, and
4. Future (2040) maximum day with fire flow.

In addition to the four scenarios listed above, a desktop water age analysis was used to evaluate water quality in the City's water tanks. The results of these analyses are described in the following sections.

6.1 Peak Hour Analysis

Peak hour demands were input into the calibrated hydraulic model to assess bottlenecks and identify locations of low pressure within the distribution system. Peak hour demands were established for both current and future conditions. These demands were input into the calibrated hydraulic model and run. Results were analyzed for deficient pressures.

A peaking factor of 3.0, as identified in Section 3 Demand Analysis, was applied to the estimated current average day demand of 2.08 mgd, to arrive at a current peak hour demand of 6.24 mgd, or approximately 4,333 gpm. Future peak hour demands were determined by incorporating the additional 0.23 mgd to current average day demands and then applying the peaking factor of 3.0 to arrive at a future peak hour demand of 6.93 mgd, or 4,814 gpm.

For the peak hour hydraulic simulations, all storage tanks within the City system, including the two SCWA tanks, were assumed to contain 1 foot of storage. This conservative assumption was used to verify that the water system provided acceptable pressure independent of water levels in the tanks. All pumps were also assumed to be off during the simulation, and the pressure reducing valve (PRV) in between Zone 3 and Zone 1 was simulated as closed. This latter assumption required all Zone 1 demands to be supplied exclusively from the SCWA tanks.

Figures 6-1 and 6-2 illustrate model results (current and future) for the peak-hour demand analyses. The figures show that the minimum pressure criteria are satisfied in most areas of the distribution system. In addition, model results indicate that there is little difference between current and future conditions.

There are no junction locations within the entire City water system having a pressure of less than 20 psi under the peak-hour demand scenarios for both current and future conditions. Some areas within the system were found to have pressures between 20 psi and 40 psi. These include:

1. The high elevation region (110-140 ft) at the eastern end of Sonoma located around the intersection of East Napa Street and Old Winery Road. This area shows improvement compared to the 2011 WMP, due to completion of the Zone 1-2 Intertie Project. However, City staff has expressed that the PRV setting is closed until the pressure drops to 35 psi. An operational adjustment that allows this valve to be open at higher pressures may increase pressure at nodes in this region. In addition, this region may have higher pressures with higher water levels in the tanks.
2. The north-western area of Sonoma near Highway 12 and Maxwell Farms Regional Park. In this area, certain nodes may have higher pressure with upsizing AC and unknown pipes to the standard 8-inch diameter (See CIP 5 and 6). This region may have higher pressures with higher water levels in the tanks and/or an open PRV between Zone 1 and Zone 3.

While this satisfies the minimum statutory requirements for existing public water systems, pressures less than 40 psi are not allowed for new water systems under peak-hour demand conditions.

In general, the remaining areas of the system show sufficient pressure. The remainder of Zone 1 has most nodes between 40 – 80 psi, with a few above 80 psi. Zone 2 delivers water at high pressures (greater than 80 psi) throughout the zone due to the elevation of the Thornsberry Tank, with a few areas containing pressure in between 40 – 80 psi. Zone 3 contains most nodes between 40 – 80 psi with the lowest portion of Zone 3 seeing pressures greater than 80 psi. The high elevation region (100 – 150 ft) at the northern end of 4th Street East north of Lovall Valley Road has seen improvements in pressure due to the Zone 3 Expansion. While the area had shown 20-40 psi in the 2011 Water Master Plan, with the Zone 3 Expansion in operation, the area is now between 40-80 psi.

Static pressures at future peak hour conditions showed five nodes that dropped to 20 – 40 psi from 40 – 80 psi under current peak hour conditions. Upon further inspection, these nodes only dropped approximately 1 psi, from slightly above 40 psi to slightly below. In the 2040 model, added flow demands from planned development at their nearby nodes were checked against the five nodes that dropped to under 40 psi, and there were no matches, signifying that the drops in the five nodes were due to the overall increase in demand.

6.2 Fire Flow Analysis

The calibrated hydraulic model was also used to assess two fire flow scenarios under both current and future maximum day demands. Current and future maximum day demands were estimated at 4.16 mgd and 4.62 mgd respectively, using a peaking factor of 2.0 as presented in Section 3 (Demand Analysis).

Fire flow requirements were assigned to junctions within the hydraulic model consistent with the requirements of 1,500 gpm for residential areas within City limits and 2,000 gpm for all other land-use categories and residential areas outside of City limits presented in Section 7 (Fire Flow Requirements). The fire flow analysis was performed in the hydraulic model by assigning the corresponding fire flow iteratively to each junction within the model in addition to maximum day demands occurring throughout the system. The system is either capable of meeting the fire flow requirement while maintaining a 20 psi residual pressure at a fire flow junction, or is unable to maintain the required 20 psi residual pressure, in which case the model determines the available fire flow while still meeting the pressure constraint.

Similar to the peak hour demand scenario, all storage tanks within the City system, including the two SCWA tanks, were assumed to contain only 1 foot of storage for satisfying maximum day demands and fire flow requirements. This assumption was made to ensure the City is capable of providing fire flows at adequate pressures throughout the system under worst case storage conditions. All pumps were also assumed to be off during the simulation, and the PRV in between Zone 3 and Zone 1 was simulated as closed. This latter assumption requires all Zone 1 demand to be fed off of the SCWA tanks.

Figures 6-3 and 6-4 present the results of the fire flow analyses under current and future maximum day demands. At future max day conditions (Figure 6-4) there were four nodes that were categorized as not meeting fire flow when able to meet fire flow at current max day. Upon further inspection, these nodes dropped between 26 and 38 gpm, from slightly above the given requirement to slightly below. In the model, added flow demands from planned development at their nearby nodes were checked against the four nodes that dropped to not meet fire flow requirements and there were no matches, signifying that the drops in the three nodes were due to the overall increase in demand.

Junctions that did not meet fire flow requirements are colored based on the amount of deficient fire flow in gpm. The California Fire Code and the local fire authority establish fire flow requirements. Per Appendix B of the California Fire Code[18], Section B103, "the Fire Chief is authorized to reduce fire flow requirements for isolated buildings or a group of buildings in rural areas or small communities where the development of full fire flow requirements are impractical". An agreement between Public Works and the local fire authority can assist in operating tank levels and pump station scheduling to meet fire flow requirements.

The following areas show fire flow deficiency:

1. Zone 2 shows fire flow deficiencies downstream of the Napa St. Tank and Pump Station. Increased fire flow is possible when the Napa Street pump station is active. In addition, this region may have higher fire flow with higher water levels in the tanks.
2. The high elevation region (100 – 150 ft) at the northern end of 4th Street East north of Lovall Valley Road. This region has shown improvement due to the Zone 3 expansion since the 2011 WMP, and may have higher fire flow with higher water levels in the tanks.
3. Another high elevation region (110-140 ft) at the eastern end of Sonoma located around the intersection of East Napa Street and Old Winery Road. This area shows improvement compared to the 2011 WMP, due to the Zone 1-2 Intertie Project. However, City staff has expressed that the PRV setting is closed until the pressure drops to 35 psi. An operational adjustment that opens this valve at a higher pressure may increase fire flow in this region. In addition, this region may have higher fire flow with higher water levels in the tanks.
4. In Zone 1, nearly all junctions with deficient fire flow occur within unlooped or dead end branches. As part of CIP 5 and 6 mentioned in the following paragraph and Section 8, the first recommendation is to upsize Asbestos Cement and Unknown pipe to the standard 8-inch diameter. An additional option is to loop the system. The local fire authority could also make the judgment in connecting to nearby fire hydrants, depending on distance.

[18] California Fire Code. Appendix B. Fire Flow Requirements for Buildings. 2013

Figure 6-5 shows AC pipes and unknown pipes under 8 inches connected to nodes with deficient fire flow. Since 8 inches is a general minimum diameter for water mains, the future model was updated under the scenario of undersized AC and unknown pipes upsized to 8 inches. Results are presented in Figure 6-6, and show improvements in fire flow. Upsizing AC pipe to 8 inches is the basis for CIP 5, and upsizing unknown pipe to 8-inch is the basis for CIP 6. Both are further discussed in Section 8. For other pipe materials, only one pipe was found next to a fire flow deficiency node (6-inch PVC at 304 ft between McDonnel St and Maple St).

6.3 Water Age Analysis

A desktop water age analysis was also performed to estimate flow and turnover requirements for Zone 2 and Zone 3. As a general rule of thumb, residual chlorine in potable water dissipates over a period of approximately four days. Water entering Zone 1 via the SCWA tanks is assumed to be "fresh" with a water age of zero.

Zones 2 and 3 are fed by the Thornsberry Tank and Norrbom Tank, respectively. For the purposes of this water age analysis, the following storage volumes and resulting turnover requirements were determined for Zones 2 and 3.

Table 6-1 Water Age Analysis for Zones 2 and 3

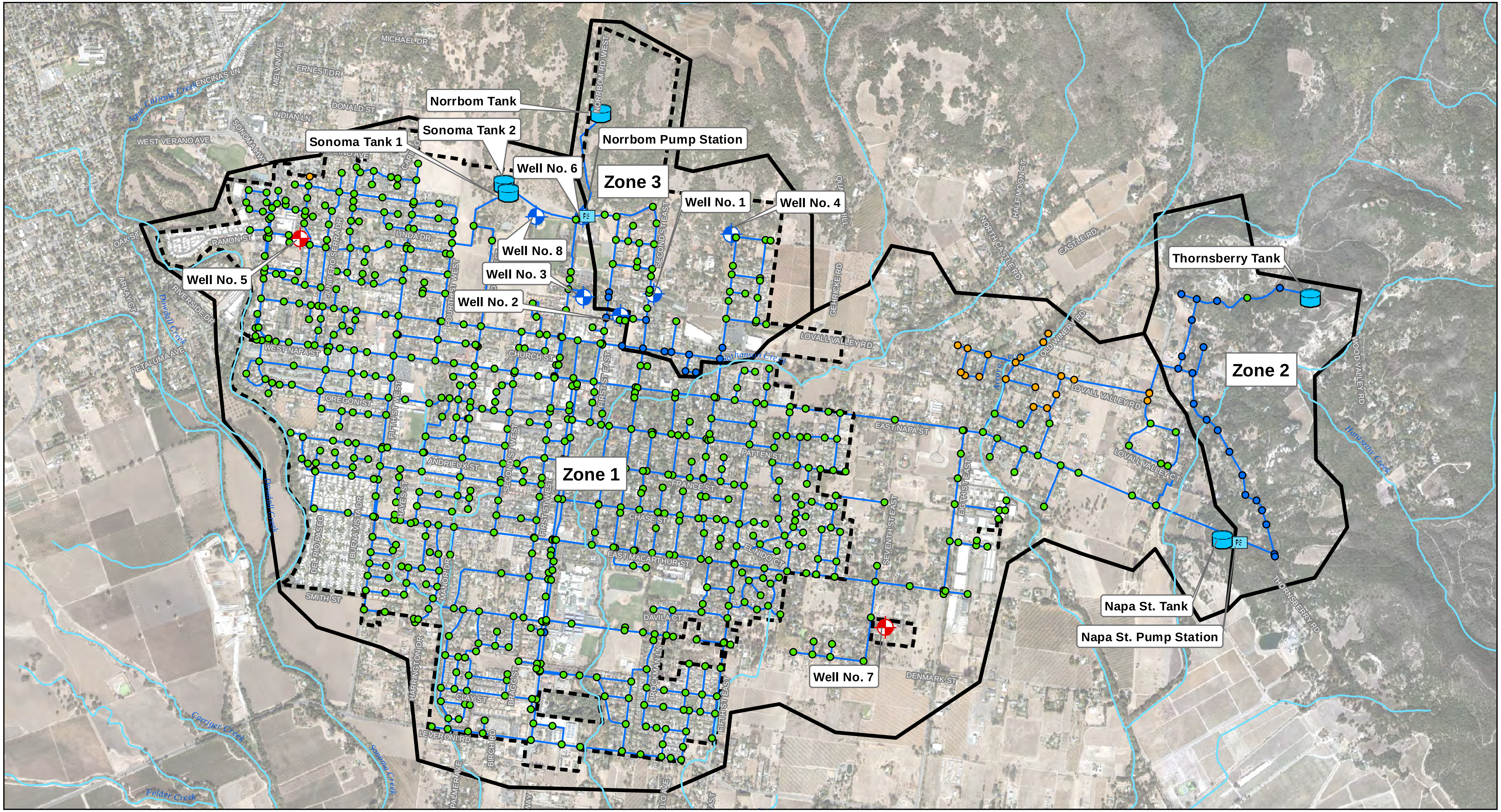
Parameter	Zone 2	Zone 3
Storage Tanks	Thornsberry Tank[2]	Norrbom Tank
Total Storage Volume (MG)	0.5	3
Turnover Criteria (days)	4	4
Flowrate Requirement (mgd)	0.13	0.75
Flowrate Requirement (gpm)	86	520
Current Average Day Demand (gpm)[1]	26	106.5

[1]Average Day Demand for each Tank provided by City from SCADA

[2]Average day demand for Thornsberry Tank, however, with the Zone 1-2 Intertie, the demand can increase depending on PRV operation.

As shown in Table 6-1, in order to satisfy the four-day turnover criteria, Zone 2 and Zone 3 would have to continuously consume 86 gpm and 520 gpm, respectively. These flow rates are much greater than the current average day demands of 26.5 gpm and 106.5 gpm. Thus, without any means to increase circulation through the tanks, chlorine residuals at the tanks may drop below minimum acceptable concentrations.

To mitigate the low rates of turnover in the tanks, the City diverts water from Zone 3 into Zone 1 via a PRV that is located inside the Norrbom pump station building. This valve is opened and closed via a preprogrammed schedule that is programmed into the City's SCADA system. Every ten days the valve opens for two days to allow water to drain from the Norrbom tank into Zone 1.



