Appendix A Historic Volatile Organic Compound (VOC) Data

A.1 Volatile Organic Compound (VOC) Figures

The figures in this Appendix show historic VOC data at the City of Fullerton's groundwater wells from 2000 to 2019. Horizontal lines representing either federal or State of California (State) limits are shown on figures where the chemical levels are close to or in exceedance of the limits.

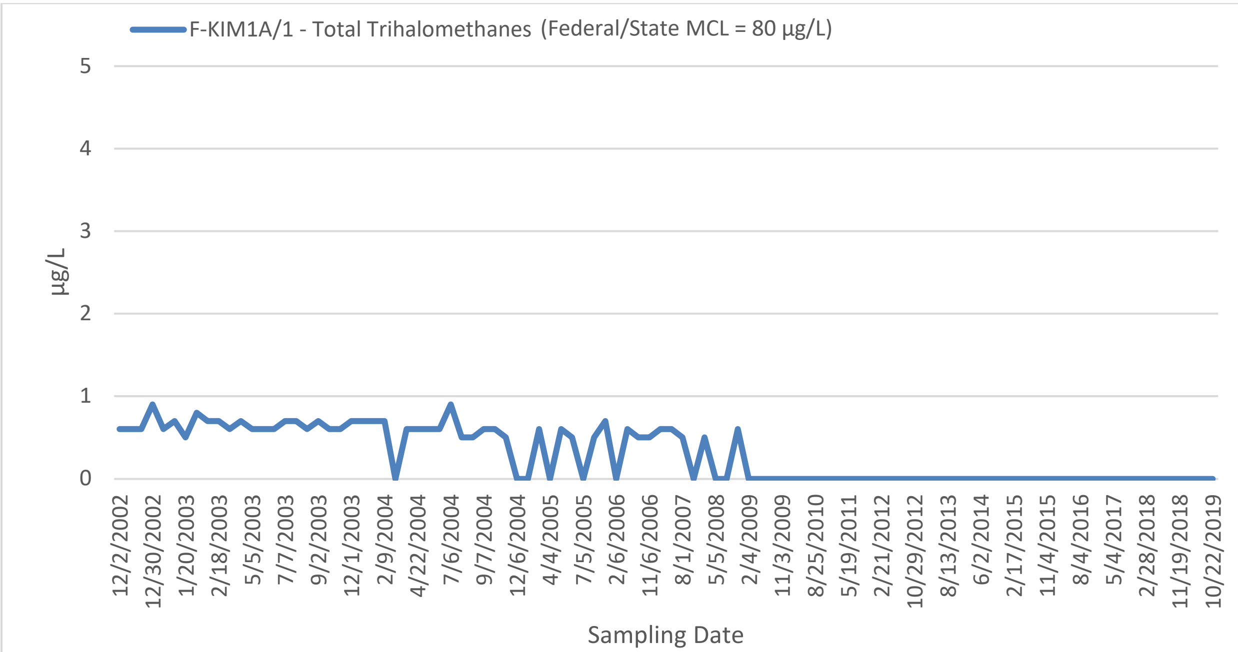
The following wells are still operational:

- Well KIM1A
- Well KIM2
- Well 5
- Well 6
- Well 8
- (Airport) Well 9
- (Sunclipse) Well 10
- (Christlieb) Well 15A

The following wells have been taken offline after the year 2000 for varying reasons:

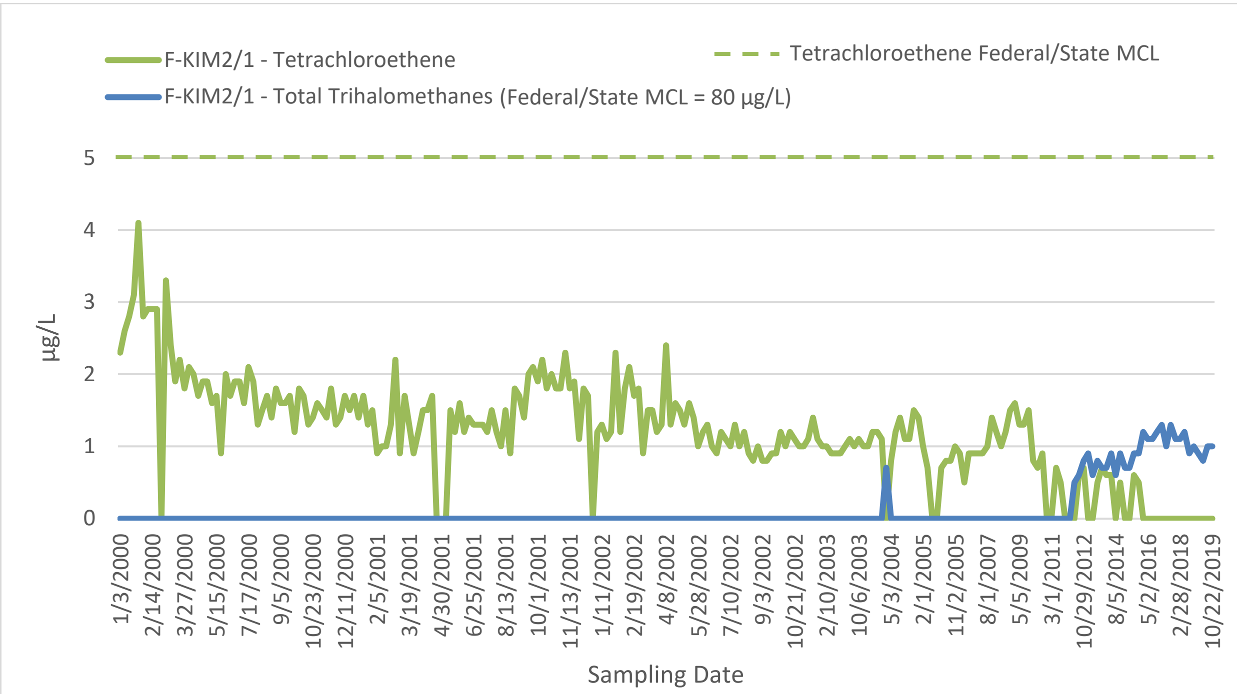
- Well KIM1
- Well 3A
- Well 4
- Well 7
- (Coyote) Well 12A

A.1.1 KIMBERLY WELL 1A



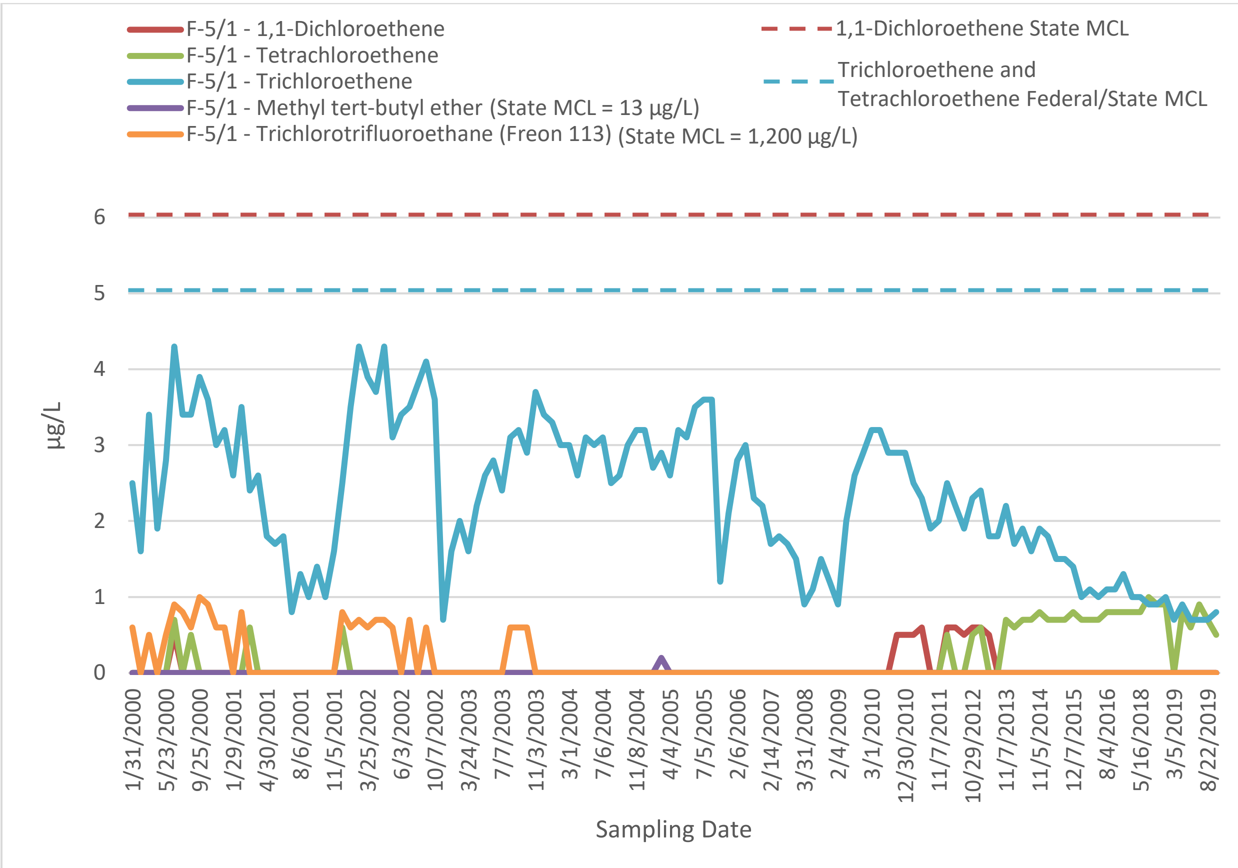
Values reported are significantly below the 80 micrograms per liter (µg/L) federal and State MCL for total trihalomethanes.

A.1.2 KIMBERLY WELL 2



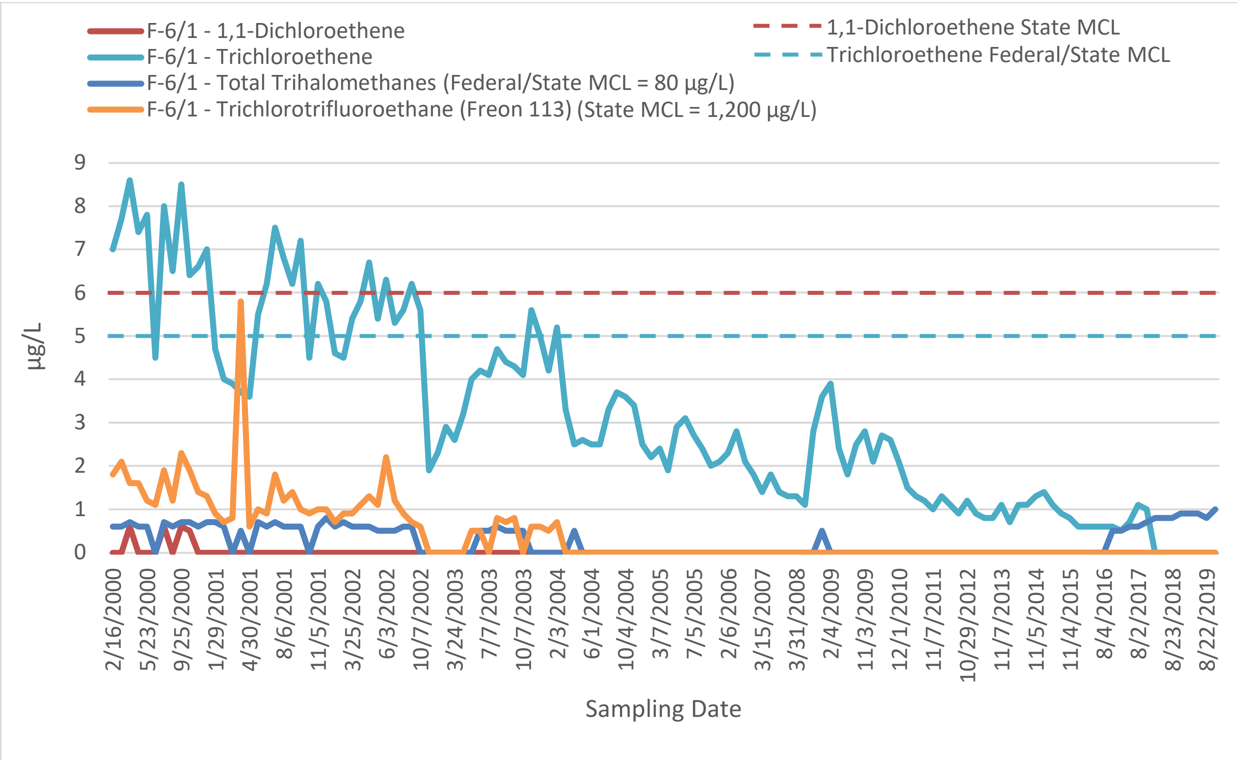
Values reported are significantly below the 80 µg/L federal and State MCL for total trihalomethanes and below 5 µg/L federal and State MCL for tetrachloroethene.

A.1.3 WELL 5



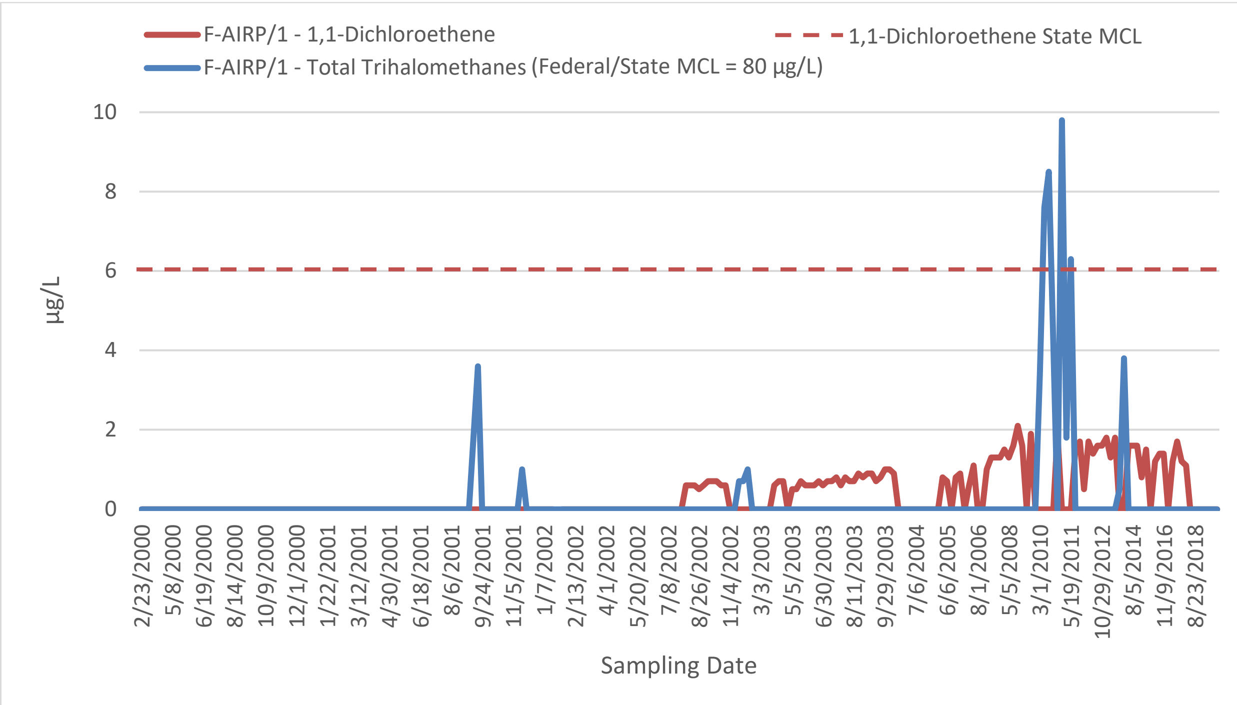
Values reported are significantly below the 1,200 µg/L State MCL for trichlorotrifluoroethane (Freon 113) and 13 µg/L State MCL for methyl tert-butyl ether (MTBE).

A.1.4 WELL 6



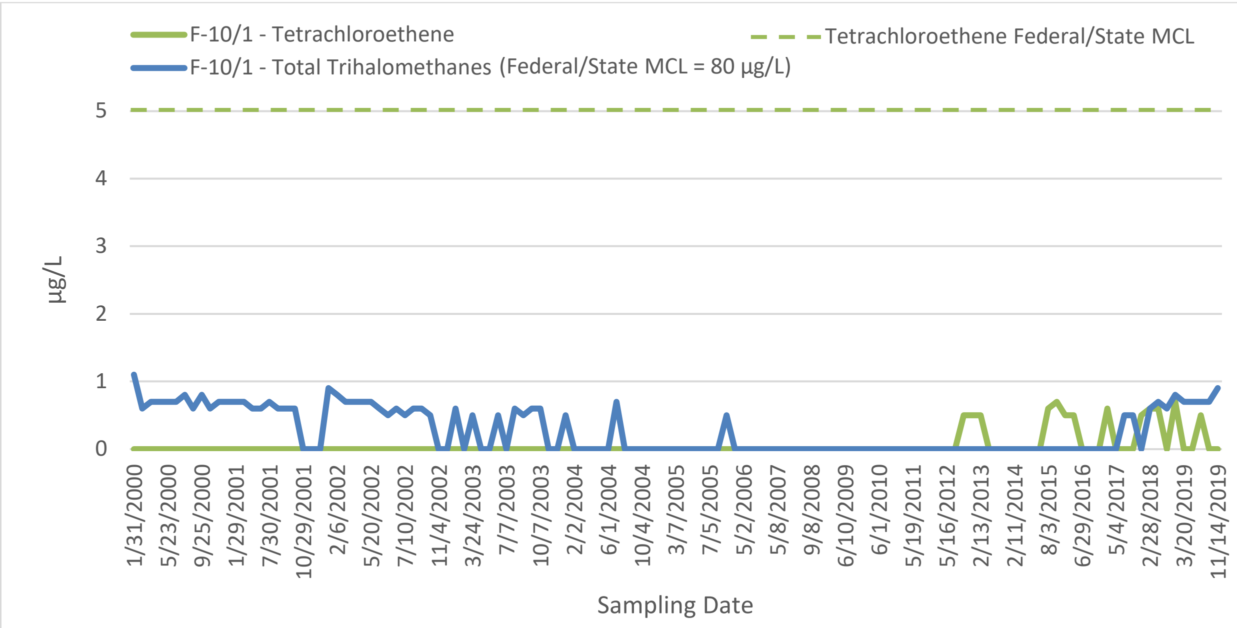
Values reported are significantly below the 1,200 µg/L State MCL for Freon 113 as well as below the 80 µg/L federal and State MCL for total trihalomethanes.

A.1.5 AIRPORT WELL 9



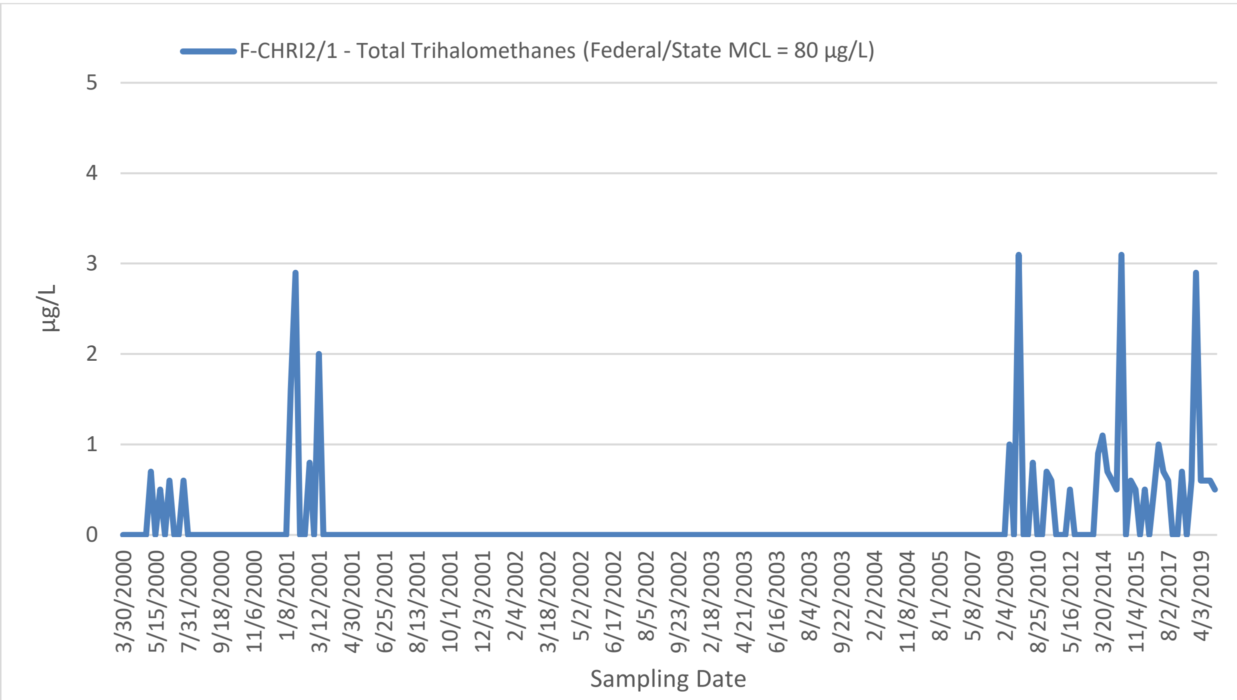
Values reported are significantly below the 80 µg/L federal and State MCL for total trihalomethanes.

A.1.6 SUNCLIPSE WELL 10



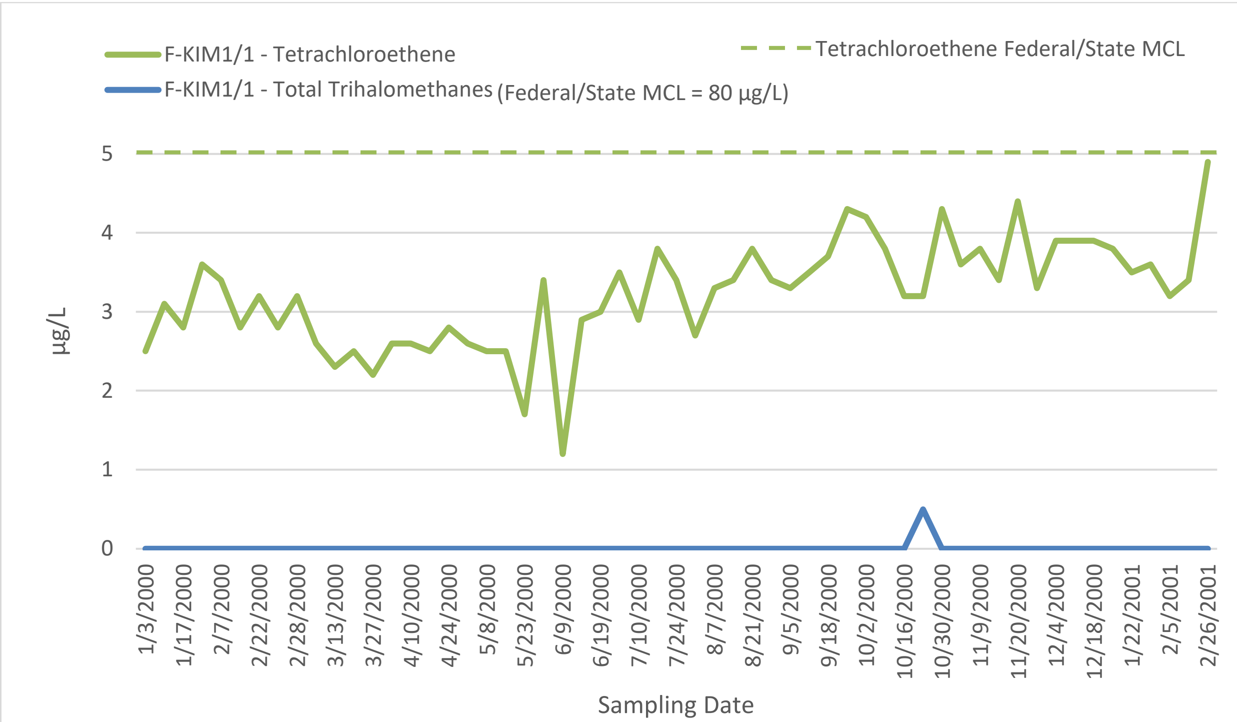
Values reported are significantly below the 80 µg/L federal and State MCL for total trihalomethanes and lower than the 5 µg/L federal and State MCL for tetrachloroethene.

A.1.7 CHRISTLIEB WELL 15A



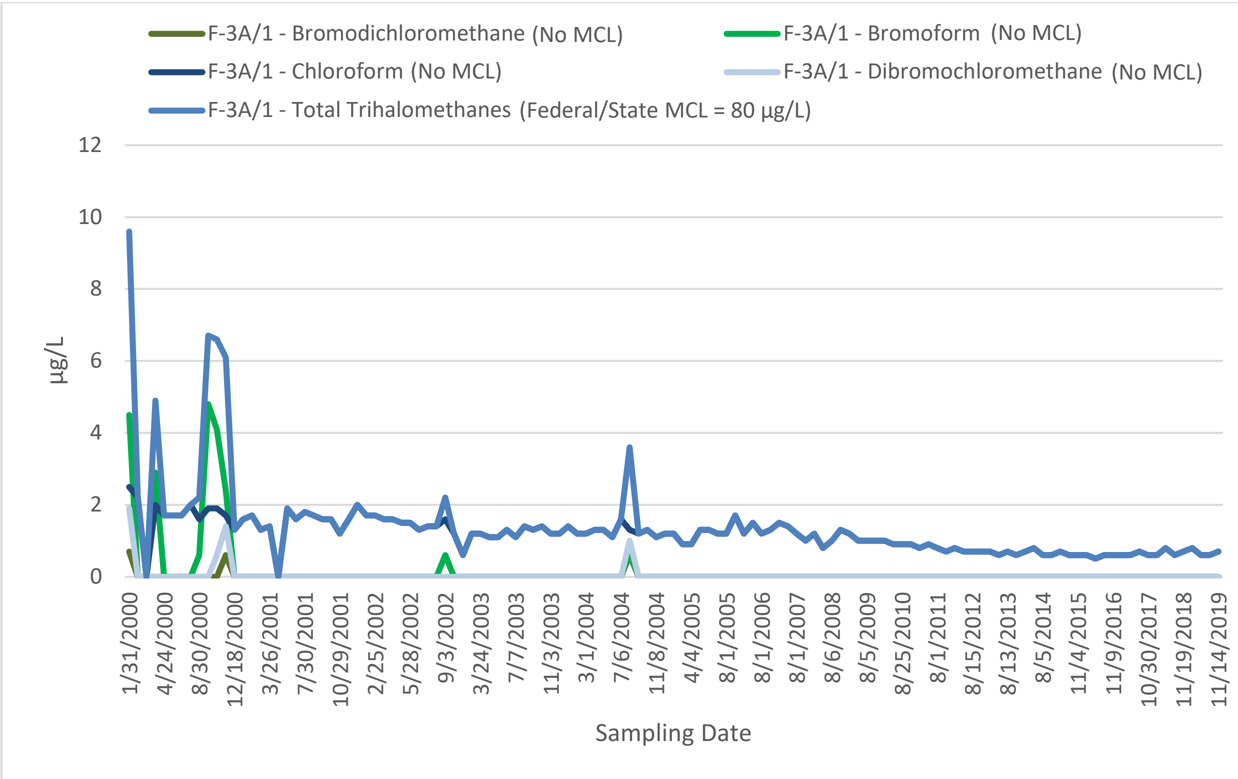
Values reported are significantly below the 80 µg/L federal and State MCL for total trihalomethanes.

A.1.8 KIMBERLY WELL 1



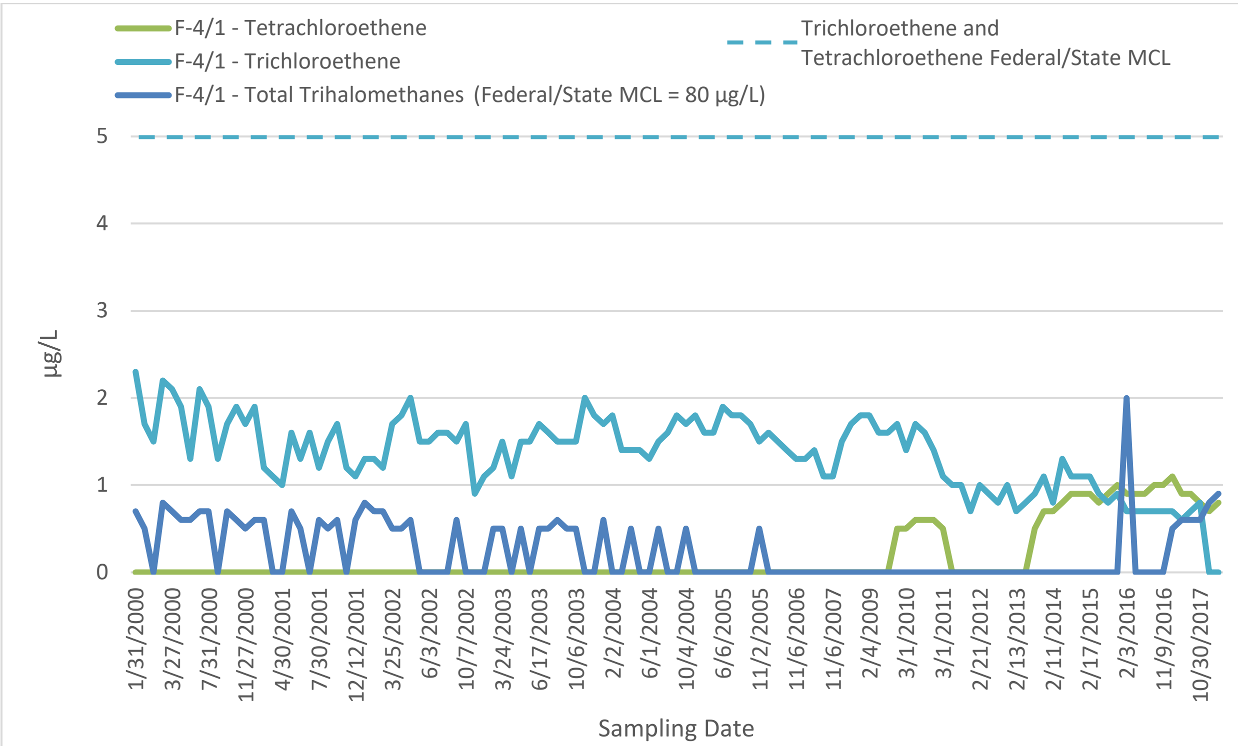
Values reported are significantly below the 80 µg/L federal and State MCL for total trihalomethanes.

A.1.9 WELL 3A



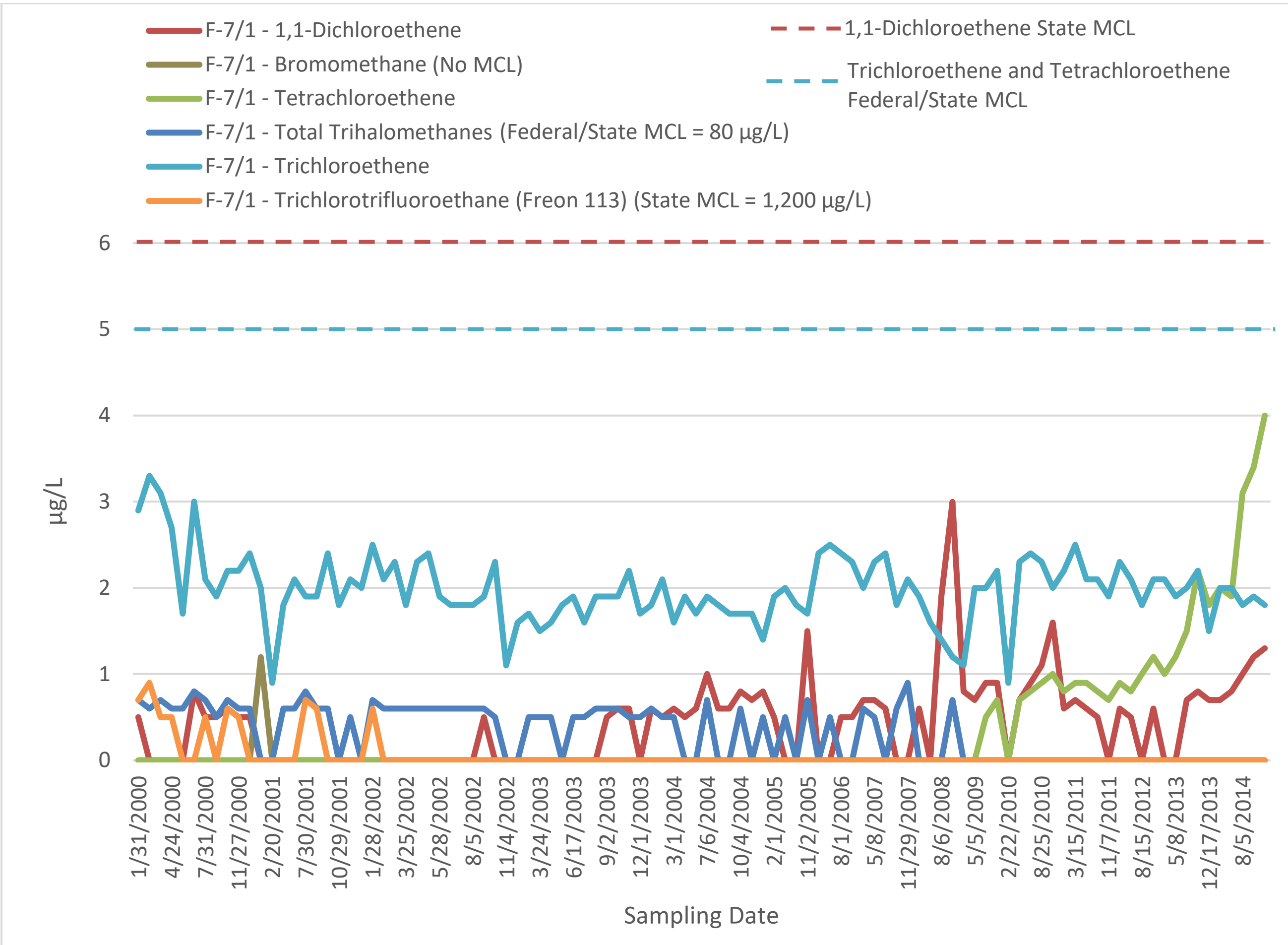
Values reported are significantly below the 80 µg/L federal and State MCL for total trihalomethanes. The MCL for total trihalomethanes is the sum of bromodichloromethane, bromoform, chloroform, and dibromochloromethane. These individual chemicals do not have MCLs defined by the California State Water Resources Control Board and are limited by their sum. In addition, bromodichloromethane, bromoform, chloroform, and dibromochloromethane do not have federal MCLs.