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N

- Tank
- Pump Station
- Production Well
- Non-Production Well
- Mains
- Creeks
- Pressure Zones
- City Limits

Static Pressure

- < 20 psi
- 20 - 40 psi
- 40 - 80 psi
- > 80 psi

City of Sonoma
Water Master Plan Update

Job Number	11140097
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Date	10 Jan 2018

Static Pressures at Peak Hour Demand (6.24 MGD) - Current Conditions (2015)

Figure 6-1

Data source: Sonoma Veg Mapping, Imagery, 2013; City of Sonoma GIS, Water Utility, Roads and Streams, 2010; GHD, Water Demands, 2017. Created by:afisher2

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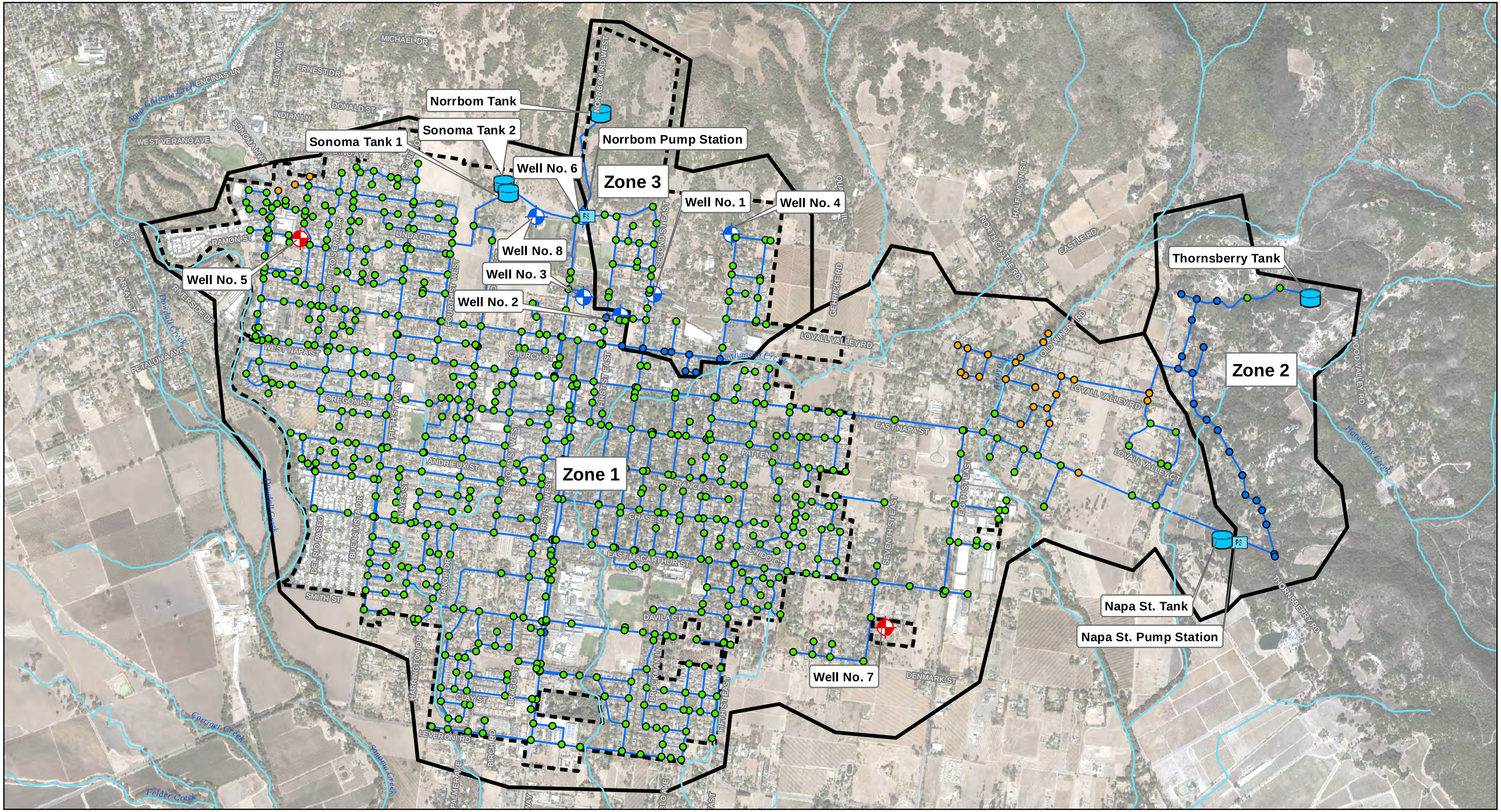

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N

- Tank
- Pump Station
- Production Well
- Non-Production Well
- Mains
- Creeks
- Pressure Zones
- City Limits

Static Pressure

- < 20 psi
- 20 - 40 psi
- 40 - 80 psi
- > 80 psi

City of Sonoma
Water Master Plan Update

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Date	10 Jan 2018

Static Pressures at Peak Hour Demand (6.93 MGD) - Future Conditions (2040)

Figure 6-2

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Data source: Sonoma Veg Mapping, Imagery, 2013; City of Sonoma GIS, Water Utility, Roads and Streams, 2010; GHD, Water Demands, 2017. Created by:afisher2

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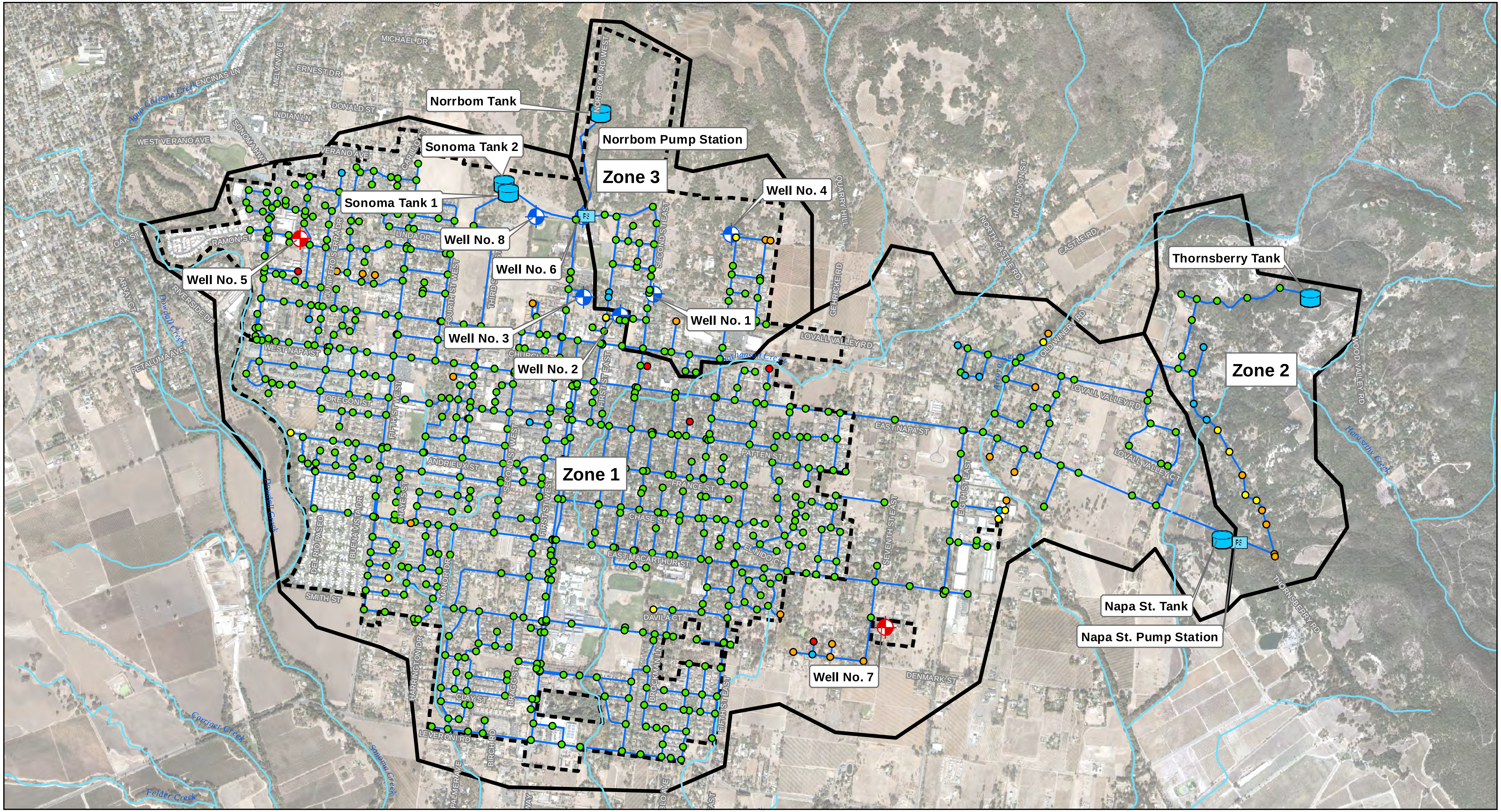

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Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California II FIPS 0402 Feet

N

Tank
Pump Station
Production Well
Non-Production Well

Mains
Creeks
Pressure Zones
City Limits

Available Fire Flow

- Yes
- No, < 100 gpm need
- No, 100 - 250 gpm need
- No, 250 - 750 gpm need
- No, > 750 gpm need

City of Sonoma
Water Master Plan Update

Available Fire Flow @ 20 psi
Max Day Demand (4.16 MGD) -
Current Conditions (2015)

Job Number	11140097
Revision	1
Date	10 Jan 2018

Figure 6-3

\\ghdnet\ghd\US\Santa Rosa\Projects\111\11140097 Sonoma Water Master Plan Update\08-GIS\Maps\Deliverables\FINAL\6-3 Available Fire Flow Max Day Demand Current - 2015.mxd

Data source: Sonoma Veg Mapping, Imagery, 2013; City of Sonoma GIS, Water Utility, Roads and Streams, 2010; GHD, Water Demands, 2017. Created by:afisher2

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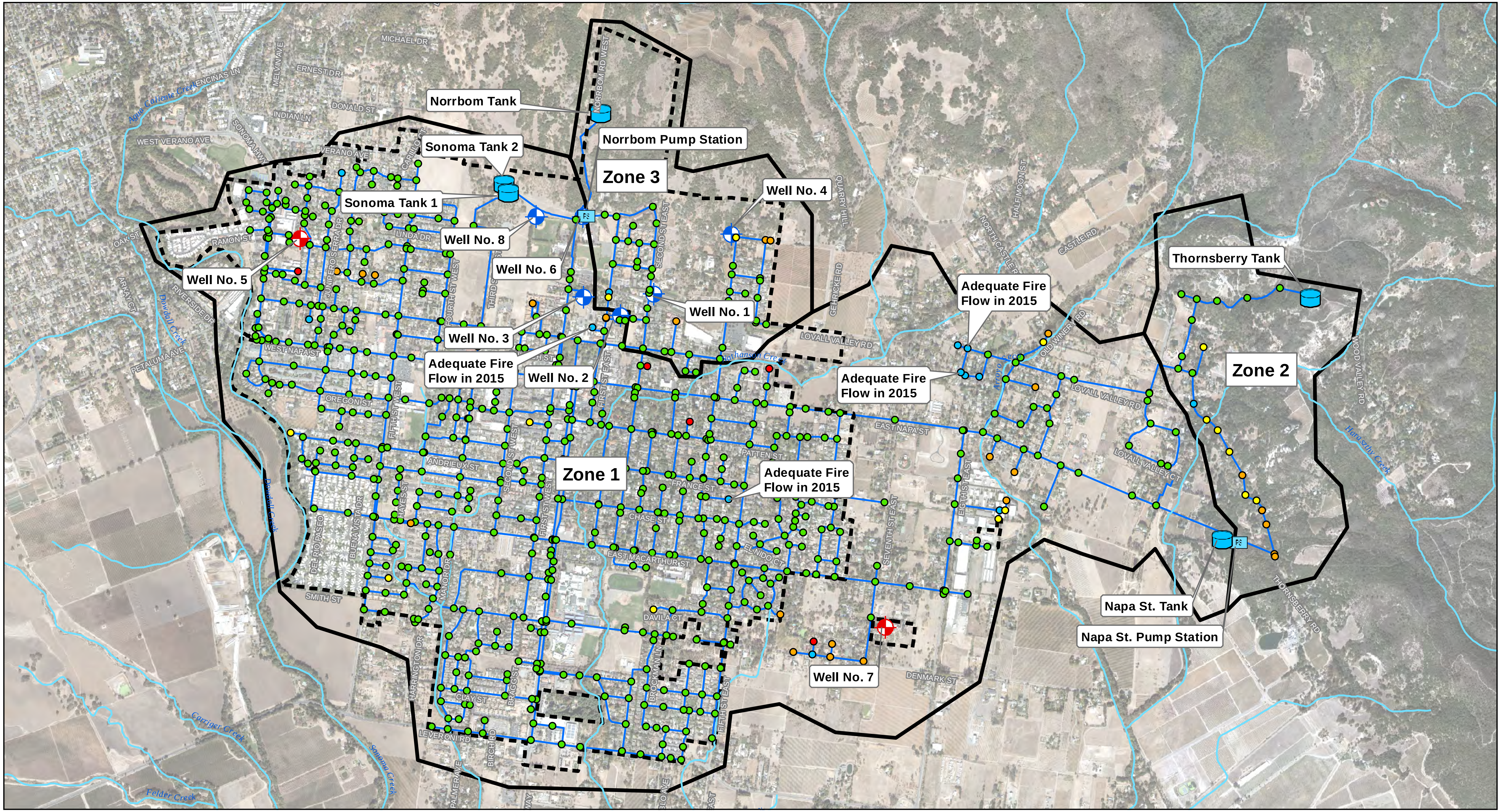

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Horizontal Datum: North American 1983
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N

Tank
Pump Station
Production Well
Non-Production Well

Mains
Creeks
Pressure Zones
City Limits

Available Fire Flow

- Yes
- No, < 100 gpm need
- No, 100 - 250 gpm need
- No, 250 - 750 gpm need
- No, > 750 gpm need

GHD

City of Sonoma
Water Master Plan Update

Available Fire Flow @ 20 psi Max Day Demand (4.62 MGD) - Future Conditions (2040)

Job Number	11140097
Revision	1
Date	11 Jan 2018

Figure 6-4

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Data source: Sonoma Veg Mapping, Imagery, 2013; City of Sonoma GIS, Water Utility, Roads and Streams, 2010; GHD, Water Demands, 2017. Created by:afisher2