A.1.10 WELL 4



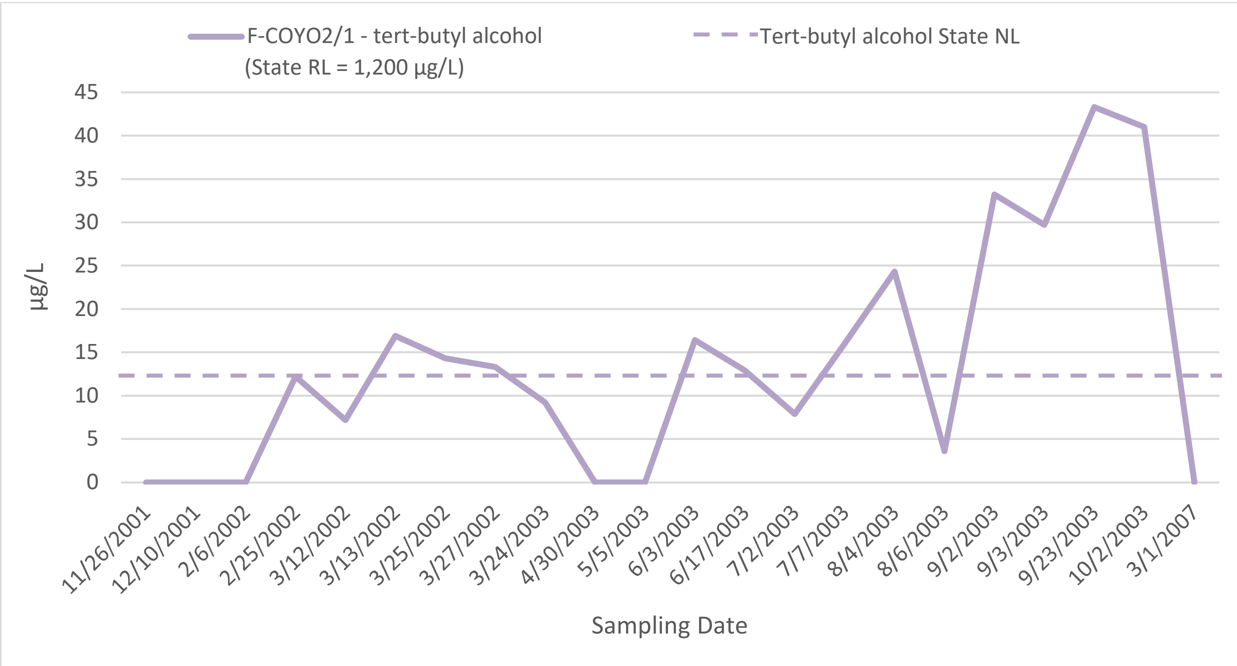
Values reported are significantly below the 80 µg/L federal and State MCL for total trihalomethanes and lower than the 5 µg/L federal and State MCL for both tetrachloroethene and trichloroethene.

A.1.11 WELL 7



Values reported are significantly below the 80 µg/L federal and State MCL for total trihalomethanes, significantly below the 1,200 µg/L State MCL for Trichlorotrifluoroethane (Freon 113), and slightly lower than the 6 µg/L State MCL for 1,1-Dichloroethene. There is currently no federal or State MCL for Bromomethane.

A.1.12 COYOTE WELL 12A



Tert-butyl alcohol does not have a federal or State MCL, but has a State Notification Level (NL) of 12 µg/L and Response Level of 1,200 µg/L.

Appendix B Policy Handbook Establishing a Standard Method of Testing and Reporting of Microplastics in Drinking Water prepared by the SWRCB of California's Division of Drinking Water

POLICY HANDBOOK ESTABLISHING A STANDARD METHOD OF TESTING AND REPORTING OF MICROPLASTICS IN DRINKING WATER

August 9, 2022

Prepared by:
THE DIVISION OF DRINKING WATER
STATE WATER RESOURCES CONTROL BOARD
STATE OF CALIFORNIA

1. INTRODUCTION

The purpose of this Policy Handbook Establishing a Standard Method of Testing and Reporting of Microplastics in Drinking Water (Policy Handbook) is to implement Health and Safety Code section 116376 by setting forth the requirements for conducting monitoring and reporting of microplastics in drinking water. The Policy Handbook includes an iterative, two-step, four-year plan for monitoring and reporting microplastics in a systematic and harmonized manner. To date, no government in the world has required monitoring for microplastics in drinking water, and the data obtained through the efforts detailed in this Policy Handbook will provide valuable insights for determining exposure to consumers through drinking water.

The State Water Resources Control Board (State Water Board) recognizes the emerging nature of microplastics and the potentially challenging effects (economically, technically, etc.) ordering a designated public water system to conduct monitoring may have on the public water system and community served. The State Water Board intends to use its monitoring authority carefully to minimize the unnecessary use of resources while obtaining necessary occurrence and exposure information to allow for more reliable characterizations of risk. The monitoring approach outlined in this Policy Handbook is informed by the method utilized by the United States Environmental Protection Agency's Unregulated Contaminant Monitoring Rule (UCMR) program.

This Policy Handbook includes flexibility for adaptation to the rapidly developing science and technology for monitoring microplastics.

2. PURPOSE AND OBJECTIVE

This Policy Handbook is adopted for the State Water Board's implementation of Senate Bill No. 1422 (2017-2018 Reg. Session) (SB 1422), which was approved by the Governor and filed with the Secretary of State on September 28, 2018. SB 1422 added Health and Safety Code section 116376 to require the State Water Board on or before July 1, 2020 to adopt a definition of microplastics in drinking water; and on or before July 1, 2021,[1] to:

- Adopt a standard methodology to be used in the testing of drinking water for microplastics;
- Adopt requirements for four (4) years of testing and reporting of microplastics in drinking water, including public disclosure of those results;
- Consider issuing a notification level or other guidance to aid consumer interpretation of testing results; and
- Accredit qualified California laboratories to analyze microplastics.

Health and Safety Code section 116376 allows the State Water Board to implement these requirements through adoption of a policy handbook that is not subject to title 22 of the Government Code, division 3, part 1, chapter 3.5, commencing with section 11340.

This Policy Handbook does not address areas outside the scope of the legislative directive.

3. DEFINITION OF 'MICROPLASTICS IN DRINKING WATER'

The term 'microplastics' in this Policy Handbook refers to the definition of 'Microplastics in Drinking Water' adopted by the State Water Board on June 16, 2020, which is as follows:

3.1. 'Microplastics in Drinking Water' are defined as solid polymeric material to which chemical additives or other substances may have been added,[2] which are particles which have at least three dimensions that are greater than 1 nanometer and less than 5,000 micrometers. Polymers that are derived in nature that have not been chemically modified (other than by hydrolysis) are excluded.

3.1.1. 'Solid' means a substance or mixture which does not meet the definitions of liquid or gas.

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[1] The COVID-19 emergency created challenges to complying with the July 1, 2021 deadline.

[2] Note that analytical methods used in this monitoring plan do not require analysis or reporting of plastic-associated chemicals. While the presence of such chemicals may cause spectroscopic interferences to the identification of microplastics, it shall not be used as justification to avoid reporting of contamination.

3.1.2. ‘Liquid’ means a substance or mixture which:
   3.1.2.1. At 50 degrees Celsius (˚C) has a vapor pressure less than or equal to 300 kPa;
   3.1.2.2. Is not completely gaseous at 20˚C and at a standard pressure of 101.3 kilopascal (kPa); and
   3.1.2.3. Which has a melting point or initial melting point of 20 ˚C or less at a standard pressure of 101.3 kPa.

3.1.3. ‘Gas’ means a substance which:
   3.1.3.1. At 50 ˚C has a vapor pressure greater than 300 kPa (absolute); or
   3.1.3.2. Is completely gaseous at 20 ˚C at a standard pressure of 101.3 kPa.

3.1.4. ‘Polymeric material’ means either (i) a particle of any composition with a continuous polymer surface coating of any thickness, or (ii) a particle of any composition with a polymer content of greater than or equal to 1% by mass.

3.1.5. ‘Particle’ means a minute piece of matter with defined physical boundaries; a defined physical boundary is an interface.

3.1.6. ‘Polymer’ means a substance consisting of molecules characterized by the sequence of one or more types of monomer units. Such molecules must be distributed over a range of molecular weights wherein differences in the molecular weight are primarily attributable to differences in the number of monomer units. A polymer comprises the following:
   3.1.6.1. a simple weight majority of molecules containing at least three monomer units which are covalently bound to at least one other monomer unit or other reactant;
   3.1.6.2. less than a simple weight majority of molecules of the same molecular weight.

3.1.7. ‘Monomer unit’ means the reacted form of a monomer substance in a polymer.

3.1.8. ‘Monomer’ means a substance which is capable of forming covalent bonds with a sequence of additional like or unlike molecules under the conditions of the relevant polymer-forming reaction used for the particular process.

3.1.9. Size-based nomenclature within the dimensions’ limits include:
   3.1.9.1. “nanoplastics” (1 nanometer to <100 nanometers);
   3.1.9.2. “sub-micron plastics” (100 nanometers to <1 micrometer);
   3.1.9.3. “small microplastics” (1 micrometer to < 100 micrometers);
   3.1.9.4. “large microplastics” (100 micrometers to <5 millimeters).

4. BACKGROUND

4.1. Monitoring Authority

Health and Safety Code sections 116271 and 116400 provide authority to the State Water Board to issue monitoring orders to public water systems[3] in accordance with conditions specified by the State Water Board, which shall be reported on a quarterly basis, unless the State Water Board finds that reasonable action requires more or less frequent analysis. Furthermore, Health and Safety Code section 116530 grants the State Water Board authority to issue monitoring orders to public water systems[3] to submit technical reports including, but not limited, to water quality information in the form and format and at intervals specified by the State Water Board.

4.2. *Health Effects*

Health and Safety Code section 116376, subdivision (b)(3) requires the State Water Board to consider issuing a notification level or other guidance to aid consumer interpretations of testing results for microplastics. State Water Board staff, in collaboration with the Southern California Coastal Water Research Project (SCCWRP) and subject matter experts, conducted research regarding the human health impacts of microplastics, and determined that there was insufficient evidence to issue a notification level or other numerical guidance for microplastics due to significant data gaps with respect to the concentrations at which effects occur in mammals, toxicity effect mechanisms (which are necessary to generalize across different particle shapes, sizes, and chemistries), and exposure through food and other potentially significant sources.[4] While numerical guidance could not be developed, this research determined that microplastics smaller than 10 micrometers in length have an increased likelihood of causing adverse health effects in mammals and should be prioritized for monitoring when possible.[4] While available analytical methods reliably quantify microplastics as small as 20 micrometers in length (Attachment D), such data is useful for estimating concentrations of smaller particles that are more relevant

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[3] Public water systems are defined in Health and Safety Code section 116275, subdivision (h).

[4] Coffin S, Bouwmeester H, Brander S, Damdimopoulou P, Gouin T, Hermabessiere L, et al. Development and application of a health-based framework for informing regulatory action in relation to exposure of microplastic particles in California drinking water. Microplastics and Nanoplastics. 2022.

for human health through the application of well-conserved size distributions.[5] [4] Although a notification level or other numerical guidance was not developed, State Water Board staff developed qualitative health-based guidance language to aid consumers in their interpretation of monitoring results.

4.3. Methodology

4.3.1. Analytical Methods

State Water Board staff, in collaboration with the SCCWRP, conducted an inter-laboratory comparison study ("Method Study") to standardize methodologies for extracting and analyzing microplastics in drinking water. Two standardized analytical methods were developed through this study, which have undergone revisions since their introduction[6].

4.3.1.1. Infrared spectroscopy (Attachment C)

4.3.1.2. Raman spectroscopy (Attachment D).

The Method Study consisted of twenty-two laboratory participants and assessed precision, repeatability, cost, and other factors. Methods for sampling extraction via filtering/sieving, optical microscopy, infrared spectroscopy, and Raman spectroscopy were evaluated. Each laboratory received three spiked samples of simulated finished drinking water and a laboratory blank. Spiked samples contained known amounts of microplastics in four size fractions (1-20 micrometers, 20-212 micrometers, 212-500 micrometers, >500 micrometers), four polymer types (polyethylene, polystyrene, polyvinyl chloride, and polyethylene terephthalate), and six colors (clear, white, green, blue, red and orange).

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[5]Microplastics size distribution data and their applicability to human health are detailed in Kooi M, Primpke S, Mintenig SM, Lorenz C, Gerdts G. Characterizing the multidimensionality of microplastics across environmental compartments. Water Research. 2021;24. and in Mohamed Nor NH, Kooi M, Diepens NJ, Koelmans AA. Lifetime Accumulation of Microplastic in Children and Adults. Environmental Science. 2021;55(8):5084–96.

[6]Analytical methods were first released on September 24th, 2021 on the State Water Board website (https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/microplastics.html) and were revised on May 27th, 2022.

Spiked samples also included false positives (natural hair, fibers and shells) that may be mistaken for microplastics. Overall, participants demonstrated excellent average recovery and chemical identification for particles greater than 20 micrometers and 50 micrometers in size using Raman spectroscopy and infrared spectroscopy, respectively, with opportunity for increased accuracy and precision through training and further method refinement.[7]

Additional method-harmonization efforts are ongoing at the time of writing this Policy Handbook, such as those being conducted by ASTM International, the European Commission's Joint Research Centre, Wageningen University and Research, and the Bundesanstalt für Materialforschung undprüfung (German). Methods developed through these or other efforts may be approved for use for required monitoring through an official request to the State Water Board. To demonstrate method equivalency, the method in question must be validated through an inter-laboratory comparison exercise and have an application for an Alternate Test Procedure using the format and guidance promulgated by the United States Environmental Protection Agency.[8]

4.3.2. Surrogate Methods

The Method Study determined that costs and analysis time for microplastics analysis using the standardized methodologies are higher than many unregulated and regulated contaminants.[7] Method Study participants evaluated the potential for inexpensive, rapid surrogate monitoring methods to indicate the presence of microplastics, which may be utilized to determine if additional monitoring using Raman or infrared spectroscopy is appropriate. While additional research is needed to determine the reliability of potential surrogates, examples of potentially

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[7] Findings from the Method Study are reported in De Frond H, Thornton Hampton L, Kotar S, Gesulga K, Matuch C, Lao W, et al. Monitoring microplastics in drinking water: An interlaboratory study to inform effective methods for quantifying and characterizing microplastics. Chemosphere. 2022 Jul;298:134282.

[8] Alternate Test Procedure details and application may be found on the United States Environmental Protection Agency website https://www.epa.gov/dwanalyticalmethods/drinking-water-alternate-test-procedure-program

viable methods include techniques that are already commonly used in public water systems including: total organic carbon, turbidity analysis, and total suspended solids (Attachment B).

4.3.3. Laboratory Accreditation

At the time of writing this Policy Handbook, no government has required monitoring for microplastics, and there are few commercial or utility laboratories capable of monitoring microplastics.[9] Additionally, there are no commercial suppliers of proficiency testing samples representative of microplastics in finished drinking water, drinking water sources, or other aqueous matrices to independently assess the performance (e.g., recovery, precision, accuracy, etc.) of laboratories. Despite a lack of proficiency testing samples, laboratory performance for microplastics larger than 20 micrometers in length can be reliably assessed using quality assurance criteria developed through the Method Study in combination with commercially available laboratory fortified blank sample materials.

4.4. Sample Collection

At the time of Policy Handbook adoption, the State Water Board is aware of one standardized method for collecting samples for microplastics, which has been promulgated by ASTM International: “ASTM D8332-20: Standard Practice for Collection of Water Samples with High, Medium, or Low Suspended Solids for Identification and Quantification of Microplastic Particles and Fibers.”[10] A significant drawback of the ASTM D8332-20 method in its dependence on open-air sieve stacks, which presents opportunities for contamination and therefore requires the collection of a field blank to determine atmospheric and self-

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[9] At the time of writing, the State Water Board is aware of at least four independent laboratories seeking ELAP accreditation for microplastics analysis with the intention to analyze samples associated with this sampling and analysis plan. Anticipated laboratory capacity is factored into decisions regarding the number and frequency of samples required for monitoring pursuant to this plan. The State Water Board anticipates that additional laboratories will become available for microplastics analysis following the first phase of monitoring. Monitoring orders will include extension clauses for monitoring requirements of public water systems in the unlikely case that no accredited laboratories are available.

[10] ASTM D8332-20 may be obtained from https://www.astm.org/Standards/D8332.htm

contamination. As part of the Pilot Phase, the State Water Board is evaluating the suitability of an alternative sampling methodology described in the scientific literature but that has not yet undergone a formal rigorous evaluation by an authoritative body that utilizes in-line filtration—therefore eliminating the possibility of contamination during sample collection and the need for a sample blank (Yuan et al. 2022).[11] If the State Water Board deems this alternative sampling method described in Yuan et al. (2022) to be superior to the ASTM D8332-20 method in terms of feasibility and quality control, the State Water Board will issue a detailed guidance manual and provide training (including online materials and in-person interactive training sessions) for sample collectors to use this method, and will require its use during Phase I. The guidance manual and subsequent sampling requirements will pay particular attention to feasibility (e.g., time required to sample, accessibility, etc.).

4.5. Monitoring Plan

The State Water Board recognizes the rapidly evolving science regarding microplastics, including the limited laboratory capacity and lack of proficiency testing samples, and the relatively high amount of resources required to sample and monitor for microplastics. The State Water Board anticipates capacity for monitoring and assessing laboratories using proficiency testing samples will be developed as a result of required monitoring.

Research conducted by State Water Board staff suggests there is a high probability for the occurrence of microplastics as large as 5,000 micrometers in length in surface waters, and that several commonly used drinking water treatment technologies incidentally remove microplastics larger than 20 micrometers in length. Additionally, groundwaters typically have low detection frequencies and surface waters typically have high detection frequencies of microplastics. Microplastics concentrations vary spatially and temporally and depend on a number of known and unknown factors.

The State Water Board will employ a two-phase iterative approach for monitoring microplastics to obtain sufficient information to estimate risk through exposure via

[11] Yuan C, Almuhtaram H, McKie MJ, Andrews RC. Assessment of microplastic sampling and extraction methods for drinking waters. Chemosphere. 2022 Jan;286:131881.

drinking water. Each step will last two (2) years, with an interim period to allow for State Water Board staff to assess results from the first phase and plan the second phase of monitoring accordingly. For both phases, the State Water Board will issue orders to public water systems and/or wholesaler providers to monitor microplastics in source waters and/or treated drinking water. In Phase I, monitoring will focus on characterizing occurrence of microplastics larger than 20 or 50 micrometers in length in source waters used for drinking in accordance with the specifications in the method employed by the laboratory (Attachments C and D. Phase II monitoring will be directed towards characterizing occurrence of microplastics both smaller than and larger than 20 micrometers in length in treated drinking water.

4.5.1. Process for Laboratory Accreditation

The Environmental Laboratory Accreditation Program (ELAP) will offer accreditation to qualified laboratories to monitor for microplastics in drinking water as follows:

4.5.1.1. Laboratories wishing to become accredited for monitoring microplastics in water must apply through the online process[12] and list the appropriate field of accreditation corresponding to one of four microplastics analytes[13] in non-potable water and drinking water matrices using one of the approved analytical methods (Attachments C and D) with the corresponding instrumentation (i.e., Raman or infrared spectroscopy).

4.5.1.2. ELAP will provide accreditation of qualified laboratories for the two approved microplastics analysis methods listed in this Policy Handbook (Attachments C and D).

4.6. *External Scientific Peer Review*

In accordance with Health and Safety Code section 57004, the State Water Board requested external scientific peer review for the scientific components of

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[12] Application information for ELAP is available on the State Water Board webpage: https://www.waterboards.ca.gov/drinking_water/certlic/labs/apply.html

[13] Microplastic analytes listed in ELAP's field of accreditations include: "microplastics > 500 micrometers"; "microplastics 500 to 212 micrometers"; "microplastics 212 to 20 micrometers"; and "microplastics 212 to 50 micrometers."

the draft policy handbook,[14] the definition of microplastics in drinking water adopted by the State Water Board,[15] analytical methods for monitoring microplastics developed by the State Water Board for the purposes of this Policy Handbook,[16] proposed health effects guidance language,[17] and underlying literature review.[18] Peer review comments received from four external experts[19] were used to inform the revised Policy Handbook and its underlying components (e.g. definition, analytical methods), the development of the pilot phase, research projects conducted by the State Water Board, and coordination with stakeholders (e.g. Microplastics Subcommittee of the Water Quality Monitoring Council). Revisions made in response to peer review comments received include the following:

4.6.1. The State Water Board is developing an open-source reporting tool to maximize usage of complex monitoring datasets and ensure data are reported in a harmonized manner that is consistent with the definition.[20] The reporting tool addresses a number of concerns from peer reviewers

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[14] Draft Microplastics in Drinking Water Policy Handbook (November 10, 2021). https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/microplastics/mcrplsts_plcy_drft.pdf

[15] Resolution 2020-0021 adopted on June 16, 2020. https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2020/rs2020_0021.pdf

[16] "Standard Operating Procedures for Extraction and Measurement by Raman Spectroscopy of Microplastic Particles in Drinking Water" (September 24, 2021); "Standard Operating Procedures for Extraction and Measurement by Infrared Spectroscopy of Microplastic Particles in Drinking Water" (September 24, 2021).

[17] Section 4.1.1 of Draft Microplastics in Drinking Water Policy Handbook (November 10, 2021). https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/microplastics/mcrplsts_plcy_drft.pdf.

[18] Coffin S, Bouwmeester H, Brander S, Damdimopoulou P, Gouin T, Hermabessiere L, et al. Development and application of a health-based framework for informing regulatory action in relation to exposure of microplastic particles in California drinking water. Microplastics and Nanoplastics. 2022.

[19] Peer reviewer letters were received by Dr. Alan Hubbard, Dr. Denise Mitrano, Dr. José Carlos Pinto, and Dr. Tony R. Walker and are available on the State Water Board website: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/microplastics.html

[20] The microplastics data harmonization and reporting protocol is being developed by the State Water Board in collaboration with the Moore Institute for Plastic Pollution Research, San Francisco Estuary Institute, and The People Lab.

regarding the importance of data granularity in assessing human health risks, ensuring comparability between laboratories, and improving feasibility of following the definition.

4.6.2. The State Water Board provided additional clarification regarding the definition and how it pertains to the sampling and monitoring plan.[21]

4.6.3. Guidance for sampling protocols and requirements for sampling volumes will be provided based on evaluation and optimization research conducted by the State Water Board.[22]

4.6.4. Analytical methods (Attachments C and D) will undergo additional inter-laboratory validation using real-world water samples during the Pilot Phase. Laboratories seeking ELAP accreditation may volunteer to participate in this additional validation exercise.

4.6.5. Analytical methods were revised following guidance from peer reviewers and public comments.[23] Revisions include stricter requirements for laboratories to spectroscopically confirm the polymer identity of particles, expansion of the types of acceptable spectroscopic instruments to be used with each method, additional details regarding variability reporting, correction of several typos, and additional minor edits.

5. PLANNED AND ONGOING WORK

5.1. The State Water Board is conducting additional research and performing work to resolve scientific and logistical challenges related to monitoring. These efforts do not count towards the four years of monitoring and reporting required by Health and Safety Code section 116376 subsection (b)(2). Work related to these efforts are planned to occur between Summer 2022 and Summer 2023 and are referred to as the "Pilot Phase."

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[21] This version of the policy handbook was revised to ensure the size-based classifications in the definition are synonymous with Resolution 2020-0021, and clarity surrounding "…chemical additives or other substances…"

[22] Details regarding planned research by the State Water Board to refine sampling protocols and provide guidance and training to operators is described in the Pilot Phase section of this Policy Handbook.

[23] Revised analytical methods were released on May 27th, 2022 on the State Water Board website. (https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/microplastics.html)

5.1.1. The primary goals of the Pilot Phase are to build infrastructure for monitoring and advance science to optimize utility of the subsequent phases.

5.1.2. The State Water Board has initiated a contract with the SCCWRP to accomplish the following scientific research goals:

5.1.2.1. Evaluate the reliability and feasibility of the ASTM D8332-20 sampling method alongside an in-line filtration method described in Yuan et al. (2022)[24] using environmental samples at a select number of volunteer public water systems;

5.1.2.2. If appropriate, develop a standardized sampling protocol using an in-line filtration based on an optimized method described first in Yuan et al. (2022)[4];

5.1.2.3. Measure microplastics levels and targeted potential surrogates in water samples from a small number of volunteer California public water systems, including treated and raw water samples;

5.1.2.4. Determine optimal sampling volumes based on source water characteristics, data quality objectives, and feasibility (e.g., ensuring sample collection times are achievable given documented time constraints of water system personnel);

5.1.2.5. If appropriate, determine if a field reagent blank should be included in the sampling protocols based on the quality control and quality assurance guidelines associated with the chosen optimized sampling protocol as described above (e.g., in-line filtration would effectively eliminate the possibility of contamination and therefore eliminate the need for a field reagent blank);

5.1.2.6. If appropriate, designate an upper limit of total particle concentrations for final samples.

5.1.3. Additional logistical and infrastructure-building goals of the Pilot Phase include:

5.1.3.1. Providing in-person and virtual training (e.g., videos, documents) to public water system operators in California for either sampling protocol that is determined to be most reliable and feasible as described above;

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[24] Yuan C, Almuhtaram H, McKie MJ, Andrews RC. Assessment of microplastic sampling and extraction methods for drinking waters. Chemosphere. 2022 Jan;286:131881.

5.1.3.2. Developing guidelines and protocols for reducing sample interferences (e.g., sample digestion) from water with high organic content or non-plastic particulates (e.g., minerals);

5.1.3.3. If appropriate, developing guidance for surrogates correlated to microplastics concentrations;

5.1.3.4. Allowing time and providing resources for laboratories to become accredited through ELAP; conducting additional inter-laboratory validation using environmental water samples obtained through the aforementioned contract work; and developing a harmonized data reporting protocol using open-source code.[25]

5.1.3.5. Developing tools for communicating risks of microplastics to consumers.[26]

5.1.3.6. Providing resources and guidance for laboratory accreditation and monitoring.

5.1.4. Any monitoring conducted during the Pilot Phase will be optional and voluntary.

6. MONITORING AND REPORTING REQUIREMENTS

Health and Safety Code section 116376 directs the State Water Board to set forth requirements for public water systems to conduct monitoring of microplastics in drinking water. Monitoring orders will be issued to specific public water systems in two phases, requiring monitoring for a period totaling four (4) years. Those systems that receive an order shall be required to sample consistent with the following requirements:

6.1. Water System Selection

Public water systems have been selected for potential monitoring based on concepts utilized by the United States Environmental Protection Agency's UCMR program (Attachment A). The UCMR program establishes monitoring requirements for priority unregulated contaminants in drinking water for all large

[25] The microplastics data harmonization and reporting protocol is being developed by the State Water Board in collaboration with the Moore Institute for Plastic Pollution Research, San Francisco Estuary Institute, and The People Lab.

[26] Consumer guidance tools as well as laboratory accreditation and analysis resources are being developed by the State Water Board in collaboration with voluntary stakeholders through the Microplastics Subcommittee of the California Water Quality Monitoring Council. Anyone may participate in the Microplastics Subcommittee.

public water systems serving greater than 10,000 people, all small public water systems serving between 3,300 and 10,000 people, and a representative sample of small public water systems serving fewer than 3,300 people.[27]

Due to significant uncertainties regarding risks of microplastics through drinking water and substantial costs to reliably monitor microplastics, an adapted version of the UCMR approach will be utilized to minimize impacts to public water systems, while obtaining sufficient data to estimate general occurrence and potential human exposure through drinking water. Accordingly, in the first phase of monitoring, a small number of public water systems will be required to monitor, with a focus on characterization of sources which serve the greatest number of consumers and optimization to reduce the total number of sources necessary to obtain adequate representation of contamination in source waters in the state. Large community water systems and wholesale water systems that provide water to greater than 100,000 people will receive the vast majority of monitoring orders in Phase I. Public water systems that depend primarily on purchased water will not receive monitoring orders during Phase I. Additional factors included in the selection of public water systems included geospatial representation, treatment capabilities, and primary water sources (e.g., surface water, groundwater, groundwater under direct influence of surface water). The State Water Board will evaluate findings from Phase I to determine sampling locations for Phase II.

6.2. *Sampling Requirements*

6.2.1. *Testing Phase*[28]

6.2.1.1. *Phase I* (Fall, 2023 – Fall, 2025)

6.2.1.1.1. Public water systems potentially selected to monitor during Phase I (Attachment A) will test for microplastics occurring in drinking water sources using one of the approved standardized methods (Attachment C, Attachment D).

[27] Additional information regarding the United States Environmental Protection Agency's UCMR can be found on their website https://www.epa.gov/dwucmr/learn-about-unregulated-contaminant-monitoring-rule

[28] Dates listed are approximate, are not binding, and are subject to change.

6.2.1.1.2. Prior to issuing monitoring orders, State Water Board staff will hold a public workshop[29] with systems listed on Attachment B to discuss and agree upon monitoring details, including but not limited to: specific sampling locations; quality assurance and quality control protocols; sample holding times; procedures for reviewing, approving, and uploading data.

6.2.1.1.3. At minimum, laboratories must report concentrations of microplastics that are 50 micrometers long or the minimum size listed in the standardized method used by the laboratory (see Attachments C and D) – whichever is smaller. Monitoring for shorter microplastics is strongly encouraged.

6.2.1.1.4. Unless otherwise stated in monitoring orders issued to public water systems, monitoring will be limited to drinking water sources only.

6.2.1.1.5. Unless stated otherwise in monitoring orders, drinking water source samples shall be collected at the same location(s) where *Cryptosporidium* and *Giardia* are typically collected.

6.2.1.1.6. The potential surrogate techniques listed as being 'required' in Attachment B will be required for monitoring.

6.2.1.1.6.1. To reduce contamination of surrogate monitoring samples, identical quality assurance protocols as stated in Attachments C and D, and further detailed in forthcoming sampling guidance issued by the State Water Board, shall be implemented during sampling.

6.2.1.1.7. Testing is required for a period of two (2) years.

6.2.1.1.8. Public water systems, in cooperation with other agencies or water suppliers, may develop and submit a plan to the State Water Board that identifies sampling site(s) for (a) drinking water source(s) that is (are) shared by multiple public water system

[29] Workshop anticipated to occur in Fall/Winter 2022 and will be open to the public. Water systems on draft list (attachment A) will be invited to submit oral and written proposals for planned sampling locations. Consolidation of monitoring between systems will be considered if sufficient evidence is provided detailing shared water sources. When available, details regarding workshop will be posted on the State Water Board website: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/microplastics.html

treatment plants and is representative of a drinking water source that is further treated and distributed to consumers. To make this demonstration, a public water system shall submit information to the State Water Board regarding the location and distribution of each sampling site, and water quality information for each sampling site. The State Water Board will use this information to determine whether the drinking water sources are used to produce finished drinking water through multiple public water system treatment plants. Upon approval of a submitted plan by the State Water Board, public water systems shall monitor at the identified sampling site(s). Monitoring conducted through an approved plan may be used to satisfy monitoring requirements upon approval by the State Water Board.

6.2.1.2. Phase II (Fall, 2026 – Fall, 2028)

6.2.1.2.1. Following a six-month interim between Fall, 2025 and Spring 2026, the State Water Board will issue additional monitoring orders for public water systems required to test subject to Phase II methodology. Public water systems subject to monitoring may include the same systems required during Phase I as well as additional systems.

6.2.1.2.2. For public water systems selected to monitor during Phase II, the system will test for microplastics occurring in finished drinking water as small as 5 micrometers in length, or the smallest microplastics for which ELAP provides accreditation at the time of the monitoring order issuance.