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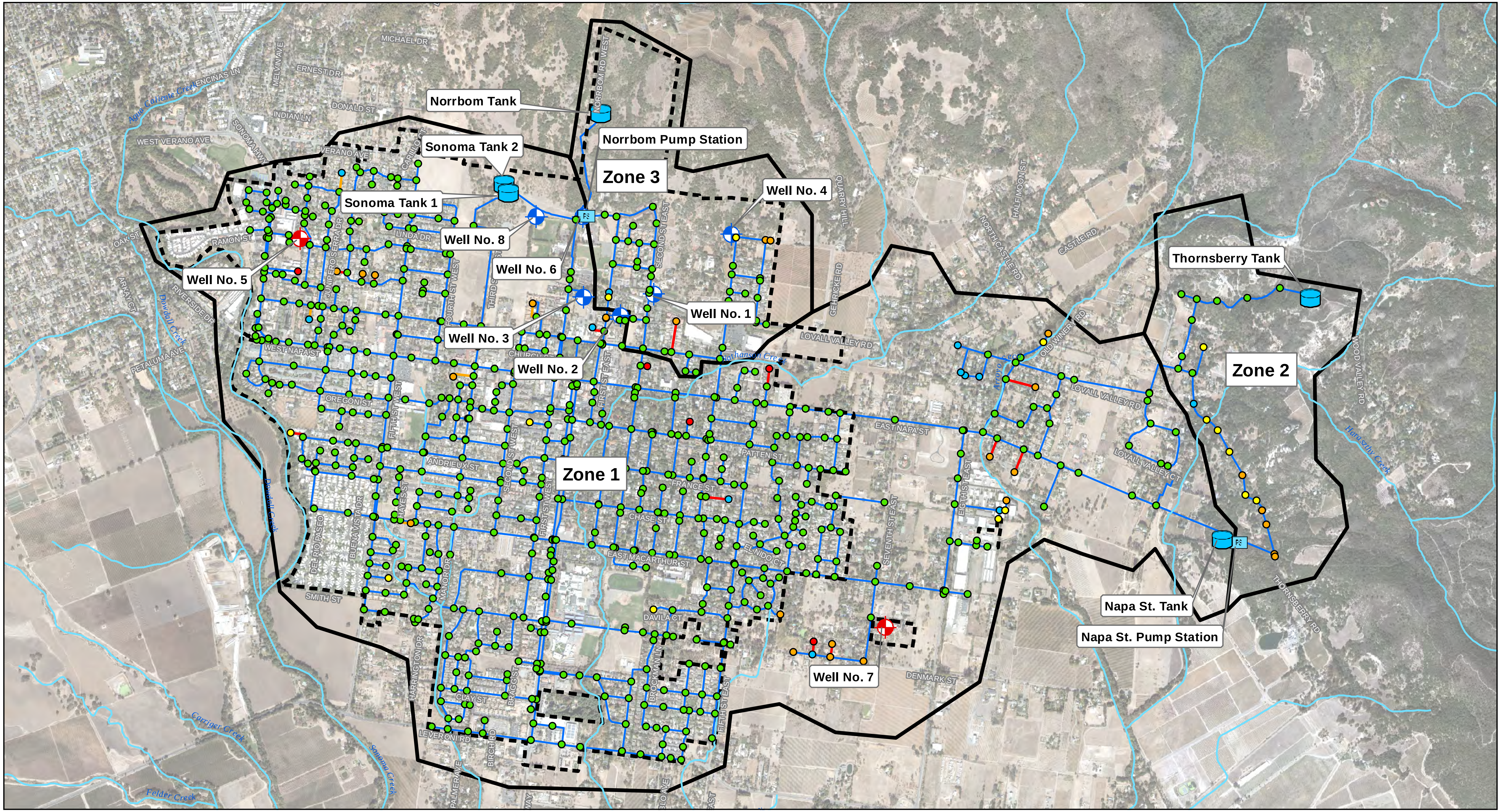

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Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California II FIPS 0402 Feet

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Tank	Mains	**Available Fire Flow**	No, 100 - 250 gpm need
Pump Station	Creeks	Yes	No, 250 - 750 gpm need
Production Well	Pressure Zones	No, < 100 gpm need	No, > 750 gpm need
Non-Production Well	City Limits		

Pipes under 8" connected to FF Deficient Nodes

Asbestos Cement — Unknown

City of Sonoma
Water Master Plan Update

Fire Flow Deficiencies with Pipes under 8 inches - 2040

Job Number	11140097
Revision	1
Date	10 Jan 2018

Figure 6-5

\\ghdnet\ghd\US\Santa Rosa\Projects\111\11140097 Sonoma Water Master Plan Update\08-GIS\Maps\Deliverables\FINAL\6-5 Fire Flow Deficiencies with Pipes under 8 inches - 2040.mxd

Data source: Sonoma Veg Mapping, Imagery, 2013; City of Sonoma GIS, Water Utility, Roads and Streams, 2010; GHD, Water Demands, 2017. Created by:afisher2

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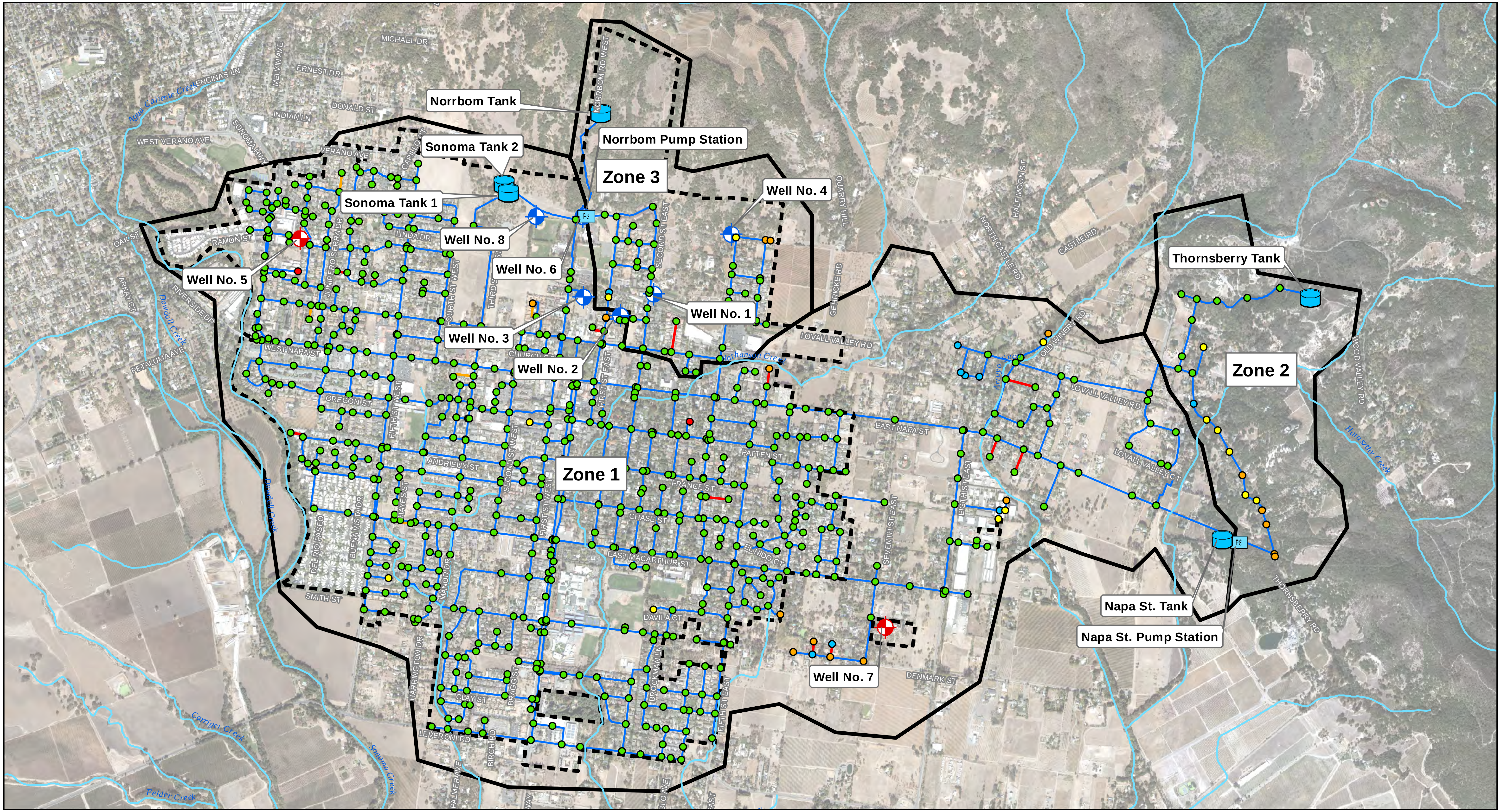

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Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California II FIPS 0402 Feet

N

Tank
Pump Station
Production Well
Non-Production Well

Mains
Creeks
Pressure Zones
City Limits

Available Fire Flow

- Yes
- No, < 100 gpm need
- No, 100 - 250 gpm need
- No, 250 - 750 gpm need
- No, > 750 gpm need

Pipes upsized to 8" connected to FF Deficient Nodes

- Asbestos Cement
- Unknown

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Water Master Plan Update

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Fire Flow Deficiencies with Pipes under 8 inches Upsized - 2040

Figure 6-6

\\ghdnet\ghd\US\Santa Rosa\Projects\111\11140097 Sonoma Water Master Plan Update\08-GIS\Maps\Deliverables\FINAL\6-6 Fire Flow Deficiencies with Pipes under 8 inches Upsized - 2040.mxd

Data source: Sonoma Veg Mapping, Imagery, 2013; City of Sonoma GIS, Water Utility, Roads and Streams, 2010; GHD, Water Demands, 2017. Created by:afisher2

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7. Fire Flow Requirements

The purpose of this section is to establish the minimum allowable fire-flow requirements for each area of the distribution system. The fire-flow requirement will be used together with the maximum-day demands to model the performance of the distribution system.

For purposes of this document, the term "fire-flow" is defined as the flow rate of water, measured at 20 psig residual pressure, which is available for firefighting. The minimum fire-flow requirement for a given area is stipulated in Appendix B of the Uniform Fire Code, and is a function of the following variables:

- Size of the building (square footage);
- Presence of automatic fire sprinklers (may with approval reduce fire flow requirements by 50%[19]);
- Type of construction (as defined in the California Building Code); and
- Building occupancy.

7.1 Fire Flow Requirements

In the context of evaluating an entire municipal water distribution system, it is impractical to identify a unique fire-flow for each building based on the variables listed above. Therefore, for purposes of this study, the City's fire marshal has divided the City's fire-flow requirements into two broad categories:

- Single and two-family homes (1,500 gpm * 2 hrs); and
- All other construction (2,000 gpm * 2 hrs).

These criteria are suitable for six to eight hose streams of 250 gpm each, and are expected to adequately cover most buildings within the City's service area.

For purposes of determining the City's fire-flow requirements, the following land-use categories are assigned a fire-flow of 1,500 gpm:

- Low-density Residential; and
- Medium-density Residential.

All other land-use categories are assigned a fire-flow requirement of 2,000 gpm. A map showing the fire-flow requirement for each parcel in the service area is provided in Figure 7-1 attached. For the area outside the City limits, a fire-flow of 1,500 gpm was used to reflect the additional hazard caused by hilly terrain and chaparral ground cover.

For purposes of identifying the volume of water that should be stored for firefighting, the flow rate of 2,000 gpm is multiplied by a duration of 2 hours to obtain a minimum volume of 240,000 gallons. This is the minimum volume that should be reserved, in each pressure zone, for firefighting.

[19] According to the Sonoma Valley Fire and Rescue Authority, there are many factors that may require adjustments, such as proximity to exposures, general location etc. Adjustments may result in increases or decreases.

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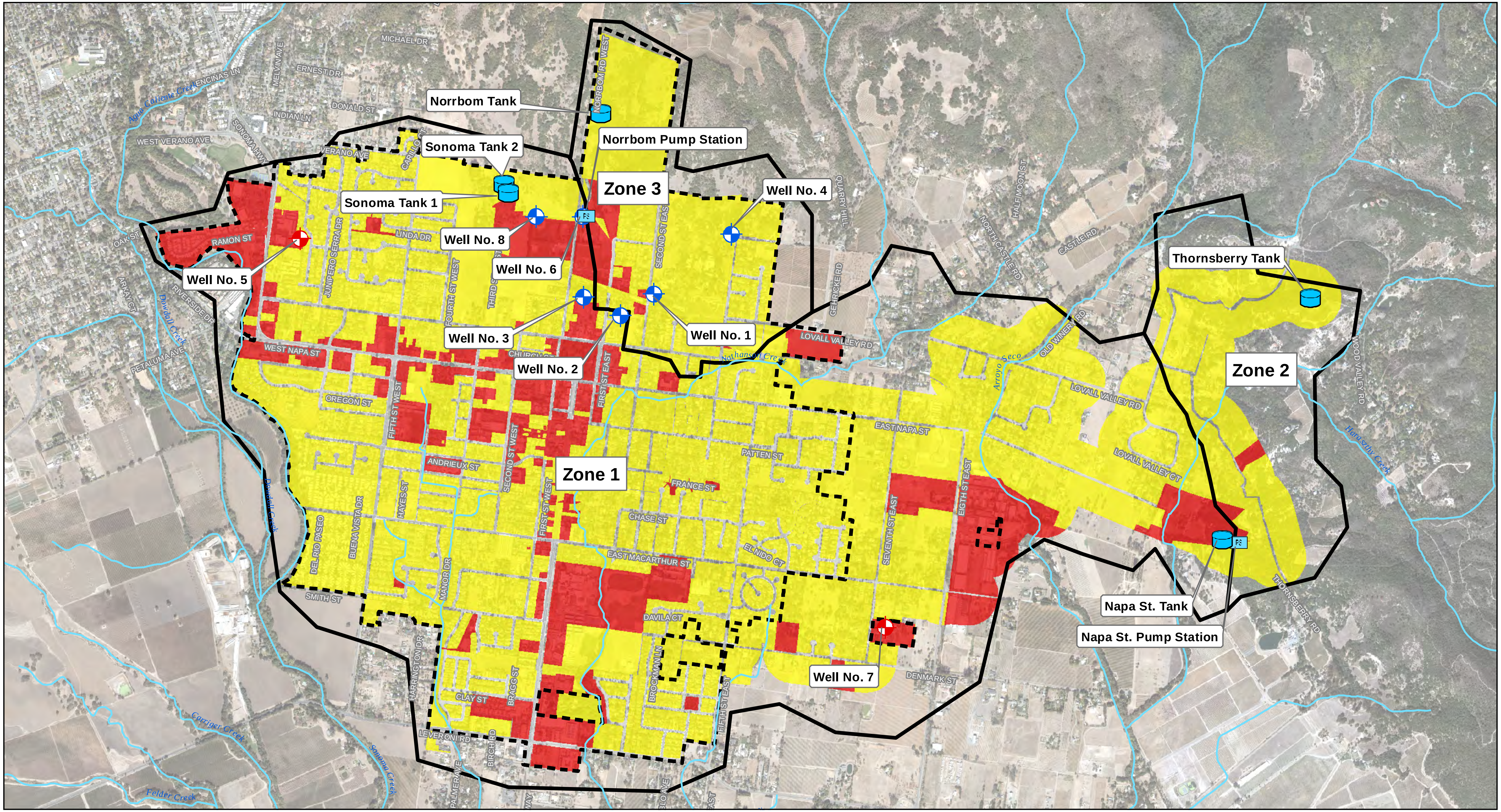

Paper Size ANSI B

0 500 1,000 1,500

Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California II FIPS 0402 Feet

N

Tank
Pump Station
Production Well
Non-Production Well

Mains
Creeks
Pressure Zones
City Limits

Fire Flow Needs (gpm)

1,500
2,000

City of Sonoma
Water Master Plan Update

Fire Flow
Needs Map

Job Number	11140097
Revision	1
Date	10 Jan 2018

Figure 7-1

\\ghdnet\ghd\US\Santa Rosa\Projects\111\11140097 Sonoma Water Master Plan Update\08-GIS\Maps\Deliverables\FINAL\7-1 Fire Flow Needs.mxd

Data source: Sonoma Veg Mapping, Imagery, 2013; City of Sonoma GIS, Water Utility, Roads and Streams, 2010; GHD, Water Demands, 2017. Created by:afisher2

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8. Recommended Capital Improvement Projects

This section contains eight recommendations for water system improvements. The proposed water system improvement projects identified in this section are tailored to meet the following four objectives:

1. **Supply Reliability**: Strengthen the City's ability to reliably supply potable water based on current and future demand.
2. **City Well Resilience:** Protect the City's potable water supply against emergencies, drought, or natural disaster by bolstering potable water supply from City wells.
3. **Public Safety:** Promote public safety by addressing system pressure and fire flow deficiencies.
4. **Cost-Effective Renewal and Replacement (R&R):** Minimize life-cycle costs by planning for the cost-effective R&R of aging water system components.