6.2.1.2.3. Unless stated otherwise in monitoring orders, finished drinking water samples shall be collected at the same location(s) where *Cryptosporidium* and *Giardia* are typically collected or following the final stage of treatment before entering the distribution system.

6.2.1.2.4. Public water systems without any detections of microplastics during Phase I may be exempt from monitoring during Phase II.

6.2.1.2.5. Testing is required for a period of two (2) years.

6.2.1.3. General Requirements

6.2.1.3.1. Public water systems who have been selected for monitoring shall submit a quality assurance project plan, standard operating protocol for sampling, and a plan for monitoring to the State Water Board for approval prior to conducting monitoring.

6.2.1.3.2. Exact sampling locations will be listed in monitoring orders issued to public water systems at a later date.

6.2.1.3.3. Unless specified otherwise in a monitoring order, public water systems shall utilize the standardized protocol for collecting water samples for microplastics as determined by the State Water Board[30].

6.2.1.3.4. Unless specified otherwise in a monitoring order, public water systems shall utilize one of the two (2) standardized protocols for analyzing samples of drinking water sources or finished drinking water for microplastics: infrared spectroscopy (Attachment C) or Raman spectroscopy (Attachment D).

6.2.1.3.5. Alternative analytical methods may be approved for use through an official request to the State Water Board. To demonstrate method equivalency, the method in question must be validated through an inter-laboratory comparison exercise and have an application for an Alternate Test Procedure using the format and guidance promulgated by the United States Environmental Protection Agency.

6.2.1.3.6. Public water systems must analyze samples with laboratories accredited by ELAP using an approved standardized methodology defined in the monitoring order.

6.2.1.3.7. Unless specified otherwise in a monitoring order, public water systems must submit water quality data for required surrogates and standard water quality monitoring parameters in Attachment B, including temperature, turbidity, total organic carbon, total dissolved solids, and total suspended solids collected during the same day of the microplastics sample at the same location. Water flow rate entering the treatment plant shall also be reported. Public water systems are encouraged to either collect

[30] The standardized operating protocol for sampling microplastics is under development at the time of writing and will be posted on the State Water Board webpage https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/microplastics.html and will also be attached to monitoring orders.

samples in parallel using these surrogate monitoring methods (if possible) or collect and report these surrogate parameters at the start and finish of sample collection. Regardless of how surrogate parameters are collected, public water systems shall identify how such samples were collected. Public water systems are encouraged (but are not required) to report surrogate data from additional techniques listed in Attachment B.

6.2.1.3.8. Unless specified otherwise in a monitoring order, public water systems are not required to collect replicate samples for analysis of microplastics. Laboratory analytical variability shall be assessed through the use of laboratory fortified reagent blanks as specified in Attachment C and Attachment D.

6.2.1.3.9. All blank contamination and root cause, if known, shall be reported to the State Water Board through the manner specified in the monitoring orders.

6.2.1.3.10. Raw data shall be uploaded without blank correction alongside quality control and quality assurance data, or as specified in the analytical methods required for use.

6.2.1.3.11. Due to the known relatively low occurrence of microplastics in groundwaters used as drinking water sources,[31] monitoring orders will be directed primarily for surface waters used as drinking water sources.

6.2.1.3.12. Unless stated otherwise in monitoring orders, samples shall be collected twice between October – April (rainy season) and twice during May – September (dry season) of each year to determine the relative influence of rain and stormwater influence as well as atmospheric deposition. Accordingly, for each sampling location a minimum of eight (8) samples will be analyzed over the two-year period.

6.2.1.3.13. Analyses required pursuant to this Policy Handbook shall be performed by laboratories accredited by the State Water Board to perform such analyses pursuant to Health and Safety Code,

[31] Viaroli S, Lancia M, Re V. Microplastics contamination of groundwater: Current evidence and future perspectives. A review. Science of The Total Environment. 2022 Jun 10;824:153851.

division 101, part 1, chapter 4, article 3, commencing with section 100825.

6.2.1.3.14. Sample collection shall be performed by personnel trained to perform such sample collections and/or tests by:

6.2.1.3.14.1. The State Water Board;

6.2.1.3.14.2. A laboratory accredited pursuant to Health and Safety Code section 100825, subdivision (a);

6.2.1.3.14.3. An operator certified by the State Water Board pursuant to Health and Safety Code section 106875, subdivisions (a) or (b).

6.2.1.3.15. Public water systems shall take all samples during normal operating conditions, which exclude those circumstances covered under the California Code of Regulations, title 22, section 64533.5, subdivision (b).

6.3. Reporting Requirements

6.3.1. Monitoring results shall be reported to the State Water Board by the analyzing laboratory using the Electronic Deliverable Format in accordance with California Code of Regulations, title 22, section 64469 and in compliance with the format specified by the State Water Board.[32]

6.3.2. Analytical results shall be reported no later than the 10th day of the month following completion of the analysis.

6.3.3. Public water systems, as defined in Health and Safety Code section 116275, shall include positive detections of microplastics in their annual Consumer Confidence Report pursuant to Health and Safety Code section 116470, subdivision (a)(4). If monitoring data is available for finished drinking water samples, such data shall be reported in addition to data for drinking water source samples. Additionally, as stated in Health and Safety Code Section 66480, a community or non-transient, non-community water systems (NTNC)[33] that sells water to another community or NTNC water system shall deliver the required monitoring data to the purchasing system

[32] Specific guidance regarding reporting format, metrics, classifications, and metadata will be provided in monitoring orders issued to public water systems. The State Water Board is currently developing a harmonized data reporting tool to assist laboratories and public water systems.

[33] Community and NTNC water systems are defined in Health and Code section 116275.

by no later than April 1 of each year or on a date mutually agreed upon by the seller and the purchaser, and specifically included in a contract between the parties.

6.3.3.1. Unless stated otherwise in a monitoring order issued by the State Water Board or other regulation, public water systems shall include or provide a reference to health-based guidance language developed by the State Water Board to aid consumer interpretations of findings of microplastics in finished drinking water (or drinking water sources), which is as follows:

6.3.3.2. "Studies of rodents exposed to some types of microplastics through drinking water indicate potentially adverse effects, including on the reproductive system. However, more research is needed to understand potential impacts on human health, including determining concentrations at which effects may occur. California is monitoring microplastics in drinking water to understand its occurrence and is supporting ongoing research."

6.3.4. A microplastics detection is a positive finding of a quantifiable amount above the minimum reporting level[34] established by the analytical laboratory.

6.3.5. Public water systems subject to monitoring shall analyze samples taken at the same location and date as the samples collected for microplastics monitoring using the required surrogate monitoring techniques in Attachment B and submit surrogate monitoring data to the State Water Board alongside microplastics monitoring results. Public water systems are encouraged but not required to monitor for additional surrogates listed as optional on Attachment B.

6.3.6. For all samples collected from a reservoir, the reservoir depth and turnover rates shall be reported.

6.3.7. Blending rates must be reported (when applicable).

6.3.8. Sampling volume shall be reported.

6.4. Timeline

To assist public water systems and laboratories in preparing for monitoring and reporting of microplastics, a general timeline is provided here. Note that dates are approximate and are subject to change under the microplastics monitoring

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[34] The method for calculating a minimum reporting level for microplastics is detailed in Attachments C and D.

orders.

6.4.1. Summer, 2022: Environmental Laboratory Accreditation Program will offer accreditation to qualified laboratories for microplastics in non-potable water and drinking water fields of accreditation.
6.4.2. Fall, 2022: State Water Board will issue monitoring orders in accordance with Phase One of planned monitoring, with monitoring requirements applicable between Fall 2023 – Fall 2025.
6.4.3. Fall, 2025 – Spring 2026: Interim period in which State Water Board staff will assess results from Phase One and determine best approach for Phase Two.
6.4.4. Spring, 2026: State Water Board will issue monitoring orders in accordance with Phase Two of planned monitoring with monitoring requirements applicable between Fall 2026 – Fall 2028.
6.4.5. Fall 2028: Completion of Phase Two of planned monitoring.

List of Attachments

ATTACHMENT A – List of water systems potentially subject to monitoring during Phase I

ATTACHMENT B – Non-exhaustive list of potential surrogate monitoring methods for microplastics

ATTACHMENT C - Standard Operating Procedures for Extraction and Measurement by Infrared Spectroscopy of Microplastic Particles in Drinking Water: May 27th, 2022 [SWB-MP1-rev1]

ATTACHMENT D - Standard Operating Procedures for Extraction and Measurement by Raman Spectroscopy of Microplastic Particles in Drinking Water: May 27th, 2022 [SWB-MP2-rev1]

ATTACHMENT A – List of water systems potentially subject to monitoring during Phase I

pwsid	Water System Name	Primary Water Source Type	Population Served	CITY	Rationale for Inclusion
CA1910087	METROPOLITAN WATER DIST. OF SO. CAL.	Surface Water	18,962,000	LOS ANGELES	Largest Providers
CA1910067	LOS ANGELES-CITY, DEPT. OF WATER & POWER	Surface Water	4,070,679	LOS ANGELES	Largest Providers
CA3810001	SAN FRANCISCO REGIONAL WATER SYSTEM	Surface Water	2,600,600	SAN FRANCISCO	Largest Providers
CA4310027	SANTA CLARA VALLEY WATER DISTRICT	Surface Water	1,540,360	SAN JOSE	Largest Providers
CA0110005	EAST BAY MUD	Surface Water	1,438,500	OAKLAND	Largest Providers
CA3710020	SAN DIEGO, CITY OF	Surface Water	1,400,016	SAN DIEGO	Largest Providers
CA4310011	SAN JOSE WATER	Surface Water	1,007,514	SAN JOSE	Largest Providers
CA3410020	CITY OF SACRAMENTO MAIN	Surface Water	884,060	SACRAMENTO	Largest Providers
CA4910020	SONOMA COUNTY WATER AGENCY	Groundwater	600,000	SANTA ROSA	Groundwater with low filtration
CA1010007	CITY OF FRESNO	Surface Water	542,148	FRESNO	Geographically Diverse Systems
CA3010001	CITY OF ANAHEIM	Surface Water	450,000	ANAHEIM	Largest Providers
CA3010092	IRVINE RANCH WATER DISTRICT	Surface Water	422,000	IRVINE	Largest Providers
CA1910128	COVINA IRRIGATING CO.	Surface Water	382,349	COVINA	Surface Water with Low Filtration
CA3610050	UPLAND, CITY OF	Surface Water	375,509	UPLAND	Largest Providers
CA0110001	ALAMEDA COUNTY WATER DISTRICT	Surface Water	351,000	FREMONT	Largest Providers
CA3410021	SAN JUAN WATER DISTRICT	Surface Water	334,669	GRANITE BAY	Largest Providers
CA3310031	RIVERSIDE, CITY OF	Groundwater UDI Surface Water	312,214	RIVERSIDE	Largest Providers
CA3610129	MOJAVE WATER AGENCY	Groundwater	292,449	APPLE VALLEY	Groundwater with low filtration
CA0110010	ZONE 7 WATER AGENCY	Surface Water	226,840	LIVERMORE	Largest Providers

CA4810003	CITY OF FAIRFIELD	Surface Water	140,259	FAIRFIELD	Surface Water with Low Filtration
CA3710006	ESCONDIDO, CITY OF	Surface Water	137,941	ESCONDIDO	Geographically Diverse Systems
CA0710001	CITY OF ANTIOCH	Surface Water	113,061	ANTIOCH	Geographically Diverse Systems
CA1910045	ANTELOPE VALLEY EAST KERN WATER AGENCY	Surface Water	110,286	PALMDALE	Surface Water with Low Filtration
CA3610019	SAN BERNARDINO VALLEY WD	Groundwater	109,608	SAN BERNARDINO	Groundwater with low filtration
CA4510005	CITY OF REDDING	Surface Water	87,548	REDDING	Geographically Diverse Systems
CA1910225	LAS VIRGENES MWD	Surface Water	75,384	CALABASAS	Geographically Diverse Systems
CA3410004	CARMICHAEL WATER DISTRICT	Groundwater UDI Surface Water	37,897	CARMICHAEL	Groundwater under direct infiltration with low filtration
CA1503341	TEJON CASTAC WD - I5 & LAVAL RD	Surface Water	30,250	LEBEC	Surface Water with Low Filtration
CA1510055	CWS - NORTH GARDEN	Surface Water	24,313	BAKERSFIELD	Geographically Diverse Systems
CA3110001	NORTH TAHOE PUD - MAIN	Surface Water	5,300	TAHOE VISTA	Geographically Diverse Systems

ATTACHMENT B Non-exhaustive list of potential surrogate monitoring methods for microplastics

Potential Surrogate Method	**Relative Availability**	**Pre-separation step required?**	**Can distinguish microplastics?**	**Required during Phase I?**
Temperature	Common	No	No	Required
Treatment plant flow rate (to calculate particles entering plant)	Common	No	No	Required
Turbidity	Common	Yes	No	Required
Total organic carbon	Common	Yes	No	Required
Total suspended solids	Common	Yes	No	Required
Total dissolved solids	Common	Yes	No	Required
Total particle count (particles/mL)	Uncommon	No	No	Optional
Microbalance	Common	Yes	No	Optional
Thermogravimetric analyzer - Differential scanning calorimeter	Uncommon	Yes	No	Optional
NIOSH Method #5040 (elemental and organic carbon)	Uncommon	Yes	No	Optional
Imaging hemocytometer	Uncommon	Yes	Likely	Optional
Microscopy with nile red	Uncommon	Yes	Yes	Optional
SiMPore transmembrane pressure filtration	Novel	Unclear	No	Optional
Flowcam and cytometry with or w/o staining	Novel	Yes	Likely	Optional
Lucendi device	Novel	Unclear	Likely	Optional
Spectral Flow Cytometer	Novel	Yes	Likely	Optional

Appendix C Model Calibration

1.0 MODEL DEVELOPMENT

The software used for the hydraulic evaluations is InfoWater v.13.0 provided by Innovyze. Although the previous master plan was performed in 1997, the City's current hydraulic operational model was last created in 2013 and last updated in 2015. Therefore, to match most closely with the existing GIS database, the hydraulic operational model was built from scratch based on a one-to-one approach for the pipelines.

The GIS database is continuously updated; the model used the most recent version available in 2022 to create the model. Additionally, available as-built or bid-set plans were obtained from the City for projects and improvements completed since the last GIS updates in 2022 or currently in construction. This enables the model to represent a complete version of the existing water system pipelines. For updates to pump facilities and controls, as-built plans were also used along with workshops conducted with the operations staff to verify current operations.

Although the system and GIS database include fire hydrants and relief valves, these were not included in the model. The GIS database provided by the City included individual layers for each facility type such as pipeline mains, pipeline laterals, hydrants, and valves. In several areas, multiple hydrants were located parallel to one pipeline main segment. To add the hydrants in the model, the pipeline mains would have to be "split". To avoid this confusion and to maintain the one-to-one approach for the pipelines, the hydrants were not included in the model. Relief valves were also not included in the model. Relief valves are typically included in hydraulic transient models (analyzing sudden pressure surges, rapid flow changes, abrupt pump failures, etc.), not hydraulic operational models (analyzing steady-state conditions, extended period simulations, normal operating conditions, etc.). Including the large quantity of relief valves would cause the model to crash and the valves are unnecessary for the purposes of a hydraulic operational model.

The demands allocated in the model were updated based on meter data from 2022 provided by the City. Then the demands were globally updated based on the MDD factor, and diurnal demand patterns were applied as described in Appendix C-3.

2.0 MODEL CALIBRATION APPROACH

The hydraulic model is calibrated to improve the accuracy of the model in predicting system performance, which can then be used to identify system deficiencies and recommend pipelines and facilities to address those deficiencies. The goal is to calibrate the model as close to MDD conditions as possible. The rationale being that hydraulic models under MDD conditions are stressed to a greater extent and, as such, a more accurate model can be developed.

Model calibration is the process of comparing model results with field results and adjusting model parameters where appropriate until the model results match corresponding field measurement data, within an acceptable difference. Typical adjustments include changes to system connectivity, operational controls, facility configurations, diurnal patterns, elevations, and roughness coefficients (C-factors) for pipelines. The pipes in the model are initially assumed to have a C-factor of 130. The C-factor was decreased for smaller diameter and older aged pipes. The C-factor was increased for larger diameter and younger aged pipes. The C-factors were also adjusted depending on location and material of the pipe. A general summary of C-factors are included in Table 2-1.