The City updated its Capital Improvement Program (CIP) in 1999, 2002, and 2011 to include recommended water system improvement projects from WMPs from those respective years. For the current update, a calibrated hydraulic model was developed and used to analyze performance of the distribution system under current and future demand conditions, including pressure and fire-flow requirements. City staff also provided knowledge of program needs that could not be captured in a hydraulic model. This knowledge was incorporated into the capital improvement projects list.

The capital improvements that are recommended for the City include building condition data for an asset management program, renewal and replacement of pipes, and well improvements to continue meeting emergency supply. Costs for individual projects are found in Appendix A, and a five year cost forecast for FY 2018 – 2023 are found in Appendix B.

After running model scenarios based on water billing records and projections, there were small differences in pressure and fire flow between current (2015) and future conditions (2040). For both current and future conditions, the City's water system has areas that need pressure improvement and areas that need more fire flow. These items are addressed as CIP projects within renewal and replacement of pipes, upsizing to 8 inches from smaller diameters when attached to nodes with low pressure or low fire flow.

8.1 Estimate of Probable Cost

The estimate of probable cost in this CIP should be considered as order-of-magnitude estimates for planning purposes only. The total project cost consists of the construction cost, design and technical effort, construction management effort, and a contingency fund. Land acquisition and/or City degradation fees are not included in the costs.

Construction costs are based on a Class 5 (planning-level) estimate of probable cost as defined by the Association for the Advancement of Cost Engineering, International (AACE). AACE defines the "Class 5" estimate as follows:

> *Generally prepared on very limited information, where little more than proposed plan type, its location, and the capacity are known, and for strategic planning purposes such as but not limited*

to market studies, assessment of viability, evaluation of alternate schemes, project screening, location and evaluation of resource needs and budgeting, long-range capital planning, etc. Some examples of estimating methods used would include cost/capacity curves and factors, scale-up factors, and parametric and modeling techniques. Typically, very little time is expended in the development of this estimate. The typical expected accuracy ranges for this class estimate are -20% to -50% on the low side and +30% to +100% on the high side.

Construction costs are based on the July 2017 Engineering News Record Construction Cost Index (ENR CCI) for San Francisco, CA (11,725.52).

A summary of the unit costs associated with each construction item is presented in Table 8-1. The unit cost estimates are based on previous project experience and contractor/supplier-provided information. Adjustments to the cost estimates can be made in the future by applying a ratio of the future ENR CCI to the value used herein.

Estimated unit costs for pipelines include pipe material, trenching (at minimum cover), installation, backfill, fittings and appurtenances, connections, pavement restoration, testing, and traffic control. Water pipelines are assumed to be Class 200 PVC for pipes 12-inch and smaller, and AWWA C200 tape-wrapped welded steel pipe for all other pipelines.

Table 8-1 Construction Unit Costs

Item	Unit Cost
Mobilization and demobilization	6% of construction costs
Temporary traffic control	5% of construction costs
Potholing to identify existing utilities	$13/lf
Shoring and trench safety	$21/lf
Trench dewatering	$42/lf
Handling, treatment and disposal of contaminated soil and groundwater	$11/lf
Replacement of pipe	
• 4” Class 200 PVC Water Pipe	$82/lf
• 6” Class 200 PVC Water Pipe	$105/lf
• 8” Class 200 PVC Water Pipe	$127/lf
• 10” Class 200 PVC Water Pipe	$149/lf
• 12” Class 200 PVC Water Pipe	$172/lf
• 14” Class 200 PVC Water Pipe	$224/lf

Design and technical effort, construction effort, and a contingency are also included in the project costs.

8.1.1 Design and Technical Effort

Design and technical efforts for a construction project include the following:

- Completing the pipeline and infrastructure designs;
- Land surveys;
- Geotechnical surveys;
- Environmental review; and
- Permitting (excluding permits associated with land acquisition).

The total costs for the design and technical efforts for construction are estimated to be approximately 15-25% of the construction cost based on previous project experience.

Design and technical efforts for an asset management project include the following:

- Collecting and organizing source data (e.g. engineering drawings);
- Scanning or digitizing source data into a GIS-based asset inventory;
- Populating condition data for inventoried assets; and
- Populating criticality data for inventoried assets.

The costs for the design and technical efforts for an asset management project are based on estimates of consulting services. The unit costs for GIS consultant services range from $130-$170 an hour.

8.1.2 Construction Management Effort

Construction management efforts include the costs for the following items:

- Site inspections;
- Project management; and
- Engineering services during construction.

The costs for the construction management efforts are estimated to be approximately 12-14% of the construction cost based on previous project experience.

8.1.3 Contingency

The actual project costs can vary greatly due to a number of possible external factors, including but not limited to climate, market conditions, government policy and material pricing. An additional 25-30 percent of the construction cost is added to the overall cost as a contingency to ensure appropriate levels of financing for the CIP.

8.2 Building Condition Data for an Asset Management Program

In order for the City to effectively use their resources for the following capital improvement programs, an upgraded dataset is recommended to build an effective asset management program. In its ideal form, an asset management program should incorporate GIS data that would be interactive with a computerized maintenance and monitoring system (CMMS). Components of the system should be organized within a hierarchy of priorities, with probabilities and consequences of failure included as factors. Business risk exposure should also be included in the asset management program.

8.2.1 Condition Data – Phase 1 (CIP 1) (Objective 4: R&R)

At the initial stage, the GIS database needs to include complete information on water main materials and age. Appurtenances to the pipes include valves, meters, services, tanks, and wells. Known condition of a water main and the year it was constructed includes similar conclusions to the valve or the services connected to it. Approximately 6 miles of the pipe material modeled in the GIS is unknown, which has led to coarse estimates of the amount of AC pipe material needing replacement. Current known pipe material is stated generally; while known pipe is expressed as AC or PVC, more detailed specifications are recommended as part of the second phase. Further assumptions were made regarding the age of pipes as there is no current information for the age of pipes in GIS. These two factors, pipe material and pipe age, are recommended to be completed initially. CIP 1 in attached Appendix A (attached) presents item descriptions and associated budgetary level costs.

8.2.2 Condition Data – Phase 2 (CIP 2) (Objective 4: R&R)

After pipe material and age attributes are more fully integrated into GIS, the City can incorporate other information to build condition data for an asset management program. Record drawings can be incorporated that are currently not in the database. Pipe material details (i.e., class number or ASTM specifications) can be incorporated into the database. Leak history can identify waterlines that demand immediate attention. Acoustic sounding is a relatively inexpensive and efficient way to detect leaks, and data from a condition assessment of AC pipes (See CIP #4 – Section 8.3.2) can be incorporated into GIS. Preventative maintenance records can show areas that were recently maintained and are not needing renewal or replacement, or areas with records that are old enough to revisit.

Many additional layers of condition data can be captured by operations staff using a CMMS during their workday. To enable operations staff to capture this data, they will need to be equipped with in-field computers. The in-field computers will run an application that displays the GIS data and allows operations staff to relate each of their maintenance or repair activities to a specific asset from the GIS, for example, a specific valve or length of pipe. The CMMS application will facilitate simultaneous multi-user read/write access to the water system database using industry-standard Relational Database Management System software.

In order to improve on the CMMS, the following may be completed in one fiscal year:

- **System Audit and Business Process Mapping – estimated cost – $40,000:** Both a System Audit and Business Process Mapping would guide the City to find the locations where work orders would be needed, and assist in defining what kind of reactive maintenance has been performed on the assets. A System Audit would generally take a week. Process Mapping is usually a three day workshop, where a report can be delivered in a month.
- **Gap Analysis – estimated cost - $30,000:** For a Gap Analysis, there would be a meeting with Staff to understand current and desired workflows and come up with a list of functional requirements they wanted to enhance their existing CMMS. During that gap analysis, the current MMS would be evaluated
- If a new MMS system is needed, the cost to purchase would be $30,000-60,000 up front, and $30,000-60,000 annually for supports and updates. Most of the new MMS systems can also work with stormwater and roads.

CIP 2 in attached Appendix A presents item descriptions and associated budgetary level costs.

At this stage, the City would be equipped with an asset inventory where a hierarchical organization is available to prioritize projects. Features can be overlaid onto water system components to the point where the City is better able to make informed decisions. Accounting can be made for probabilities and consequences of failure, as well as business risk exposure. Certain scenarios will also warrant intuitive judgment on priorities. As an example, a large water main break in front of the City Plaza is more critical than a small water main breaking in a residential street with low traffic issues.

8.3 Renewal and Replacement of Existing Pipelines

The following recommendations in this section are made using existing City GIS data and assumptions regarding the remaining useful life of existing assets. More recommendations can occur from improved condition data as described in Section 8.2.

A majority of the City water mains were built in the 1970s with AC pipe. These pipes are now 40-47 years old, and the City should be starting to renew, replace, or at least assess those pipes which can be reasonably anticipated to be in poor condition. Based on a standard approximation for the useful life of an AC pipe (50 years), some AC pipes could begin to fail in the next five years, and renewal and replacement should be incorporated during this time, especially where there are road improvements planned or other utility projects planned (i.e., sanitary sewer, storm drain, gas lines, etc.).

Figure 8-1 provides a map showing the City's AC pipe, unknown pipe, and other. According to City GIS records, approximately 47 to 58% (26 to 32 miles) of the system consists of AC pipe. The minimum (26 miles) includes all known AC pipe and the maximum (32 miles) is a conservative assumption that all unknown pipe is AC. The following Table 8-2 provides a summary of total costs to replace AC pipe for the entire system.

Table 8-2 Costs for Replacement of AC pipe

Length of Known AC (ft)	Length Unknown Pipe (ft)	Price to replace Known AC	Price to replace Known AC and Unknown Pipe
136,275	**30,668**	**$ 54,970,000**	**$ 68,090,000**

Note: The unit costs for pipe replacement of pipe accounts for the appurtenances, including valves, meters, and services.

CIP 3a in Appendix A presents item descriptions and associated budgetary level costs for replacing known AC. CIP 3b in Appendix A presents item descriptions and associated budgetary level costs for replacing known AC and unknown pipe.

8.3.1 Renewal and Replacement of AC Pipe – 2% per Year (CIP 3) (Objective 1: Supply Reliability; Objective 4: R&R)

The City's last installation of AC pipe occurred in the 1970s, and therefore, all AC pipe is assumed to be at least 40 years old. Generally, AC pipe has a useful life of 50 years. The following Table 8-3 gives scenarios for the amount of years to replace all AC pipe, with the percentage of AC replacement per year and associated cost per year.

Table 8-3 Costs per Year for Replacement of AC pipe

Years to Replace all AC Pipe	Percentage of Pipe to Replace per Year	Cost per Year (min)	Cost per Year (max)
5	20.0%	$10,994,000	$13,618,000
10	10.0%	$5,497,000	$6,809,000
12.5	8.0%	$4,397,600	$5,447,200
20	5.0%	$2,748,500	$3,404,500
50	2.0%	$1,099,400	$1,361,800

The first AC and unknown pipes to be replaced are those that address pressure and fire flow deficiencies. The following are priorities:

1) CIP 5 – Upsizing AC pipe to 8 inches near deficient fire flow and pressure nodes (See Section 8.3.3); and
2) CIP 6 – Upsizing Unknown Pipe to 8 inches near deficient fire flow and pressure nodes (See Section 8.3.4).

While these areas are addressed, it is recommended to conduct a condition assessment of AC pipe, and then replace a minimum of 2% of the City's AC pipe every year based on the assessment. The City would need input for target locations where maintenance staff has experienced leaks, loss of pressure, etc., and an asset management program would help organize priorities. In order to be more reasonable within budget, AC pipelines should be replaced in coordination with other City projects, such as road rehabilitation, along with coordinating with other utilities (PG&E, SCWA, etc.) allows for multiple projects to be completed at a minimal cost.

8.3.2 Acoustic Sounding of AC Pipe (CIP 4) (Objective 1: Supply Reliability)

To assist the City in prioritizing AC replacement, a condition assessment of AC pipe from an expert is more cost effective than replacing AC pipe with limited information. Acoustic sounding is the preferred method, and the City is currently using acoustic sounding professionals for their system. A leak detection company first listens to a large length of pipe, and if there are suspicious noises, later returns to hone in on the leak. Two microphones are put on both ends and a computer calculates where the leak occurs between them. Generally, it is easier to detect sounds in AC over PVC. Though the cost does not vary between diameters, leak detection is easier for small pipes than large pipes.wes

With information provided by acoustic sounding, an additional technical memorandum should both interpret the results and provide direction on Condition Data – Phase 2 (CIP 2). With acoustic sounding results, a condition assessment should break down the AC pipes into a numbered priority (e.g., scale of 1 to 5). AC replacement should be organized into different phases. If after the condition assessment there are AC pipes that need to be upsized for fire flow and pressure requirements, the City would coordinate the small diameter AC matching poor AC from the condition assessment as a first priority. The City should prioritize pipes under roads expected to undergo rehabilitation in the next five years. From discussions with the City, there may be the possibility of overlapping pavement data with the water system. This can be done by converting pavement data from the management software StreetSaver into a spatial format. In GIS, the City should then see areas where both road rehabilitation and AC pipe renewal are necessary. The City should also overlay development proposals with AC pipe renewal. Water mains that have larger community impacts from a water main break should be a priority. Examples include water mains near The Plaza, hospitals, or schools.

Vendor estimates of acoustic sounding at 25 miles of pipe are at $10,000 over 4-5 days. With a 30% contingency at $3,000 and the interpretation of results at $10,000, this CIP is estimated at $23,000.

8.3.3 Replacing AC Pipe – Upsizing to 8 Inches for Increased Fire Flow and Pressure (CIP 5) (Objective 1: Supply Reliability; Objective 3: Public Safety)

It is generally recommended to have water mains at a diameter of at least 8 inches to achieve adequate fire flow. Since AC pipes are recommended to be replaced, and certain known AC pipes are near model nodes with deficient fire flow and pressure, the first priority is to upsize known AC pipes near nodes with fire flow (larger diameter pipe creates more flow) and pressure deficiencies (larger diameter pipe creates less friction loss, meaning less pressure loss, in a dynamic system). Figure 6-5 shows known AC pipes and unknown pipes connected to nodes with fire flow deficiencies before any pipes are upsized. Figure 6-6 shows improved fire flow after known AC and unknown pipes are upsized to 8 inches. Though the majority of upsized pipe for increased fire flow also applies to increasing pressure, linear feet of upsized pipe that solely upgrades pressure deficiencies are also included in costs. CIP 5 in attached Appendix A (attached) presents item descriptions and associated budgetary level costs for upsizing known AC pipes that may improve fire flow and pressure deficiencies.