Table 2-1 Pipeline C-Factors

Material	Age	Diameter[a]				
		6" & Smaller	8"	10"	12"	14" & Larger
Cast Iron	< 30 Years Old	110 - 130	110 - 130	110 - 130	120 - 130	130 - 140
	30 - 60 Years Old	70 - 130	75 - 130	120 - 130	110 - 130	130 - 140
	> 60 Years Old	70 - 130	75 - 130	110 - 130	80 - 130	130 - 140
Ductile Iron	< 30 Years Old	80 - 130	100 - 130	120 - 130	120 - 130	100 - 140
	30 - 60 Years Old	80 - 130	85 - 130	90 - 130	90 - 130	100 - 140
	> 60 Years Old	70 - 110	75 - 130	90 - 130	80 - 130	100 - 140
HDPE	< 30 Years Old	120 - 130	120 - 130	120 - 130	120 - 130	130 - 140
	30 - 60 Years Old	120 - 130	120 - 130	120 - 130	120 - 130	130 - 140
	> 60 Years Old	120 - 130	120 - 130	120 - 130	120 - 130	130 - 140
PVC	< 30 Years Old	100 - 130	110 - 130	110 - 130	120 - 130	130 - 140
	30 - 60 Years Old	100 - 110	110 - 130	120 - 130	120 - 130	130 - 140
	> 60 Years Old	100 - 110	110 - 120	120 - 130	120 - 130	130 - 140
RCCP	< 30 Years Old	120 - 130	120 - 130	120 - 130	120 - 130	130 - 140
	30 - 60 Years Old	120 - 130	120 - 130	120 - 130	120 - 130	130 - 140
	> 60 Years Old	120 - 130	120 - 130	120 - 130	120 - 130	130 - 140
SCCP	< 30 Years Old	120 - 130	120 - 130	120 - 130	120 - 130	120 - 130
	30 - 60 Years Old	110 - 120	110 - 120	75 - 130	80 - 130	80 - 130
	> 60 Years Old	100 - 110	110 - 120	75 - 130	80 - 130	80 - 130
Steel	< 30 Years Old	100 - 110	110 - 120	120 - 130	120 - 130	130 - 140
	30 - 60 Years Old	100 - 110	110 - 120	110 - 120	120 - 130	100 - 140
	> 60 Years Old	100 - 110	100 - 110	100 - 110	105 - 130	100 - 140
Unknown	< 30 Years Old	120 - 130	120 - 130	120 - 130	120 - 130	120 - 130
	30 - 60 Years Old	110 - 120	110 - 120	110 - 120	120 - 130	120 - 130
	> 60 Years Old	100 - 110	100 - 110	100 - 110	120 - 130	120 - 130

[a] C-factors used based on pipe diameter, material, and age. Not all pipes with the same diameter and age assumed the same C-factor, individual adjustments were necessary for specific areas per the flow testing calibration.

Several indicators are used to determine if the model accurately simulates field conditions including water levels in storage tanks, supply flows, and static and residual pressures from fire flow tests. This also acts as the "debugging" phase for the hydraulic model where modeling discrepancies or data input errors are discovered and corrected.

The hydraulic model is calibrated based on steady-state conditions simulating fire hydrant flow tests in the model to match results from the days of field testing. Hourly SCADA information during the days of testing were used to provide reservoir, well, and pumping operations. However, flow and pressure data were not available for all the wells, MWD supply connections, and booster pump stations.

3.0 STEADY STATE PRESSURE CALIBRATION

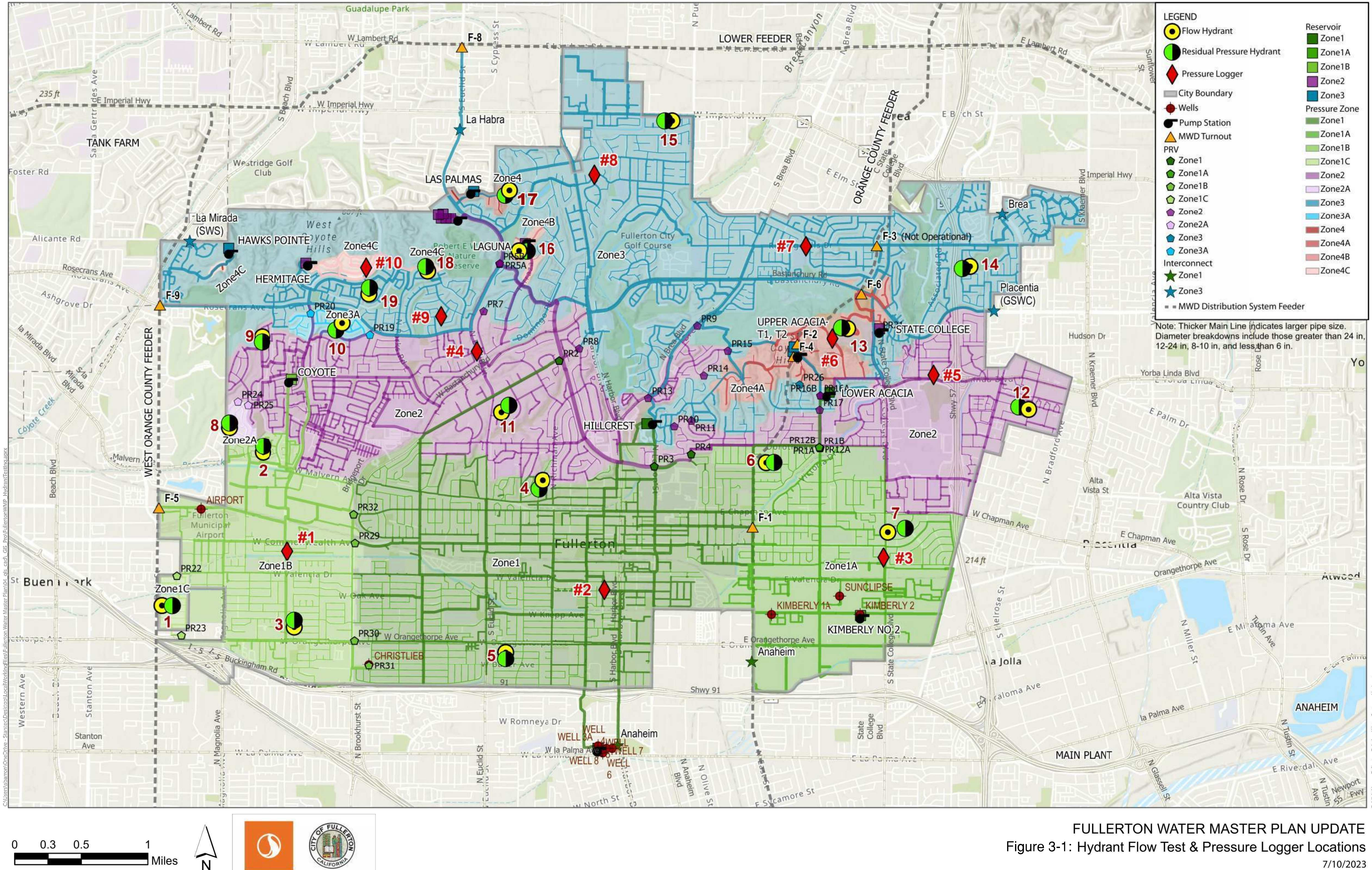
3.1 HYDRANT FLOW TESTING

Field testing was conducted for three days, July 11 through 13, 2023; chosen because this period is close to the highest annual MDD measured on 7/4/22. . Flow tests were performed at 19 fire hydrant locations throughout the City. Tests 8 and 10 are within subzones and were both tested twice to evaluate the system with one or two PRVs active. As such, a total of 21 fire hydrant flow tests were evaluated. Additionally, four pressure loggers were provided for each day of testing (total of 10 pressure logger tests) within the pressure zones being tested. The locations of the tests are listed in Table 3-1 and shown on Figure 3-1.

Table 3-1 Hydrant Flow Calibration Locations

Test No.	Zone	Test Location	Hydrant		
			Type[a]	Location	ID
1	1C	Flower Ave	Flow	800 Hastings Ave	H-21-12
			Pressure	4242 W Flower Ave	H-22-12
2	1B	Monterey Pl	Flow	2604 Monterey Pl	H-17-38
			Pressure	2628 Monterey Pl	H-2-38
3	1B	Pine Dr	Flow	2142 W Hill Ave	H-36-16
			Pressure	2142 W Cherry Ave	H-30-16
4	1	Drake Ave	Flow	644 Drake Ave	H-34-46
			Pressure	624 Drake Ave	H-41-46
5	1	Jefferson Ave	Flow	760 W Woodcrest Ave	H-9-5
			Pressure	754 W Gage Ave	H-10-5
6	1A	Glenwood Ave	Flow	1000 N Norman Pl	H-12-54
			Pressure	1000 Hollydale Dr	H-13-54
7	1A	Clarke Ave	Flow	2466 Clarke Ave	H-11-33
			Pressure	2400 Clarke Ave	H-10-33
8[b]	2A	Northampton Way	Flow	2791 Williamsburg Rd	H-46-37
			Pressure	2774 Sheridan Rd	H-42-37
9	2	Fairgreen Dr	Flow	1806 N Fairgreen Dr	H-10-63
			Pressure	1730 N Fairgreen Dr	H-13-63
10[c]	3A	Canyon Dr	Flow	2001 Canyon Dr	H-68-65
			Pressure	1909 Canyon Dr	H-67-65
11	2	Rodeo Rd	Flow	958 Rodeo Rd	H-15-45
			Pressure	934 W Rodeo Rd	H-10-45
12	2	Garnet Ln	Flow	3172 Garnet Ln	H-23-61
			Pressure	3130 Garnet Ln	H-26-59
13	4A	Edinburgh Way	Flow	1942 Edinburgh Way	H-17-81
			Pressure	1918 Edinburgh Way	H-13-81
14	3	Eucalyptus Pl	Flow	2824 Eucalyptus Pl	H-11-86
			Pressure	2800 Eucalyptus Pl	H-16-86
15	3	San Ramon Dr	Flow	730 San Ramon Dr	H-6-96
			Pressure	700 San Ramon Dr	H-5-96
16	4B	Madera Pl	Flow	821 Madera Pl	H-2-72
			Pressure	800 Madera Pl	H-3-72
17	4	Las Palmas Dr	Flow	831 W Las Palmas Dr	H-34-93
			Pressure	909 W Las Palmas Dr	H-33-93
18	4C	Atherton Cir	Flow	1416 Atherton Cir	H-3-70
			Pressure	2567 Camino Del Sol	H-1-70
19	3	Berkshire Dr	Flow	1975 Berkshire Dr	H-43-68
			Pressure	1999 Berkshire Dr	H-31-68

[a] "Flow" type refers to the hydrant opened to measure flow. "Pressure" type refers to the nearby hydrant installed with a pressure gauge to measure the residual pressure.
[b] Test 8 was conducted twice, the first time with pressure relief valve (PRV) PR-24 open and PR-25 closed, the second time with both PRVs open.
[c] Test 10 was conducted twice, the first time with PRV PR-20 open and PR-19 closed, the second time with both PRVs open.



FULLERTON WATER MASTER PLAN UPDATE

Figure 3-1: Hydrant Flow Test & Pressure Logger Locations

7/10/2023

3.2 HYDRANT FLOW TEST MODEL CALIBRATION

City operations staff provided screen captures of SCADA readings from the system control computers during the times of the testing. These images show major system valve flows, reservoir levels, and which pump stations and wells were operating. Reservoir level SCADA for every hour during the days of testing was also provided. The data included facility status and levels to be accurately estimated in the model based on the corresponding time of each flow test.

The model was updated with a calibration scenario that contains a total of 42 steady-state simulations. Although the evaluation included 19 test locations, Tests 8 and 10 were tested twice to evaluate the pressure subzones with one or two PRVs open. As such, a total of 21 fire hydrant flow tests were modeled and calibrated. For each of the 21 tests, the model simulates two scenarios – one “static” simulation prior to the hydrant being opened to flow and one “dynamic” simulation of the hydrant flowing, where the flow and residual pressure can be evaluated. For each flow test simulation, the model results are compared with the field measurements, where a total of 42 data points were compared. It is generally considered acceptable when model results match field results within a 10-percent tolerance.

The initial step in the calibration process was to update the demands in the system to match the demands for the day and time of the tests. This was done by analyzing the boundary supply conditions and production facilities from the SCADA information. After the demands and boundary conditions are satisfactorily calibrated, pressure logger and static readings are compared and verified with field data and ground elevations at each hydrant data point.

The model is ultimately calibrated to match field pressure and flow data at the test locations by adjusting the C-factors, or roughness coefficient, of the pipelines. The C-factor has a direct impact on the pipe headloss and therefore the resulting pressures at upstream and downstream model junction nodes. The C-factor is estimated based on pipe material and pipe age, or year of installation. An older pipe with small diameter and multiple service connections will be estimated to have a lower C-factor than a large new diameter pipe with no connections and smooth pipe material such as PVC. These model C-factors were adjusted accordingly for the model results to match the field testing results within the acceptable tolerance of 10-percent. Table 3-2 shows the model results compared with the field test results.

Table 3-2 – Hydrant Flow Test Results

Test #	Zone	Hydrant ID	Hydrant Type	Flow Rate (gpm)	Pressure (psi)							
					Static				Residual			
					Field	Model	Diff.	%. Diff.	Field	Model	Diff.	% Diff.
1	Zone 1C	H-21-12	Flow	949								
		H-22-12	Pressure		68	69	1	1%	63	60	-3	-5%
2	Zone 1B	H-17-38	Flow	888								
		H-2-38	Pressure		53	51	-2	-3%	51	49	-2	-4%
3	Zone 1B	H-36-16	Flow	1900								
		H-30-16	Pressure		80	75	-5	-7%	68	68	0	0%
4	Zone 1	H-41-46	Flow	1815								
		H-34-46	Pressure		51	50	-1	-2%	39	38	-1	-3%
5	Zone 1	H-9-5	Flow	1941								
		H-10-5	Pressure		82	84	2	2%	75	74	-1	-1%
6	Zone 1A	H-12-54	Flow	1253								
		H-13-54	Pressure		56	54	-2	-3%	38	40	2	4%
7	Zone 1A	H-11-33	Flow	1299								
		H-10-33	Pressure		56	53	-3	-6%	53	49	-4	-8%
8A	Zone 2A	H-46-37	Flow	1727								
		H-42-37	Pressure		55	57	2	4%	42	43	1	2%
8B	Zone 2A	H-46-37	Flow	1815								
		H-42-37	Pressure		55	57	2	4%	46	48	2	5%
9	Zone 2	H-10-63	Flow	1772								
		H-13-63	Pressure	251	67	69	2	3%	58	66	8	12%
10A	Zone 3A	H-68-65	Flow	1482								
		H-67-65	Pressure		69	71	2	3%	29	29	0	0%
10B	Zone 3A	H-68-65	Flow	1815								
		H-67-65	Pressure		88	95	7	7%	46	47	1	1%
11	Zone 2	H-15-45	Flow	2206								
		H-10-45	Pressure		74	76	2	3%	64	69	5	8%
12	Zone 2	H-23-61	Flow	1534								
		H-26-59	Pressure		60	58	-2	-3%	43	48	5	10%
13	Zone 4A	H-17-81	Flow	1633								
		H-13-81	Pressure		80	80	0	0%	43	42	-1	-3%
14	Zone 3	H-11-86	Flow	1633								
		H-16-86	Pressure		85	87	2	2%	50	71	21	30%
15	Zone 3	H-6-96	Flow	1534								
		H-5-96	Pressure		76	76	0	0%	44	44	0	0%
16	Zone 4B	H-2-72	Flow	1585								
		H-3-72	Pressure		60	65	5	8%	47	47	0	0%
17	Zone 4	H-34-93	Flow	1633								
		H-33-93	Pressure		80	88	8	9%	30	33	3	10%
18	Zone 4C	H-3-70	Flow	1314								
		H-1-70	Pressure		83	84	1	2%	15	14	- 1	-7%
19	Zone 3	H-43-68	Flow	1633								
		H-31-68	Pressure		63	66	3	5%	37	41	4	10%

Diff. = pressure difference between field and model results
%. Diff. = percent difference between field and model results

Approximately 88 percent, or 36 out of the 42 data points in Table 3-2, showed the model to be within 10 percent of the field records. Five hydrant tests resulted in a percent difference between 10 and 12 percent. Five tests required additional modifications to calibrate with the field data as described below.

Test 10A is located in Zone 3A, supplied by pressure reducing vales near the westerly portion of Zone 3, with PR-20 open and PR-19 closed. During initial calibration, the pressure hydrant results did not calibrate in the model showing residual pressures 38 percent higher in the model than in the field. Given its close proximity, the updates from Test 19 as described below were also applied to Test 10A. The C-factors for 8-inch pipelines in the zone were decreased to 100. In addition, minor loss was added to the PR-20 facility, at the 8-inch pipeline (ID P17755) immediately downstream of valve. After these updates were made to the model, the model results matched the field results within 1 percent.

Test 10B is the same as Test 10A with the exception that both PRVs open. All of the same updates were made to Test 10B as Test 10A. During initial calibration, the pressure hydrant results did not calibrate in the model also showing residual pressures 38 percent higher in the model than in the field. Minor loss was added to PR-19 at the 8-inch pipeline (ID P112201) immediately downstream of valve. After these updates were made to the model, the model results matched the field results within 1 percent.

Test 14 is also within Zone 3 and located in the easterly portion of the zone, east of the 57 Freeway. Calibration showed the pressure hydrant with a resulting modeled pressure 30 percent above the field residual pressure. To calibrate this test, the C-factors for localized 8-inch diameter pipelines were decreased to 100. The adjustments to the friction factor were not sufficient and pipes were closed in the vicinity to determine if perhaps a valve in the area is closed in the field. Field investigations of the valves in the area did not find a closed valve. The poor calibration at this location could have been due to a bad reading or misread gauge reading and is disregarded since better calibrated could not be achieved.

Test 17 is in Zone 4 near the Las Palmas Reservoir and Pump Station facility. During initial calibration, the pressure hydrant results in the model did not show enough of a pressure drop, yielding modeled pressure above the field residual pressures by 34 percent. To calibrate this test, C-factors were decreased for pipelines 60-years or older within the zone: 6-inch pipes were updated to a C-factor of 90, 8-inch pipes to 100, and 12-inch pipes to 105. In addition, the Las Palmas Pump Station pump curve for Pump #2 was updated to adequately supply fire flow and reflect the hydropneumatic tank operation. With these updates to the model, the model results match the field data within 10 percent.

Test 19 is located within the westerly portion of Zone 3, between the Hawks Pointe and Tank Farm facilities. The initial pressure hydrant results in the model did not show enough of a pressure drop and did not meet residual pressures in the field by 39 percent. The City indicated there is a closed 16-inch butterfly valve on Rosecrans Avenue (ID P8055), isolating everything west of it due to inadequate cycling of the Hawks Pointe Reservoir 3C. In addition to closing the pipe in Rosecrans Avenue, the control valve to the Tank Farm Reservoir was updated to have a setting of 25 psi. After these updates were made to the model to calibrate and match field conditions, the model results matched the field within 10 percent.

4.0 EXTENDED PERIOD SIMULATION (EPS) MODEL CALIBRATION

EPS model calibration provides a better understanding of the water distribution system operations than a steady-state model. The goal of the EPS calibration is to estimate the accuracy with which the model simulates the field operations over a 24-hour period. The EPS calibration is performed for each pressure zone for the 24-hour period comparing the model results with the hourly SCADA data on July 4, 2022, the maximum day demand in 2022, for each facility to determine if the model reflects the actual system operating conditions (Appendix C.1).

SCADA data was available for reservoir water levels. Discharge pressure and flow data was limited and was not included for all facilities. Pressure data for PRVs between zones was not available and therefore could not be calibrated. A list of facilities with SCADA is provided in Appendix C.2. Additionally, pump design curve data was not available for all the well pumps and booster pumps. Where pump curve data was not available, recent SCE test data was used to input pump flow and head operating points. A single design point was input for the model for the pumps that did not have design curve data or sufficient SCE test data.

The City also provided screenshots of pump, well, and MWD connection control settings in SCADA which indicated the facility control set points and is controlled by tank level, downstream pressure, or flow. The control settings in the EPS were calibrated using these control settings. For modeling purposes to achieve a successful EPS run, facilities controlled based on downstream pressure were instead controlled by tank levels.

Although relief valves were not added to the model, as indicated in Section 1.0, the only ones included were relief valves used for pump station operation to limit the discharge pressure to zone at Hawks Pointe 3C-4C, Hermitage 2B-4C, and Upper Acacia 3A-4A Pump Stations. The valves at these pump stations are used in the field to circulate flow to maintain pressures in the closed-loop zone.

The model calibration is considered achieved as the model output and SCADA data are within 10 percent difference.

4.1 CALIBRATION DEMANDS

Average day demands (ADD) of 20.46 mgd were allocated in the model based on the geolocation of meter data for each land use type and assigned to the adjacent junction node in the model. The demands in the model used for calibration were updated in the model and based on the MDD experienced on July 4, 2022. Production data from this day was used to determine the total supply for the day from each supply source. The MDD updated in the model is 27.0 mgd.

For each pressure zone service area where sufficient data was available to develop a diurnal demand pattern, a MDD diurnal pattern was applied to each demand node. Appendix C.3 provides the diurnal demand patterns used during the model calibration and based on the hourly SCADA available from July 4, 2022. Appendix C.3 also includes ADD diurnal patterns. MDD and ADD diurnal patterns may differ based on seasonal demands, MDD is based on summer water use patterns. ADD includes winter demands which typically includes the reduction of irrigation.

4.2 ZONE 1 AND 1A CALIBRATION

Updates to the facility controls and pump station operating setpoints were conducted based on the SCADA information provided. Additionally, Zone 1 and 1A are hydraulically connected through a pressure relief valve, two PRVs (PR12), and the 12-inch pipeline located on Dorothy Lane. Currently one of the PRVs at PR12 is maintained in the open position and water can be freely conveyed between the two zones through the 12-inch pipeline. This allows the 12-inch pipeline to act as a hydraulic link between the two zones. Water is allowed to flow freely through these two valves in between Zones 1 and 1A to maintain pressures.

The hydraulic connection also allows the Zone 1A wells (Kimberly Well 1A, Kimberly 2, and Sunclipse Well 10) to be controlled by and fill the Lower Acacia Reservoir 1D. The Main Plant Booster Pump Station is controlled by the water level in Hillcrest Reservoir 1A. The Main Plant Booster Pump Station has not had sufficient capacity to fill Lower Acacia Reservoir 1D. For the day of calibration, Well 3A and Well 6 were not in operation.

Comparison charts showing the model versus the SCADA for the wells and reservoir facilities in operation (including the Main Plant Pump Station and Forebay) are provided in Appendix C.1. The average flowrates and discharge pressures of the wells calibrated to be within ten percent of the SCADA.

4.3 ZONE 1B CALIBRATION

Zone 1B was calibrated based on SCADA data provided. Data was not available for Zone 1C since it is a sub-zone supplied through PRV stations. Zone 1B is supplied by Well 9 and Well 15A. Well 9 is controlled by pressure but was set to operate continuously all 24-hours per day. Sunclipse Well 15A is controlled by water level in Coyote Reservoir 1C. Imported water connection F-05 is also a supply source to Zone 1B but was not in operation for the day of calibration. According to staff, with Airport Well 9 operating most of the time, F-05 connection is opened only occasionally as needed under specific circumstances.

Comparison charts showing the model versus the SCADA for the wells and reservoir facilities are provided in Appendix C.1. The model was able to calibrate the flow rates at an average of 8 percent within SCADA for the wells and 2 percent for the water level in the Coyote Reservoir 1C and discharge pressures at the wells.

4.4 ZONE 2 CALIBRATION

Zone 2 was calibrated with model results for discharge pressure and reservoir levels, and were within 4 percent and 9 percent of SCADA results, respectively. Zone 2 receives imported water supply from F-08 and the Tank Farm through PRV stations (PR5A and PR5B) as well as several other smaller PRV stations throughout the zone. However, SCADA data was not available for these PRV stations. Groundwater is supplied to the zone through pump stations boosting the water from Zone 1A and 1B, via Lower Acacia 1D-2 and Coyote 1C-2 Pump Stations. There are three reservoirs that provide storage: Hermitage 2B, Laguna 2A, and State College 2C. The Lower Acacia 1D-2 Pump Station is controlled by water levels in State College Reservoir 2C. The Coyote 1C-2 Pump Station is controlled by the Hermitage Reservoir 2B water levels.

Comparison charts showing the model versus the SCADA for the pump station and reservoir facilities are provided in Appendix C.1.

4.5 ZONE 3 CALIBRATION

Zone 3 is supplied primarily from MWD imported water connections: F-04, F-06, F-08, and F-09. Additional supply can be provided from Zone 1 with groundwater pumped up through the booster pump stations at Hillcrest (1A-3) and Lower Acacia (1D-3). The F-08 turnout was calibrated using the total daily production data modeled as a flow pattern based on the hourly SCADA data. Flow from F-08 splits to fill either the Las Palmas Reservoir or the Tank Farm Reservoirs. The Las Palmas Reservoir floats on the Zone 3 hydraulic grade. The Tank Farm Reservoir elevations are between the Zone 2 and Zone 3 hydraulic grades and requires a pressure control and sustaining valve at the Tank Farm facility to control the flow into the reservoirs. The setting of this control valve was adjusted to a setting of 37 psi to provide the appropriate flow allocation to the zone and balance the Las Palmas Tank level to match SCADA.

The model also assumes that the 16-inch pipeline in Rosecrans Avenue (east of the Hawks Pointe Reservoir service area) has a closed valve, as per City staff. All supply facility flowrates and pressures are calibrated to within 10 percent of SCADA, with the exception of F-09. The flowrate through F-09 is calibrated to 28 percent, however, this percent difference equates to only 125 gpm out of 447 gpm (per SCADA) and is considered acceptable. Comparison charts showing the model versus the SCADA for the pump station and reservoir facilities are provided in Appendix C.1.

4.6 ZONE 4 CALIBRATION

Zone 4 is a closed-looped system supplied from the Zone 3 Las Palmas Reservoir 3B via the Las Palmas Pump Station 3B-4. The Las Palmas Pump Station is equipped with a 7,000-gallon hydropneumatic tank to control the discharge pressure and flow to meet the variation of demand in the zone. To represent this in the model, the pump station was modeled as a single pump with a flat curve to provide a consistent discharge pressure at various flowrates. The manufacturer’s pump curve was modified accordingly to reflect the capacity of the two pumps plus the fire flow capability of the station based on the hydrant flow test data.

Flow data was not available for the pump station in SCADA, however discharge pressure was available for calibration. The model results are an average of 61 psi, within two psi of the average SCADA pressure of 59 psi with a 5 percent difference. The flow and pressure comparison charts are provided in Appendix C.1.

4.7 ZONE 4A CALIBRATION

Zone 4A is supplied from the Upper Acacia Reservoir via the Upper Acacia Pump Station 3A-4A and is a large closed-loop system. The Upper Acacia Pump Station is equipped four constant speed vertical turbine pumps. One small jockey pump (Pump #1) and three large pumps, with one of the large pumps as standby. One pump was operating during the calibration period, the large Pump #3. Pumps #3 and #4 are typically used with Pump #1 turning on only during peak demand periods.

This pump station is operated using the pressure relief valve bypass to regulate discharge pressure to meet the various flows demand by the pressure zone. Flow is allowed to recirculate through the bypass.

SCADA indicated an average flow rate of 404 gpm through the flow meter, which is located after the bypass assembly and represents the water demand to the zone. Pump #3 has a capacity of 1,000 gpm The setting of the pressure relief valve, which is modeled as a throttle control valve with a setting of 85. The model indicates the remaining average of 794 gpm flows back through the bypass valve assembly.

The model shows flow through the meter matches within 11 percent of SCADA on average, or 44 gpm, with an average flow of 360 gpm. The discharge pressure is modeled at 58.8 psi, within 1 psi of the SCADA pressure of 59.2 psi. Flow and pressure comparison charts of the model versus the SCADA for the pump station are provided in Appendix C.1.

4.8 ZONE 4B CALIBRATION

Zone 4B is a small closed-looped system with supply pumped from Zone 2 and Laguna Reservoir 2A through the Laguna Pump Station 2A-4B. The Laguna Pump Station is equipped with two constant speed vertical turbine pumps and a 5,000-gallon hydropneumatic tank. To model the pumps and hydropneumatic tank operation to meet the various demand conditions with a consistent discharge pressure, the pump station was modeled as a single pump with a flat curve to provide a consistent discharge pressure at the various flowrates. The manufacturer's pump curve was modified accordingly to reflect the capacity of the two pumps plus the fire flow capability of the station based on the hydrant flow test data.

The Laguna Pump Station does not have flow data available in SCADA, however pressure data was available. The pump station was modeled to flow at an average flowrate of 45 gpm. The discharge pressure was modeled to be an average of 53 psi. The SCADA discharge pressure was 52 psi, resulting in a calibration within 2 percent. Flow and pressure comparison charts of the model versus the SCADA for the pump station are provided in Appendix C.1.

4.9 ZONE 4C CALIBRATION

Zone 4C is two separate service areas and will be discussed for calibration purposes separately below as the Zone 4C East and Zone 4C West service areas.

4.9.1 Zone 4C East

Zone 4C East is a closed-loop service area that is supplied from Zone 2 via the Hermitage Pump Station 2B-4C, boosting water from the Hermitage Reservoir 2B. Although the Hermitage Pump Station has a hydropneumatic tank onsite, staff reports that this tank does not function. The pump station is allowed to recirculate water through the pressure relief bypass assembly to limit pressures in the zone while meeting the various flowrates demanded. The station is equipped with two constant speed vertical turbine pumps with a 300-gpm design capacity and one horizontal engine drive pump sized for a design flow of 2,500 gpm. As previously mentioned in Section 4.0, where pump curve data was not available, recent SCE test data was used to input pump flow and head operating points. The pump curves for Hermitage Pump Station were not available, as such, the SCE test was used to provide a design point for the duty pumps. The pressure relief valve was modeled as a throttle control valve, with a setting of 15. The model indicates the remaining average of 869 gpm flows back through the bypass valve assembly. One pump, Pump #2, was turned on and operated during the EPS scenario without any other controls or on/off setpoints.

SCADA flow information was not available for the pump flowrate calibration. Discharge pressure from SCADA averaged approximately 99 psi and the modeled pressure averaged approximately 101 psi, equating to a 2 percent difference. Pressure comparison charts of the model versus SCADA for the pump station are provided in Appendix C.1.

4.9.2 Zone 4C West

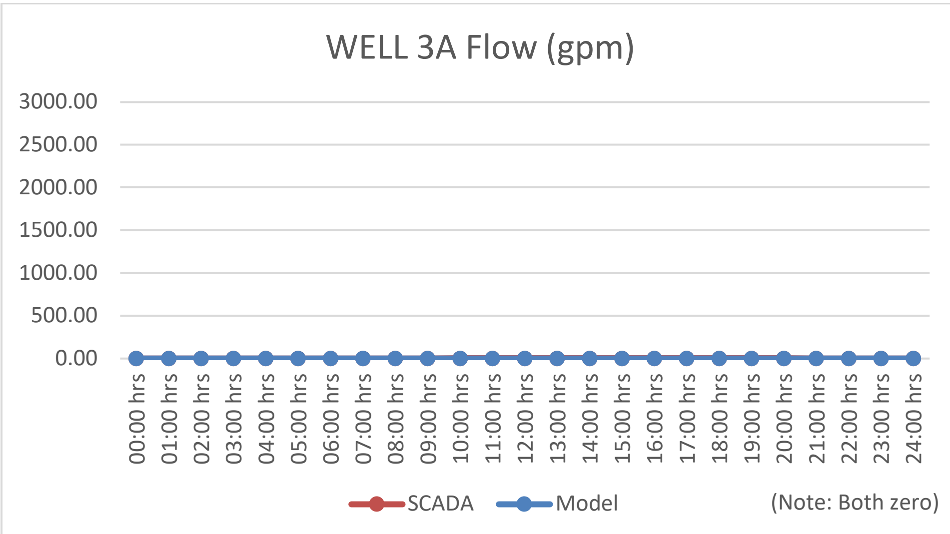
Zone 4C West is a small closed-loop service area that includes approximately 59 residential homes. Zone 4C is supplied by the Hawks Pointe Pump Station 3C-4C that boosts water to the zone from the Hawks Pointe Reservoir 3C. The Hawks Pointe Pump Station consists of two constant speed vertical turbine pumps. One pump, Pump #2, was on during the calibration scenario and allowed to operate during the EPS run without any control.