8.3.4 Replacing Unknown Pipe – Upsizing to 8 Inches for Increased Fire Flow (CIP 6) (Objective 1: Supply Reliability; Objective 3: Public Safety)

It is generally recommended to have water mains at a diameter of at least 8 inches to achieve adequate fire flow. Since AC pipes are recommended to be replaced, and certain AC pipes are near model nodes with deficient fire flow and pressure, the first priority is to upsize known AC pipes to increase fire flow (larger diameter pipe creates more flow) and pressure (larger diameter pipe creates less friction loss, meaning less pressure loss, in a dynamic system) (See Section 8.3.3). The second priority is to upsize unknown pipes. Figure 6-5 shows unknown pipes connected to nodes with fire flow deficiencies before any pipes are upsized. Figure 6-6 shows improved fire flow after known AC and unknown pipes are upsized to 8 inches. On analysis of pressure requirements, unknown pipes did not show any increase in pressure categories after they were upsized to 8 inches. CIP 6 in attached Appendix A presents item descriptions and associated budgetary level costs for upsizing unknown pipes that may improve fire flow deficiencies.

8.4 Emergency Supply

In response to an event where the water from SCWA was shut off due to water quality issues, an earthquake, or other form of damage, the City's well supply must be capable of meeting City demand. As detailed in Section 4.3, based on a January 2016 review of the current well supply and the minimum demand over the last three years, the City has just enough water supply for a short duration of time under conservative demand assumptions. This can be accomplished through staggering the pump run times as seen in Table 4-7, and includes scenarios where the highest producing well (Well

No. 1) is not running. However, as the wells age, supply will decrease and may not continue to provide adequate emergency supply to meet City demand.

To preserve an adequate emergency supply for the future well system, it is recommended to replace Well No. 3, and/or develop a new well source as Well No. 9. The preferred option is to develop Well No. 9, due to a greater amount of yield compared to cost. Methods and costs are presented in this section, and a selection of these options will be based on how much emergency supply the City would want above the current match between supply and demand.

8.4.1 Option 1 (Not Preferred) – Well No. 3 Replacement – (Objective 2: City Well Resilience)

Well No. 3 is currently operational at a short-term cycled flow rate of 150 gpm, and the pumping efficiency of the well, as measured by the wells specific capacity, has significantly degraded in comparison to the original installation in 1947. The specific capacity (well flow rate divided by the corresponding drop in water level within the well; units of gpm/ft) of the well degraded nearly 40% between 1976 and 1990. An additional reduction in specific capacity occurred when the well was relined with a smaller diameter well screen in 2001. A new well pump was also installed in 2001.

In 2010, Well No. 3 operated at a specific capacity of approximately 1.5 gpm/ft. This is only 35% of the specific capacity recorded in 1976 (4.32 gpm/ft) and 30% of the specific capacity recorded in 1961 (4.95 gpm/ft). When installed in 1947, the specific capacity of Well No. 3 was not recorded but was likely even higher than the 4.95 gpm/ft recorded in 1961. Based on the higher historic specific capacity of Well No. 3 and current flows of nearby Wells No. 1 (350 gpm) and No. 2 (150 gpm), a replacement of Well No. 3 at this location could yield significantly higher flow rates. The well would be limited to 200 gpm, the historic 1961 flow rater as restricted by CEQA Guidelines Section 15302 (Class 2, Replacement or Reconstruction). Well No. 3 Replacement project is also required to provide additional pumping capacity to supplement/replace supply from Well No. 1. Although Well No. 1 is currently the highest producing well in the system, Well No. 1 is old and unavoidable declines in the production capacity of the well are expected during the 10-year planning period.

Replacing Well No. 3 involves identifying a nearby location for the installation of the new well. The existing location in Depot Park has open areas that can be used to stage equipment and supplies needed during installation. The location of the replacement well should be at least 30 feet away from the existing well location to minimize the possibility of drilling across or pushing drilling fluids into the existing well. Some of the existing water disinfection equipment could be reused, but if existing Well No. 3 is left intact, it can serve as a backup well adding needed redundancy to the system. Siting of a new well in the vicinity of the existing well may be difficult given site conditions at Depot Park.

Wellhead protection should be provided in the form of a perimeter fence around the well site and small (10 ft X 10 ft) building for the disinfection equipment. A larger building with a removable roof may be required if the well was located inside the equipment building. A sewer connection is also needed to receive water discharged during maintenance activities. CIP 7 in attached Appendix A presents item descriptions and associated budgetary level costs for a complete project including design, construction and construction management.

In summary, Well No. 3 Replacement would increase groundwater supply an estimated 50 gpm for an approximate cost of $2.0 million. Initial pump testing is recommended to confirm the amount the

City can yield, which is included in Phases 2 and 3 of CIP 7 in attached Appendix A. An initial estimate of this cost is approximately $210,000 and includes Sales Tax Materials, Mobilization/Demobilization, Contractor's Bonds and Insurance, Contractor's Overhead and Profit, and Construction Contingency.

8.4.2 Option 2 (Preferred) - New Well Source (Well No. 9) (CIP 7) (Objective 2: City Well Resilience)

In the near term, a new well would be considered a backup well or reserve well, rather than a well to increase supply for growth. Well No. 9 could help maintain capacity during an emergency, and would initially not need to run during normal operations. Over time, Well No. 9 may need to run during normal operations, and would be considered a primary well.

As mentioned in Section 4.3, for planning purposes, in 2010 it was assumed from a water supply analysis[20] that an additional well would yield approximately 60 AF/Y per well or 180 AF/Y total (each well operating at approximately 140 gpm for the 18 week pumping peak season). This is a conservative assumption, as the additional Well No. 8 currently runs at 320 gpm. An initial step for Well No. 9 is to perform pump testing to confirm an accurate potential yield from a new well, which is included in Phases 1, 3 and 4 of CIP 8 in attached Appendix A. An initial estimate of this cost is approximately $452,000.

The most likely area for a new well is in the general area north of West Spain Street, west of First Street West and east of Fifth Street West. This area was used in the past by the City during the 1950's and 1960's as a groundwater source when the City operated the Vallejo Home Wells, Well No. 1 and Well No. 2. In order to ensure that Well No. 9 is in the vicinity yet has an adequate distance away from Well No. 8, a good location within this general area is west of Vallejo's home, north of the bike path, and west of Fourth Street West.

Based on the available data from wells within 1,000 feet of the Study Area, a specific capacity of 3 to 6 gpm/ft can be expected in the area. Seasonal static water level varies between a depth of 50 and 100 feet. At a flow rate of 400 gpm with a specific capacity of 4.5 gpm/ft (average of 3 and 6 gpm/ft), approximately 111 feet of drawdown can be expected in the well. Therefore, the well screen should be roughly 221 feet below grade to avoid exposing the screen to cascading water in the well. The well should be constructed with a minimum 10-inch casing to allow for flexibility in pump selection. The depth of the well should allow for a sufficient length of screen in the aquifer to intersect water bearing fractures in the volcanic bedrock material and to allow for sediment to settle in the bottom of the well over time. Based on City well data, much of the flow comes from small sections of screen. It is inferred that these are areas where the well intersects bedrock fractures. Because of this, the well gravel pack should be extended from the bottom of the annular seal (which is installed to a depth of 100 feet) to the bottom of the well. This will maximize the opportunity of the well to intersect the unscreened fractures in the upper part of the Sonoma Volcanic Formation. Summing the depths discussed above, a well approximately 400-450 feet deep is anticipated. Well 8, located at approximately the equivalent elevation and less than 1,000-feet east of the proposed new Well 9 location, has an 8-inch diameter casing constructed to a depth of 300 feet and pumps 300+ gpm. Therefore, the proposed new Well No. 9 estimated construction depth and yield are conservative.

[20] Technical Memorandum No. 6. Sonoma Water Master Plan – Water Supply Analysis. Prepared by Winzler & Kelly on behalf of the City of Sonoma. July 2010. W&K Job Number 02418-10-019

Water quality in this area is expected to be good with treatment only for disinfection. CIP 8 in attached Appendix A presents item descriptions and associated budgetary level costs for a complete project including design, construction and construction management.

In summary, the new Well No. 9 would give a conservative flow estimate between 140 gpm to 320 gpm at approximately $2.2 million. Initial pump testing is recommended to confirm the actual City yield, which is included in Phases 1, 3 and 4 of CIP 8 in attached Appendix A. An initial estimate of this cost is approximately $452,000 and includes Sales Tax Materials, Mobilization/Demobilization, Contractor's Bonds and Insurance, Contractor's Overhead and Profit, and Construction Contingency.

8.5 Meter System Upgrades

Currently, the City uses mechanical meters which are read using a drive by automatic meter reading system (more information on the existing meter system can be found in Section 2.2). The City could cost-effectively achieve the following objectives by replacing the existing hybrid-mechanical system with Advanced Metering Infrastructure (AMI):

1. Enhance customer service;
2. Improve water savings; and
3. Provide near real-time water usage data to consumers.

8.5.1 Advanced Metering Infrastructure (AMI) – (CIP 8) (Objective 1: Supply Reliability; Objective 4: R&R)

AMI systems measure, collect, and analyze water usage as well as communicate with metering devices such as water meters, pressure sensors, and other instrumentation either on-request or on a predetermined schedule. These systems include hardware, software, communications, consumer water displays and controllers, customer associated systems, Meter Data Management (MDM) software, and supplier business systems. More information can be found in Appendix C.

The benefits of implementing AMI, when compared to hybrid-mechanical meters, include the following:

- Improved Customer Billing resulting in more accurate billing, savings in manual reads and re-reads, fewer estimated bills and final reads, and consistent billing dates;
- Enhanced Customer Service resulting in more efficient ad hoc reads for changes in tenancies, proactive notification, fair and equitable fees, revenue protection, ability for customers to view and track daily water usage, ability to detect leaks faster, and expedited service starts;
- Reduced Non-revenue Water and Apparent Losses resulting in reduced meter reading lag efforts and non- and under-registration errors, and improved water balances;
- Reduced Meter Renewals resulting in reduced meter renewal and replacement costs; and
- Improved Water System Operation and Energy Efficiency resulting in collection of critical data for water staff assessment of infrastructure replacement needs for water mains, pipelines, and meters, reduced greenhouse gas emissions due to elimination of the need for vehicular travel to read water meters, water and energy savings due to faster leak detection, and more predictable budget planning.

AMI benefits both the customers and the utility when customers have easy access to their water consumption usage patterns as it better assists them with questions regarding high or low consumption complaints. This results in significant reduction in customer service calls and assists with proactive customer notifications regarding leaks within properties. AMI also enhances customer water use and conservation education through access to the detailed data that previously was not available. These benefits include more detailed understanding of end water use that can be used to encourage the customer to retrofit more water efficient terminal plumbing fixtures and appliances, inform amendments to plumbing codes and facilitate changes to the water usage charge structure.

General Assessment Framework for AMI Systems

It is recommended the City's objective assessment process for evaluating AMI solutions give special consideration to each of the following criteria:

- **Measurement Requirements**: Consider metrological requirements, pattern approvals, and standards with specific relevance to continuously and accurately monitoring a wide range of customer water usages.
- **Operation, environment, and materials**: Consider parts of the data pathway/chain that are liable to data anomalies and failures. This includes identifying the potential susceptibility of the meter technology to damage and/or under-performance in normal and extreme operating conditions.
- **Data conversion, logging & radio communications**: Consider the capability of each component of the system to accurately, efficiently, effectively, and securely record, cipher, transmit, receive, and process data. Consider options for obtaining an assurance of ongoing performance prior to investing in battery-powered technologies.
- S**oftware and Analytics**: Consider metering software and analytics packages in terms of meter data management (MDM) functional layers.
- **Lifecycle Analysis**: Consider utilizing capital budgeting techniques such as Cost Benefit Analysis C/B, Net Present Value (NPV), and/or Earnings Before Interest & Tax (EBIT) to re-evaluate the financial viability of AMI using the specifications of the best AMI solution identified during the technology assessment. A detailed financial analysis will also identify the best rollout timeframe and duration.

It is also recommended the City define sub-criteria of each of the main criteria listed above and define decision-making rules for weighting and aggregating the scores of several AMI solutions.

Cost Estimates:

Provision should be made for an estimated cost of $25,000 to develop a stakeholder engagement strategy. The estimated $25,000 cost of developing a stakeholder engagement does not include the ultimate cost of implementing that strategy. That cost would be estimated during the strategy development process. This process should begin as soon as possible.

A next step is a feasibility study that would evaluate the planning numbers provided. This feasibility study is estimated at $75,000.

Assuming a complete replacement, the total costs and benefits for a 15-year investment period are listed in Table 8-4 below.

Table 8-4 Costs and Benefits for 15-year Investment Period

Benefits	Total Value of Benefits($)	Costs	Total Costs
Reduction in apparent losses (GHD assumed) ($180,000/yr))	$1,751,568	Meter purchases	$671,435
More efficient remote reads	$2,167,500	Software - Communication	$688,213
Reduced repairs & replacements	$1,437,500	SaaS and Analytics	$225,001
		Meter replacement & repairs	$62,500
		Installation of meter (remove old and replace new)	$845,600
Totals for 15-years	$5,356,568		$2,492,748

8.6 Planning Documents

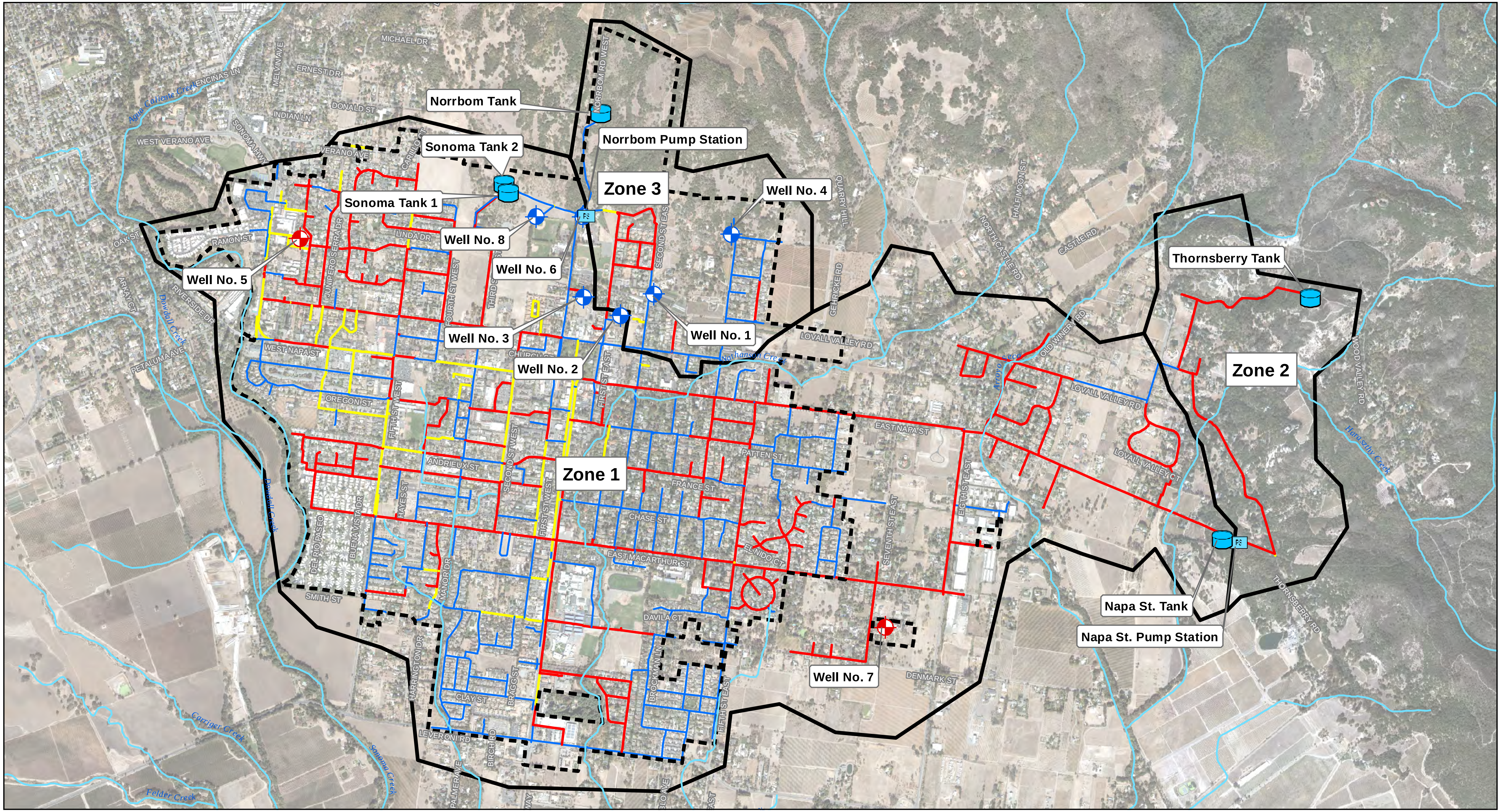
8.6.1 Planning Documents (CIP 9); (Objective 1: Supply Reliability; Objective 2: City Well Resilience)

The following documents are recommended for the next five years.

A 2020 Urban Water Management Plan will be required for the City. Any municipal water supplier serving over 3,000 connections or 3,000 acre-feet per year are required under the California Urban Water Management Planning Act.

As part of a Water Master Plan Update for the future, the City will need to incorporate water system projects that the City has completed since the current date, revise water supply and demand data, and identify proposed water system improvement projects for inclusion in the City's Capital Improvement Program (CIP).

An estimate of $75,000 is assumed for both the 2020 UWMP and a future Water Master Plan



City of Sonoma
Water Master Plan Update

Job Number 11140097
Revision 1
Date 10 Jan 2018

Asbestos Cement and Unknown Pipe Materials

Figure 8-1

Paper Size ANSI B
0 500 1,000 1,500
Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California II FIPS 0402 Feet

- Tank
- Pump Station
- Production Well
- Non-Production Well
- Creeks
- Pressure Zones
- City Limits

Water Pipe Material

- Asbestos Cement
- Unknown
- Other

2235 Mercury Way Suite 150 Santa Rosa CA 95407 USA T 707 523 1010 F 707 527 8679 E santarosa@ghd.com W www.ghd.com

\\ghdnet\ghd\US\Santa Rosa\Projects\111\11140097 Sonoma Water Master Plan Update\08-GIS\Maps\Deliverables\FINAL\8-1 AC and Unknown Pipes.mxd

Data source: Sonoma Veg Mapping, Imagery, 2013; City of Sonoma GIS, Water Utility, Roads and Streams, 2010; GHD, Water Demands, 2017. Created by:afisher2

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Appendices

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Appendix A - CIP Cost Estimates

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City of Sonoma
Water Distribution System Master Plan
Planning Level Opinion of Probable Cost

City of Sonoma - Water CIP
Project No. 1 - Condition Data - Phase 1

ENR Construction Cost Index:	
Jul-17	11,725.52

Description	Quantity	Unit	GIS Consultant Hourly Rate	Total Cost
Updates				
* Unknown GIS pipe material - without specifications	30	Hrs	$150	$4,500
* Unknown GIS pipe age	80	Hrs	$150	$12,000
Other Direct Costs[(1)]		LS	$660	$660
TOTAL ESTIMATE OF PROBABLE COST				
Subtotal (Rounded)				$18,000
Total Estimate of Probable Project Cost (Rounded)				**$18,000**

Notes:
(1) OTHER DIRECT COSTS include telephone, mileage, printing, photocopies and other miscellaneous direct expenses.

City of Sonoma
Water Distribution System Master Plan
Planning Level Opinion of Probable Cost

City of Sonoma - Water CIP
Project No. 2 - Condition Data - Phase 2

ENR Construction Cost Index:	
Jul-17	11,725.52

Description	Quantity	Unit	Unit Cost	Total Cost
System Audit and Business Process Mapping	1	LS	$40,000	$40,000
Gap Analysis	1	LS	$30,000	$30,000
New MMS System	1	LS	$45,000	$45,000
Yearly Fee	4	Yrs	$45,000	$180,000
Incorporating into GIS database				
* Record Drawings	80	Hrs	$150	$12,000
* Leak History	80	Hrs	$150	$12,000
* Preventative Maintenance	80	Hrs	$150	$12,000
* Work Orders	20	Hrs	$150	$3,000
* Information from Operations Staff	20	Hrs	$150	$3,000
* Unknown GIS material - with specifications (C900, AWWA cert, etc)	80	Hrs	$150	$12,000
Other Direct Costs(1)		LS	$1,680	$1,680
TOTAL ESTIMATE OF PROBABLE COST				
Subtotal (Rounded)				$351,000
Total Estimate of Probable Project Cost (Rounded)				**$351,000**

Notes:
(1) OTHER DIRECT COSTS include telephone, mileage, printing, photocopies and other miscellaneous direct expenses.

City of Sonoma
Water Distribution System Master Plan
Planning Level Opinion of Probable Cost

City of Sonoma - Water CIP
Project No. 3a - Renewal & Replacement - Minimum AC Pipe

ENR Construction Cost Index:		
Jul-17	11,725.52	SF

Description	Diameter (in)	Quantity	Unit	Unit Cost	Total Cost
Mobilization and Demobilization (6%)		1	LS	$1,787,000	$1,787,000
Temporary Traffic Control (5%)		1	LS	$1,489,000	$1,489,000
Potholing		136,275	LF	$13	$1,719,000
Shoring and Trench Safety		136,275	LF	$21	$2,865,000
Dewatering		136,275	LF	$42	$5,730,000
Handling, Treatment, and Disposal of Contaminated Soil and GW		136,275	LF	$11	$1,433,000
4" Class 200 PVC Water Pipe	4	2,841	LF	$82	$233,000
6" Class 200 PVC Water Pipe	6	34,339	LF	$105	$3,591,500
8" Class 200 PVC Water Pipe	8	61,164	LF	$127	$7,779,300
10" Class 200 PVC Water Pipe	10	13,742	LF	$149	$2,051,200
12" Class 200 PVC Water Pipe	12	20,196	LF	$172	$3,481,500
14" Welded Steel Water Pipe	14	3,993	LF	$224	$894,100
TOTAL ESTIMATE OF PROBABLE CONSTRUCTION COST					
Subtotal (Rounded)					$33,054,000
Construction Subtotal (Rounded)					$33,060,000
Contingency (25%) (Rounded)					$8,265,000
Total Estimate of Probable Construction Cost (Rounded) [1]					**$41,330,000**
Program Management (1%)					$413,300
Design, Survey, Geotechnical, Environmental Review, Permits (25% of Construction)					$8,266,000
Inspection/CM/ESDC (12% of Construction)					$4,959,600
Easement/Land Acquisition [1]					0
Project Total (Rounded) - July 2017					**$54,970,000**

Notes:
(1) Does not include property acquisition, permit costs, or other City fees.

City of Sonoma
Water Distribution System Master Plan
Planning Level Opinion of Probable Cost

City of Sonoma - Water CIP
Project No. 3b - Renewal & Replacement - Maximum AC Pipe

ENR Construction Cost Index:		
Jul-17	11,725.52	SF

Description	Diameter (in)	Quantity	Unit	Unit Cost	Total Cost
Mobilization and Demobilization (6%)		1	LS	$2,214,000	$2,214,000
Temporary Traffic Control (5%)		1	LS	$1,845,000	$1,845,000
Potholing		167,676	LF	$13	$2,116,000
Shoring and Trench Safety		167,676	LF	$21	$3,526,000
Dewatering		167,676	LF	$42	$7,051,000
Handling, Treatment, and Disposal of Contaminated Soil and GW		167,676	LF	$11	$1,763,000
4" Class 200 PVC Water Pipe	4	3,162	LF	$82	$259,231
6" Class 200 PVC Water Pipe	6	39,672	LF	$105	$4,149,186
8" Class 200 PVC Water Pipe	8	75,169	LF	$127	$9,560,555
10" Class 200 PVC Water Pipe	10	21,356	LF	$149	$3,187,631
12" Class 200 PVC Water Pipe	12	20,835	LF	$172	$3,591,709
14" Welded Steel Water Pipe	14	7,071	LF	$224	$1,583,143
16" Welded Steel Water Pipe	16	412	LF	$251	$103,503
TOTAL ESTIMATE OF PROBABLE CONSTRUCTION COST					
Subtotal (Rounded)					$40,950,000
Construction Subtotal (Rounded)					$40,950,000
Contingency (25%) (Rounded)					$10,238,000
Total Estimate of Probable Construction Cost (Rounded) [(1)]					**$51,190,000**
Program Management (1%)					$511,900
Design, Survey, Geotechnical, Environmental Review, Permits (20% of Construction)					$10,238,000
Inspection/CM/ESDC (12% of Construction)					$6,142,800
Easement/Land Acquisition [(1)]					0
Project Total (Rounded) - July 2017					**$68,090,000**

Notes:
(1) Does not include property acquisition, permit costs, or other City fees.

City of Sonoma
Water Distribution System Master Plan
Planning Level Opinion of Probable Cost

City of Sonoma - Water CIP
Project No. 5 - Renewal & Replacement - Fire Flow and Pressure Improvemen
Upsizing AC Pipe to 8" PVC

ENR Construction Cost Index:		
Jul-17	11,725.52	SF

Description	Diameter (in)	Quantity	Unit	Unit Cost	Total Cost
Mobilization and Demobilization (6%)		1	LS	$36,000	$36,000
Temporary Traffic Control (5%)		1	LS	$30,000	$30,000
Potholing		2,799	LF	$13	$36,000
Shoring and Trench Safety		2,799	LF	$21	$59,000
Dewatering		2,799	LF	$42	$118,000
Handling, Treatment, and Disposal of Contaminated Soil and GW		2,799	LF	$11	$30,000
8" Class 200 PVC Water Pipe	8	2,799	LF	$127	$356,000
TOTAL ESTIMATE OF PROBABLE CONSTRUCTION COST					
Subtotal (Rounded)					$665,000
Construction Subtotal (Rounded)					$670,000
Contingency (25%) (Rounded)					$168,000
Total Estimate of Probable Construction Cost (Rounded) [(1)]					**$840,000**
Design, Survey, Geotechnical, Environmental Review, Permits (25% of Construction)					$210,000
Inspection/CM/ESDC (12% of Construction)					$100,800
Easement/Land Acquisition [(1)]					0
Project Total (Rounded) - July 2017					**$1,160,000**

Notes:
(1) Does not include property acquisition, permit costs, or other City fees.

City of Sonoma
Water Distribution System Master Plan
Planning Level Opinion of Probable Cost

City of Sonoma - Water CIP
Project No. 6 - Renewal & Replacement - Fire Flow Improvements
Upsizing Unknown Pipe to 8" PVC

ENR Construction Cost Index:		
Jul-17	11,725.52	SF

Description	Diameter (in)	Quantity	Unit	Unit Cost	Total Cost
Mobilization and Demobilization (6%)		1	LS	$15,000	$15,000
Temporary Traffic Control (5%)		1	LS	$13,000	$13,000
Potholing		1,154	LF	$13	$15,000
Shoring and Trench Safety		1,154	LF	$21	$25,000
Dewatering		1,154	LF	$42	$49,000
Handling, Treatment, and Disposal of Contaminated Soil and GW		1,154	LF	$11	$13,000
8" Class 200 PVC Water Pipe	8	1,154	LF	$127	$146,800
TOTAL ESTIMATE OF PROBABLE CONSTRUCTION COST					
Subtotal (Rounded)					$277,000
Construction Subtotal (Rounded)					$280,000
Contingency (25%) (Rounded)					$70,000
Total Estimate of Probable Construction Cost (Rounded) (1)					**$350,000**
Design, Survey, Geotechnical, Environmental Review, Permits (25% of Construction)					$87,500
Inspection/CM/ESDC (12% of Construction)					$42,000
Easement/Land Acquisition (1)					0
Project Total (Rounded) - July 2017					**$480,000**

Notes:
(1) Does not include property acquisition, permit costs, or other City fees.

City of Sonoma
Water Distribution System Master Plan
Planning Level Opinion of Probable Cost

City of Sonoma - Water CIP
Project No. 7 - Well No. 3 Replacement

ENR Construction Cost Index:		
Jul-17	11,725.52	SF

	QUANTITY		COST			
ITEM DESCRIPTION	**No.**	**Unit**	**Material**	**Labor**	**Total**	**TOTAL COST**
General						
Phase 1 – Site Preparation						
CEQA (Cat. Ex, or Neg Deg)	1	LS	$0	$2,500	$2,500	$2,500
Survey	1	LS	$0	$6,500	$6,500	$6,500
Geotechnical	1	LS	$0	$10,500	$10,500	$10,500
Phase 2 – Pilot Hole, Water Quality Analysis and Estimate of Yield			$0	$0		
Pilot Boring and Monitoring Well Permitting by PRMD	1	LS	$0	$2,500	$2,500	$2,500
Drill Pilot Boring to 405 feet	405	LF	$0	$50	$50	$20,250
E-logging	1	LS	$0	$5,000	$5,000	$5,000
Phase 3 - Conceptual Design for Well Site			$0	$0		
Monitoring well construction in pilot boring to 405 feet.	405	LF	$0	$50	$50	$20,250
Monitoring well develop and DDW water quality sampling/zone testing.	1	LS	$0	$30,000	$30,000	$30,000
DDW permitting/tech memo design criteria and well head protection evaluation	1	LS	$0	$25,000	$25,000	$25,000
Phase 4 - Well Installation, Pilot Treatment Test and Aquifer Testing			$0	$0		
DDW, City, USA, Disposal Facilities & Noise Mitigation	1	LS	$2,000	$6,500	$8,500	$8,500
Replacement Well Drilling to 405 feet/Casing (16" diameter)	405	LF	$0	$350	$350	$141,750
Well Development	1	LS	$0	$30,000	$30,000	$30,000
Aquifer Capacity Test, Title 22 Analysis and DDW Meeting	1	LS	$0	$28,500	$28,500	$28,500
Site Cleanup and Disposal of Fluids, Clays and Soil	1	LS	$0	$24,000	$24,000	$24,000
Phase 5 - Pump and Disinfection Installation			$0	$0		
Power, piping and pad	1	LS	$119,500	$126,500	$246,000	$246,000
Control / Chlorination Building	1	LS	$140,700	$84,000	$224,700	$224,700
Pump and column pipe	1	LS	$79,500	$20,000	$99,500	$99,500
Water level recorder	1	LS	$6,500	$3,500	$10,000	$10,000
Sampling	1	LS	$4,000	$4,000	$8,000	$8,000
Subtotal Materials	--	--	$352,200	--		
9% Sales Tax Materials						$31,698
Construction Subtotal						$975,148
Mobilization/Demobilization (4%)						$37,738
Contractor's Bonds and Insurance (3%)						$28,304
Contractor's Overhead and Profit (15%)						$141,518
Estimated Bid Price						$1,182,707
Construction Contingency (30%)						$354,812
Total Estimate of Probable Construction Cost						$1,537,600
Engineering/CM						
- Pre-Design (5%)	1	LS				$76,900
- Contract Documents (11%)	1	LS				$169,200
- Engineering Support During Construction - Office (4%)	1	LS				$61,600
- Construction Management - Field (14%)	1	LS				$215,300
Grand Total - July 2017						**$2,060,600**

City of Sonoma
Water Distribution System Master Plan
Planning Level Opinion of Probable Cost

City of Sonoma - Water CIP
Project No. 8 - New Well Source - Well No. 9

ENR Construction Cost Index:		
Jul-17	11,725.52	SF

	QUANTITY		COST			
ITEM DESCRIPTION	**No.**	**Unit**	**Material**	**Labor**	**Total**	**TOTAL COST**
General						
Phase 1 – Site Selection						
Testing/water quality analysis of nearby wells	1	LS	$0	$26,500	$26,500	$26,500
Acquisition assistance	1	LS	$0	$19,900	$19,900	$19,900
CEQA	1	LS	$0	$55,000	$55,000	$55,000
DDW permitting process initiation	1	LS	$0	$13,300	$13,300	$13,300
Phase 2 – Site Preparation			$0	$0		
Survey	1	LS	$0	$13,300	$13,300	$13,300
Geotechnical	1	LS	$0	$19,900	$19,900	$19,900
Phase 3 – Pilot Hole, Water Quality Analysis and Estimate of Yield			$0	$0		
Pilot Boring and Monitoring Well Permitting by PRMD	1	LS	$0	$2,500	$2,500	$2,500
Drill Pilot Boring to 450 feet	450	LF	$0	$50	$50	$22,500
E-logging	1	LS	$0	$5,000	$5,000	$5,000
Phase 4 - Conceptual Design for Well Site			$0	$0		
Monitoring well construction in pilot boring to 450 feet.	450	LF	$0	$50	$50	$22,500
Monitoring well develop and DDW water quality sampling/zone testing.	1	LS	$0	$30,000	$30,000	$30,000
DDW permitting/tech memo design criteria and well head protection evaluation	1	LS	$0	$25,000	$25,000	$25,000
Phase 5 - Well Installation, Pilot Treatment Test and Aquifer Testing			$0	$0		
DDW, City, USA, Disposal Facilities & Noise Mitigation	1	LS	$2,000	$6,700	$8,700	$8,700
New Well Drilling to 450 feet/Casing (16")	450	LF	$0	$350	$350	$157,500
Well Development	1	LS	$0	$30,000	$30,000	$30,000
Aquifer Testing, Title 22 Analysis and DDW Meeting	1	LS	$0	$28,500	$28,500	$28,500
Site Cleanup and Disposal of Fluids, Clays and Soil	1	LS	$0	$23,900	$23,900	$23,900
Phase 6 - Pump and Disinfection Installation, Aquifer Testing			$0	$0		
Power, piping and pad	1	LS	$145,500	$96,300	$241,800	$241,800
Control / Chlorination Building	1	LS	$140,700	$84,000	$224,700	$224,700
Pump and column pipe	1	LS	$79,400	$19,900	$99,300	$99,300
Water level recorder	1	LS	$6,700	$3,400	$10,100	$10,100
Sampling	1	LS	$4,000	$4,000	$8,000	$8,000
Subtotal Materials	--	--	$378,300	--		
9% Sales Tax Materials						$34,047
Construction Subtotal						$1,007,247
Mobilization/Demobilization (4%)						$38,928
Contractor's Bonds and Insurance (3%)						$29,196
Contractor's Overhead and Profit (15%)						$145,980
Estimated Bid Price						$1,221,351
Construction Contingency (30%)						$366,405
Total Estimate of Probable Construction Cost						$1,587,800
Engineering/CM						
- Pre-Design (5%)	1	LS				$194,100
- Contract Documents (11%)	1	LS				$174,700
- Engineering Support During Construction - Office (4%)	1	LS				$63,600
- Construction Management - Field (14%)	1	LS				$222,300
Grand Total - July 2017						**$2,242,500**

Appendix B - 5 Year Water Capital Improvement Program

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City of Sonoma
Water Distribution System Master Plan
Planning Level Opinion of Probable Cost

	City of Sonoma						
	5-Year Water Capital Improvement Program - FY 2018 - 2023 (all costs shown in 2017 dollars)						Jan 2018
ID #		FY 18-19	FY 19-20	FY 20-21	FY 21-22	FY 22-23	Totals
1	Condition Data - Phase 1	$ 18,000					$ 18,000
2	Condition Data - Phase 2	$ 115,000	$ 100,680	$ 45,000	$ 45,000	$ 45,000	$ 350,680
3	Renewal and Replacement of Existing Pipelines			$ 1,099,400	$ 1,099,400	$ 1,099,400	$ 3,298,200
4	Condition Assessment of AC Pipes	$ 23,000					$ 23,000
5	Fire Flow Improvements - Upsizing AC Pipe 8" PVC	$ 580,000	$ 580,000				$ 1,160,000
6	Fire Flow Improvements - Upsizing Unknown Pipe to 8" PVC		$ 480,000				$ 480,000
7	New Well No. 9	$ 452,058	$ 289,500	$ 750,471	$ 750,471		$ 2,242,500
8	Meter System Upgrades	$ 25,000	$ 75,000	$ 830,916	$ 830,916	$ 830,916	$ 2,592,748
9	2020 UWMP and Minor Water Master Plan Update			$ 75,000			$ 75,000
	Totals	**$ 1,213,058**	**$ 1,525,180**	**$ 2,800,787**	**$ 2,725,787**	**$ 1,975,316**	**$ 10,240,128**

Appendix C - Advanced Metering Infrastructure

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Memorandum

22 December 2017

To	Matt Winkelman, Senior Civil Engineer/Principal, GHD Inc.		
From	Edgar Johnson, Chartered Professional Engineer (Engineers Australia), GHD Inc.	Tel	+61 8 8111 6770
Subject	**City of Sonoma's Water Master Plan (WMP Update) – Advanced Metering Infrastructure (AMI)**	Job no.	33/18141 (011140097)

This technical memorandum provides guidance to the City of Sonoma (City) for evaluating, planning, and implementing advanced metering infrastructure (AMI) for the City's potable water distribution system. The City requested that consideration of AMI be included in the Water Master Plan because other local water providers have upgraded water meters to enhance customer service, improve water savings, provide near real-time water usage data, and reduce greenhouse gas emissions. This guidance includes the following:

1.) A summary of the City's existing water metering and meter-reading infrastructure, and an evaluation of the advantages of upgrading to AMI;

2.) A roadmap for evaluating AMI solutions given their technical complexity;

3.) An estimation of the capital and operating expenses as well as the financial benefits associated with upgrading the City's metering infrastructure to AMI;

4.) A cost/benefit (C/B) comparison of the current infrastructure with AMI, and estimations of the payback period for upgrading to AMI; and

5.) A roadmap for identifying other expenses or pitfalls associated with upgrading the City's metering infrastructure to AMI.

1 Description of Current Meter Fleet

The City currently operates a fleet of 4,378 mechanical water meters. The meter fleet is largely composed of Neptune T-10 meters that have a nutating disc-measuring chamber and a Metrological Description Ratio (MDR) of approximately 1:50 within a ±2% accuracy envelop. An MDR describes the flow range capability of a water meter as a ratio of the permanent flowrate divided by the minimum flow rate. This ratio helps illustrate the degree with which the meter can accurately measure both high and low flows. Meters with smaller MDRs and narrower accuracy envelopes minimize apparent losses, which typically occur when the meter is reading low flows (e.g. leaks).

The City's fleet of mechanical meters are read using an automatic meter reading (AMR) system that remotely reads meters with a drive-by system consisting of 900i Encoder electronics attached to the existing mechanical meters. The existing system is a hybrid-mechanical metering system.

A summary of the City's existing meter fleet is provided in Table 1 below.

Table 1 Existing Meter Fleet

Description	No.	%	Current Annual Usage (Million Gallons [MG])
Single family residential	3,330	76.1	542
Multifamily residential	253	5.8	137
Commercial / municipal	361	8.2	184
Irrigation	284	6.5	169
Fire service	150	3.4	0[1]
Total	4,378	100	1,032

1 City reported zero water usage in 2017 from fire services.

The size distribution for the meter fleet is illustrated in Figure 1 below with $^5/_8$" and $^3/_4$" meters comprising 68% of the total fleet.

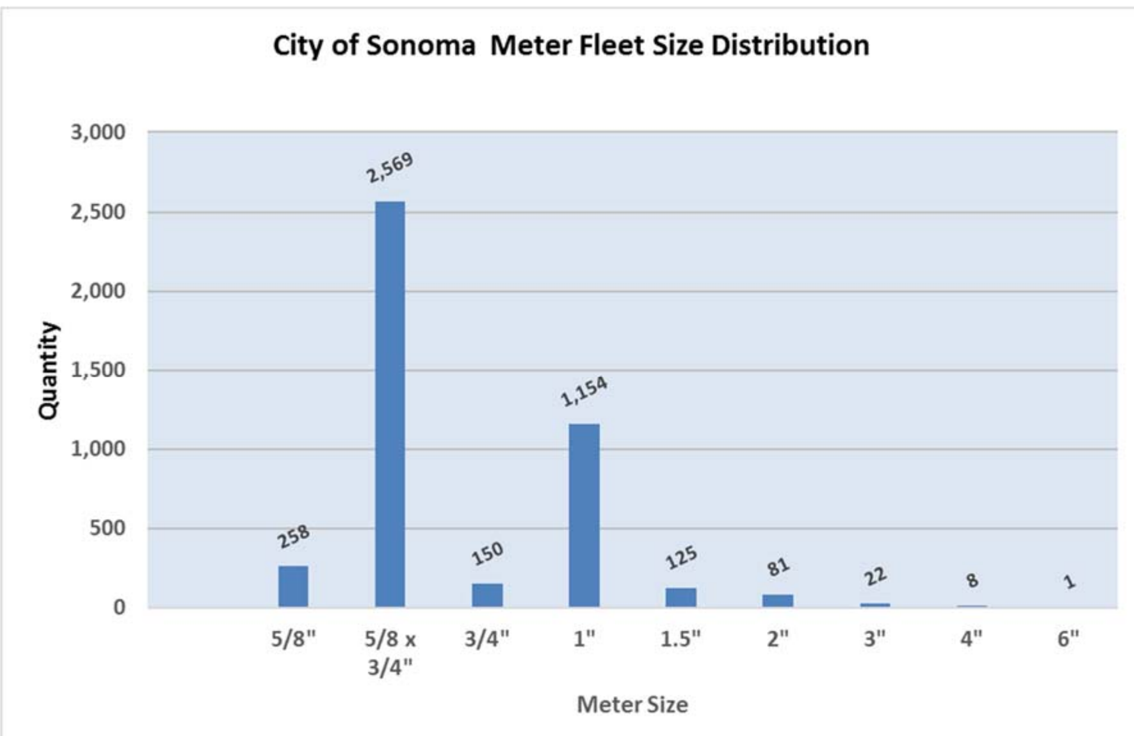

Figure 1 Meter Fleet Size Distribution

2 Problem Statement and Objectives

2.1 Objectives for AMI

The City is seeking to cost-effectively achieve the following objectives by replacing the existing hybrid-mechanical AMR system with AMI:

1. Enhance customer service;
2. Improve water savings; and
3. Provide near real-time water usage data to consumers.

2.2 Principles of AMI Technologies

AMI systems measure, collect, and analyse water usage as well as communicate with metering devices such as water meters, pressure sensors, and other instrumentation either on-request or on a predetermined schedule. These systems include hardware, software, communications, consumer water displays and controllers, customer associated systems, Meter Data Management (MDM) software, and supplier business systems.

The City's current mechanical metering technology was developed in the last century and adapted for 'smart' applications through the addition of electronic devices to the mechanical meters.

An increased degree of sophistication in the meter-reading technology is required to ensure complex water usage charges can be implemented, improvement in water use efficiencies achieved, and useful data recorded for the benefit of customers.

Figure 2 below shows how advances in water metering and meter-reading technologies correlate with expanded capabilities for implementing complex water usage charges. The City's current hybrid mechanical meters place it in the middle of the spectrum.

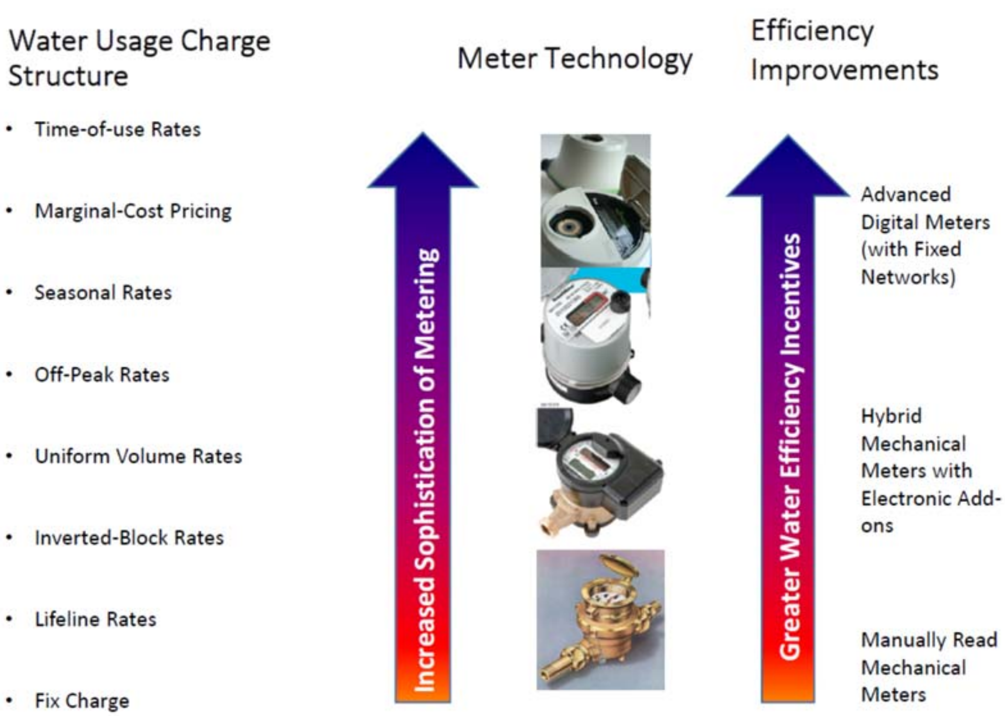

Figure 2 Meter Technology Sophistication Requirements

In recent years, there has been a quantum leap in water metering technologies. The key characteristics of these newer technologies include the following:

- A Metrological Quality Description Ratio (R) that exceeds that of mechanical metering technologies by 4 to 20 times. This can considerably reduce metering losses due to non-registration (i.e. apparent losses).
- New solid-state digital electronics that are not subject to mechanical wear and tear that causes measurement error decay (i.e. degradation). This can reduce metering losses due to under-registration (i.e. apparent losses).
- Battery life that matches the design life of the meter.
- Meters with very low failure rates. This can reduce maintenance and replacement costs by as much as 95%.
- Measurement sampling frequencies that allow for the accurate representation of actual water usage patterns.
- Long-range radio transmission capabilities with protocols that ensure secure encryption of data, accuracy of data, reliable communications, and increased coverage. This ensures data privacy, optimises the communication infrastructure, and assures that the integrity of the data chain is maintained.
- Dedicated MDM systems include functional layers for data collection, communications interfaces, data management, analytics, customer web portals, and specialist applications.

2.3 Benefits of Implementing AMI

The generic benefits of implementing AMI, when compared to hybrid-mechanical meters, include the following:

1) **Improved Customer Billing**
   i) Accurate billing
   ii) Savings in manual reads and re-reads
   iii) Fewer estimated bills
   iv) Fewer final reads
   v) Consistent billing dates
2) **Enhanced Customer Service**
   i) More efficient ad hoc reads for changes in tenancies
   ii) Proactive notification
   iii) Fair and equitable tariffs
   iv) Revenue protection
   v) Ability for customers to view and track daily water usage
   vi) Ability to detect leaks faster
   vii) Expedited service starts
3) **Reduced Non-revenue Water and Apparent Losses**

i) Reduced meter reading lag errors

ii) Reduced non- and under-registration errors

iii) Improved water balances

4) **Reduced Meter Renewals**

i) Reduced meter replacement and renewal costs

5) Improved Water System Operations and Energy Efficiency

i) Collection of critical data for Water staff assessment of infrastructure replacement needs for water mains, pipes and meters

ii) Reduced Greenhouse Gas emissions due to elimination of the need for vehicular travel to read water meters

iii) Water and energy savings due to faster leak detection

iv) More predictable budget planning.

The estimated financial benefits (for a selected sample of benefits) resulting from implementing a new AMI system are detailed with their estimated costs later in this report.

AMI benefit both the customers and the utility when customers have easy access to their water consumption usage patterns as it better assists them with queries regarding high or low consumption complaints. This results in significant reduction in customer service calls and assists with proactive customer notifications regarding leaks within properties. AMI also enhances customer water use and conservation education through access to the detailed data that previously was not available. These benefits include more detailed understanding of end water use that can be used to encourage the customer to retrofit more water efficient terminal plumbing fixtures and appliances, inform amendments to plumbing codes and facilitate changes to the water usage charge structure.

2.4 General Assessment Framework for AMI Systems

AMI systems are technically complex, as illustrated in Figure 3 below. It is strongly recommended that the City evaluate available AMI systems using an objective assessment process that accounts for the lifecycle management of the metering assets as well as the relative susceptibility of each system component to data error.

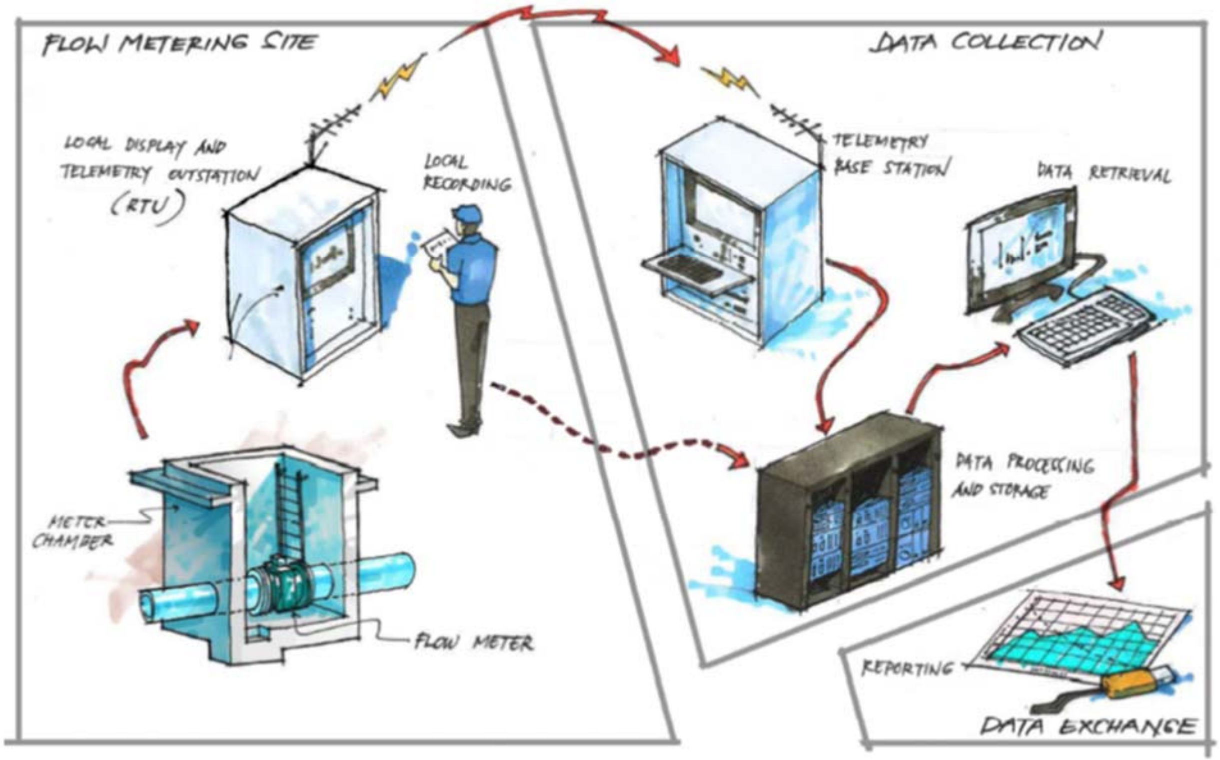

Figure 3 AMI Data Pathway/Chain

It is strongly recommended that the City's objective assessment process for evaluating AMI solutions give special consideration to each of the following criteria:

- **Metrology and measurement**: Consider metrological requirements, pattern approvals, and standards with specific relevance to continuously and accurately monitoring a wide range of customer water usages.
- **Operation, environment, and materials**: Consider parts of the data pathway/chain that are liable to data anomalies and failures. This includes identifying the potential susceptibility of the meter technology to damage and/or under-performance in normal and extreme operating conditions.
- **Data conversion, logging & radio communications**: Consider the capability of each component of the system to accurately, efficiently, effectively, and securely record, cipher, transmit, receive, and process data. Consider options for obtaining an assurance of ongoing performance prior to investing in battery-powered technologies.
- **Software and Analytics**. Consider metering software and analytics packages in terms of meter data management (MDM) functional layers.
- **Lifecycle Analysis**. Consider utilizing capital budgeting techniques such as C/B, Net Present Value (NPV), and/or Earnings Before Interest & Tax (EBIT) to re-evaluate the financial viability of AMI using the specifications of the best AMI solution identified during the technology assessment. A detailed financial analysis will also identify the best rollout timeframe and duration.

It is strongly recommended that the City define sub-criteria of each of the main criteria listed above and define decision-making rules for weighting and aggregating the scores of several AMI solutions. It is strongly recommended that the City use a tabular format similar to that shown in Table 2 below.

Table 2 Example of Metering Technology Comparison Template

Advanced Water Metering Technology		Mechanical Water Meters with 'add-on' electronic transmitters/loggers			Static Solid State Electronic Flow Meters with integral transmitters/loggers		
Key Criteria	**Sub-criteria**	**Technology A**	**Technology B**	**Technology C**	**Technology D**	**Technology E**	**Technology F**
Illustration							
Meter's principle of flow measurement							
Criteria 1 etc.	1.1						
	1.2 etc.						
RISK CONTINUUM							
Enhanced customer service	Red = High risk	**High Risk**			**Medium Risk**		**Low Risk**
Improved water savings	Red = High Risk	**High Risk**			**Medium Risk**		**Low Risk**
Real time water usage data	Red = High Risk	**High Risk**			**Medium Risk**		**Low Risk**

3 Costs for AMI, including Capital Expenses and Operating Expenses

3.1 City of Sonoma's Existing Meter Fleet Costs

The operating costs of the City's current meter fleet are listed in Table 3 below. The meter failure rate due to register or battery failures is high with approximately 600 per year (14.2%). At this rate, the existing meter fleet will be renewed approximately every 7.3 years assuming the failures occur chronologically.

Table 3 Existing Meter Fleet Operating Costs

Description	Cost ($)
City's annual operating expense for meter reads	$170,000
Average cost per meter read	$3.35
Replace registers ($/yr)	$50,000
Replace meters ($/yr)	$50,000

The apparent losses determined by the City for calendar year 2016 were valued at $50,487, which represented an apparent loss volume of 24.910 acre-feet (AF) or 8,117 million gallons (MG). This translates to a unit cost for apparent losses of $6.22 per MG. This apparent loss of 0.8% of billed volume is very low and inconsistent with the wear and tear characteristics of the City's current metering technologies, the estimated average age of the meter fleet (i.e. 7.3 years), and the general norm for other US meter fleets. GHD estimates that the level of apparent losses should be approximately $181,000 per year.

3.2 Estimated Costs for AMI System

The estimated capital and operating costs of a new AMI system are listed in Table 4 below.

Table 4 Estimated Costs of New Advanced Metering System

Description of Costs	Costs
Meter purchases (Capital Expense) ($)	$671,435
Software – Communication (Capital Expense) ($)	$688,213
Installation of meters (remove old and replace new, estimated at $200 per meter) (Capital Expense)	$845,600
Software as a Service (SaaS) and Analytics (Operating Expense) ($/yr)	$15,000
Apparent Losses (estimated as 1% of billed volume) ($/yr)	$64,207
Meter replacement & repairs ($/yr) (Allow for 0.5% failures)	$4,167

The estimated financial benefits from increased revenues and reduced operating expenditures are listed in Table 5 below.

Table 5 Estimated Benefits from Implementing New Advanced Metering System

Description of Benefits	Benefits ($/yr)
Reduction in apparent losses due to improvement in measurement accuracies achieved by new meters. Increased revenue.	$116,771
More efficient remote reads when compared to existing meter reads therefore reducing an existing (Operating Expense)	$144,500
Reduced repairs & replacements categorised as an ongoing	$95,833

Description of Benefits	Benefits ($/yr)
savings in operating expenses.	

The total costs and benefits for a 15-year investment period have been calculated from the estimates in Tables 4 and 5 above, and are listed in Table 6 below.

3.3 Cost/Benefit Analysis

C/B analysis is an unsophisticated capital budgeting technique, since it does not account for the time value of money by discounting cash flows (e.g., benefits and costs) to determine present value. However, this provisional analysis will assist the City with the initial decision making process as well as preparation for the application of more sophisticated capital budgeting techniques, such as NPV analysis. The total costs and benefits for a 15-year investment period are listed in Table 6 below.

Table 6 Costs and Benefits for 15-year Investment Period

Benefits	Total Value of Benefits($)	Costs	Total Costs
Reduction in apparent losses (GHD assumed) [(i)]	$1,751,568	Meter purchases	$671,435
More efficient remote reads	$2,167,500	Software - Communication	$688,213
Reduced repairs & replacements	$1,437,500	SaaS and Analytics	$225,001
		Apparent Losses (1% of billed volume)	$963,106
		Meter replacement & repairs	$62,500
		Installation of meter (remove old and replace new)	$845,600
Totals for 15-years	**$5,356,568**		**$3,455,854**

[(i)]$181,000 per year

The standard decision criteria for accepting or rejecting a particular investment scenario are as follows:

1. If the payback period is less than the maximum acceptable payback period (or C/B ratio <1), then accept the investment option.
2. If the payback period is greater than the maximum acceptable payback period (or C/B ratio > 1), then reject the investment project.

A payback period of 15 years is equal to the ratio of 1.0. The C/B ratios and payback periods for various AMI implementation scenarios are provided in Table 7 below.

Table 7 Cost/Benefit Ratios and Payback Periods

Description	C/B Ratio	Payback Period (Years)
With GHD assumed benefit from reduced apparent losses [(i)]	0.65	9.7

Description	C/B Ratio	Payback Period (Years)
Without any benefit from reduction in apparent losses (e.g. $0)	0.96	14.4
With City-reported apparent losses remaining the same [ii]	0.95	14.2

[i]$181,000 per year
[ii]$50,487 per year

This high-level analysis indicates that the implementation of an advanced new metering system is financially viable. However, further detailed assessment is needed that should include the following:

- The application of an objective and comprehensive multi-criteria approach for their selection and specification of the new advanced metering system.
- Application of a sophisticated capital budgeting technique, such as net present value (NPV) that considers the time value of money and in the case of advanced water meters, over their full design life of the system selected.

3.4 Other Considerations and Next Steps

3.4.1 Stakeholder Engagement and Communications Strategy

Provision should be made for an estimated cost of $25,000 to develop a stakeholder engagement strategy. The estimated $25,000 cost of developing a stakeholder engagement does not include the ultimate cost of implementing that strategy. That cost would be estimated during the strategy development process.

3.4.2 Assessment of Risks at Key Stages

It is strongly recommended that the City evaluate potential pitfalls associated with the following key stages for planning and implementing AMI:

- Assessment of metering technologies and development of a business case.
- Procurement that includes preparation of specifications, undertaking objective assessments of vendors, reporting, and preparation of related documentation. This includes defining the assessment criteria and decision-making rules for weighting and aggregating scores to obtain an objective assessment of AMI solutions.
- Planning and implementation of a phased approach that facilitates early and ongoing assessment of outcomes and benefits during AMI roll-out.
- Contract supervision and control of the roll-out of the metering program to facilitate the simultaneous integration into the City's existing systems and processes.

3.4.3 Data Transmission Services

Generally, data transmission systems used for other utilities, such as electricity, do not provide technically or financially viable solutions for the joint application with AMI. Communication and data compatibility issues are prevalent when attempting to integrate advanced water metering systems with communication systems for other utilities.

3.4.4 Costs Excluded

These estimated costs exclude consultant's fees required to assess, plan, specify, and successfully implement this new advanced metering system.

The City of Sonoma's internal costs associated with this project are also excluded (other than those already previously mentioned).

As mentioned previously, the costs for the implementation of stakeholder engagement strategy are excluded as well.