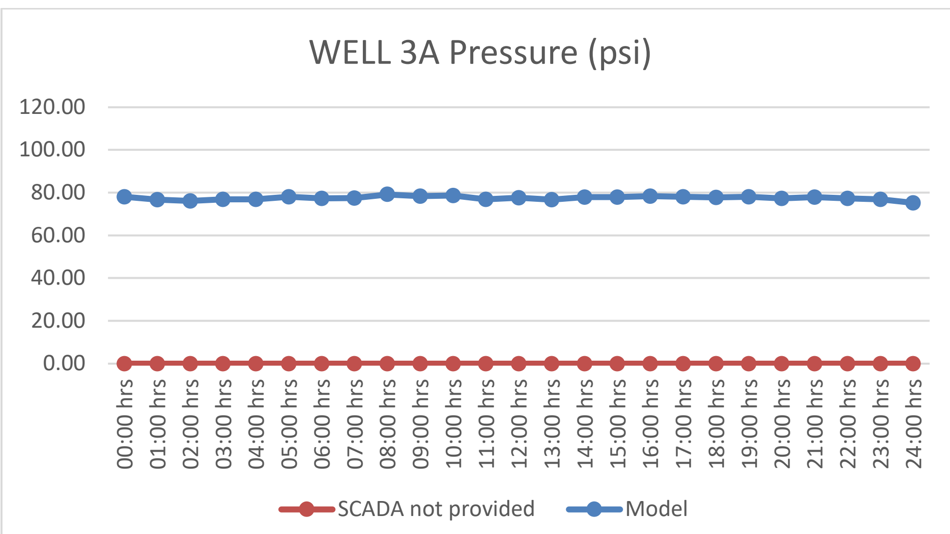
SCADA shows that the flowrate averages approximately 19 gpm and the modeled flow is 9 gpm. Although this represents a 52 percent difference with the SCADA, the modeled results differ by only 10 gpm and is likely due to the demands in the zone for the day of calibration. The discharge pressure at the pump station in SCADA is 59 psi and the modeled pressure is 53 psi, a difference of 10 percent. Flow and pressure comparison charts of the model versus the SCADA for the pump station are provided in Appendix C.1.

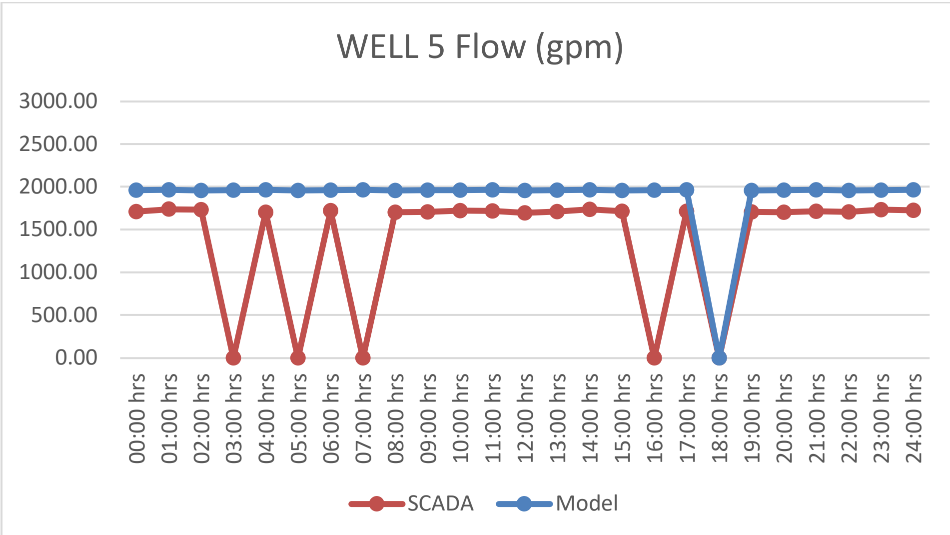
C.1 EPS Model Calibration vs SCADA Charts

C.1.1 ZONE 1 EPS MODEL CALIBRATION VS SCADA CHARTS

Zone 1 Wells



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3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
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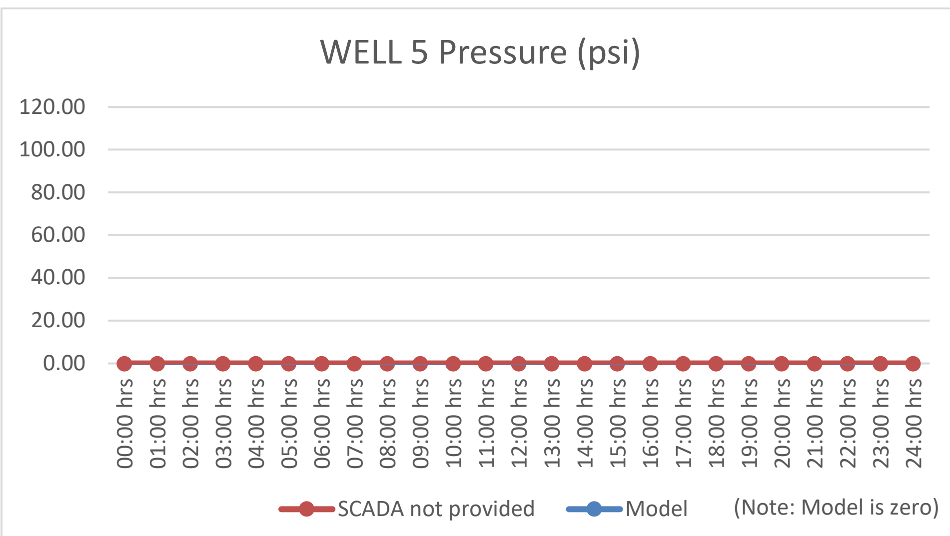
24:00 hrs
SCADA
Model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120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
01:00 hrs
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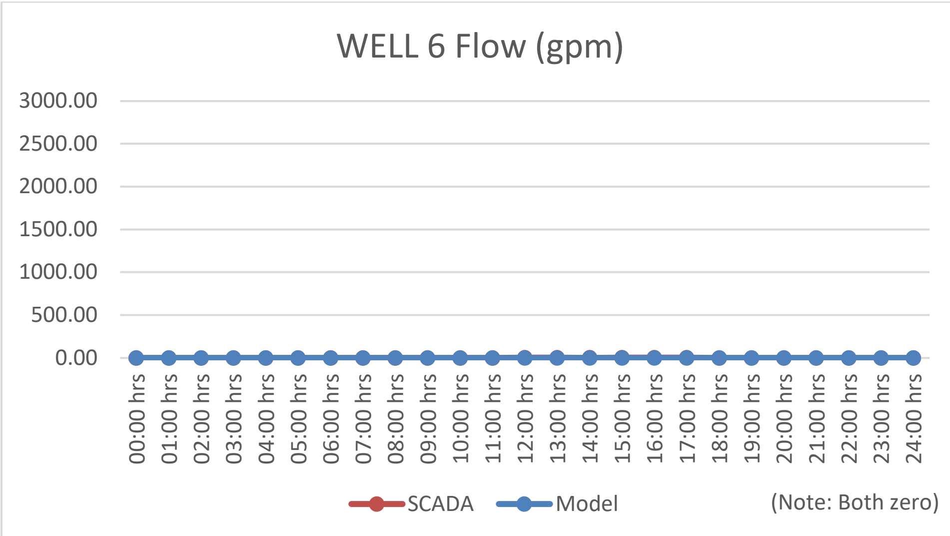
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA not provided
Model
(Note: Model is zero)


WELL 6 Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
01:00 hrs
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03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
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15:00 hrs
16:00 hrs
17:00 hrs
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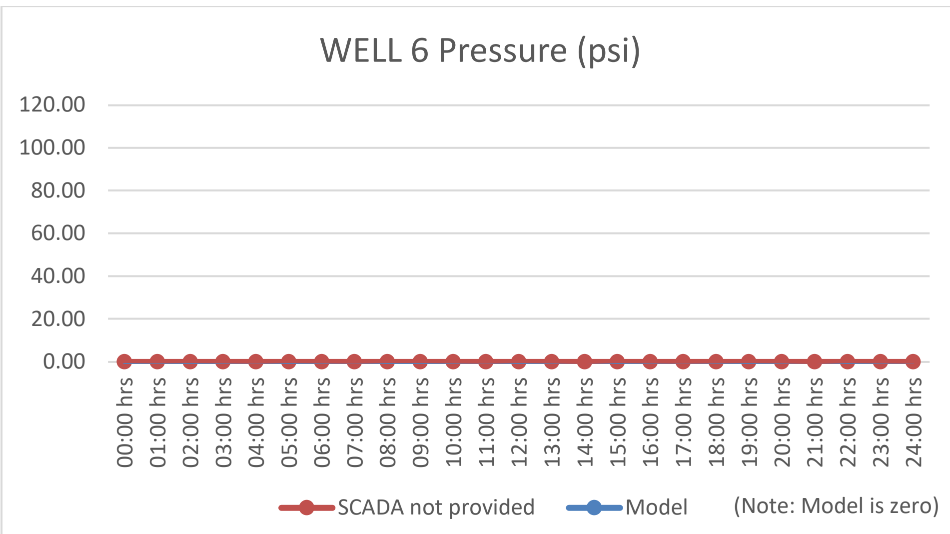
24:00 hrs
SCADA
Model
(Note: Both zero)


WELL 6 Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
01:00 hrs
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04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
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14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
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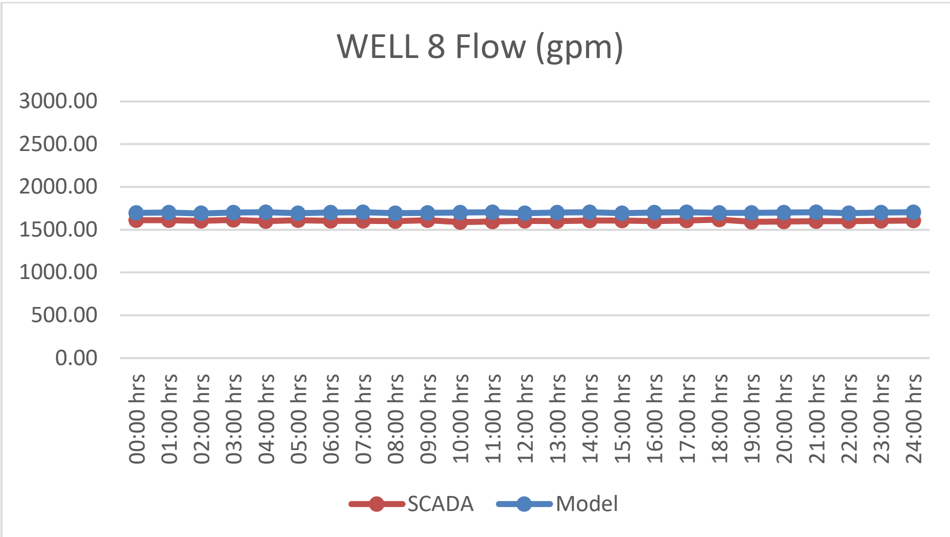
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA not provided
Model
(Note: Model is zero)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3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
01:00 hrs
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03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
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15:00 hrs
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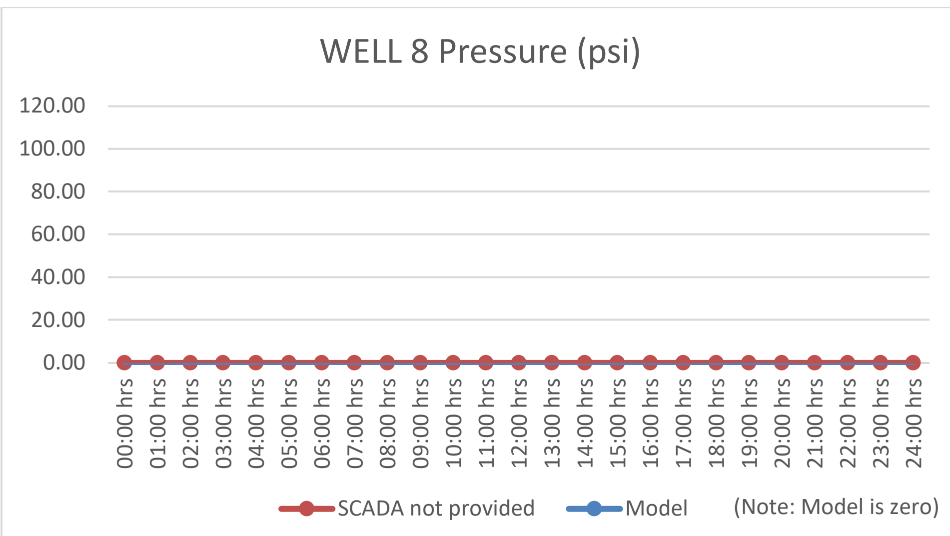
24:00 hrs
SCADA
Model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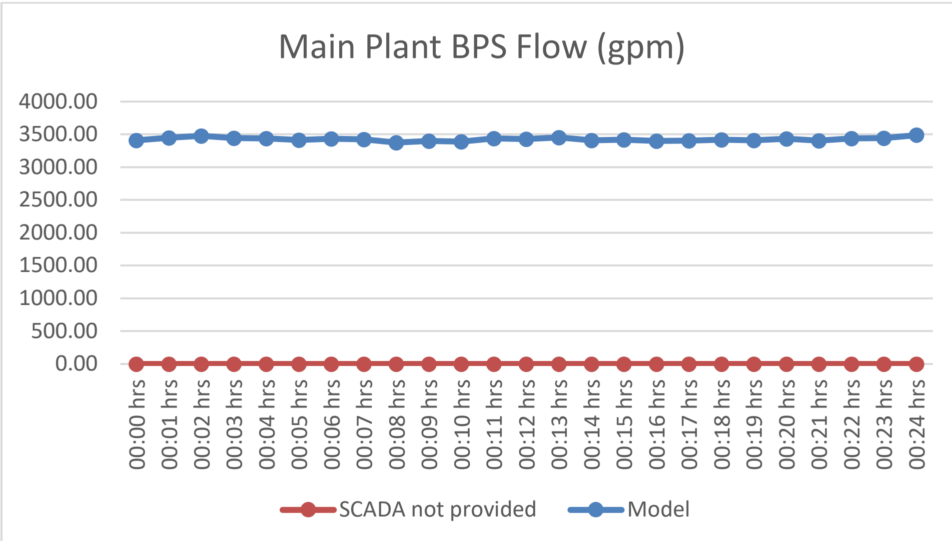
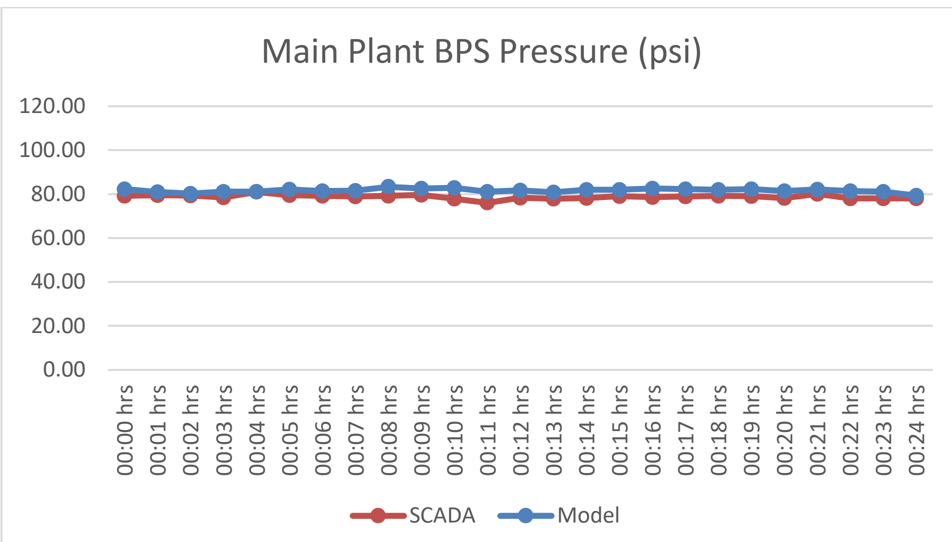
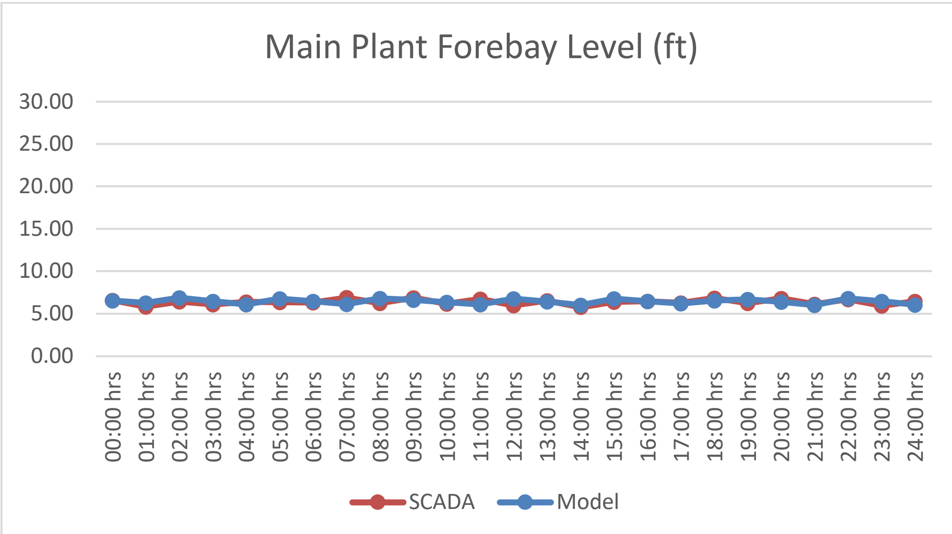
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA not provided
Model
(Note: Model is zero)

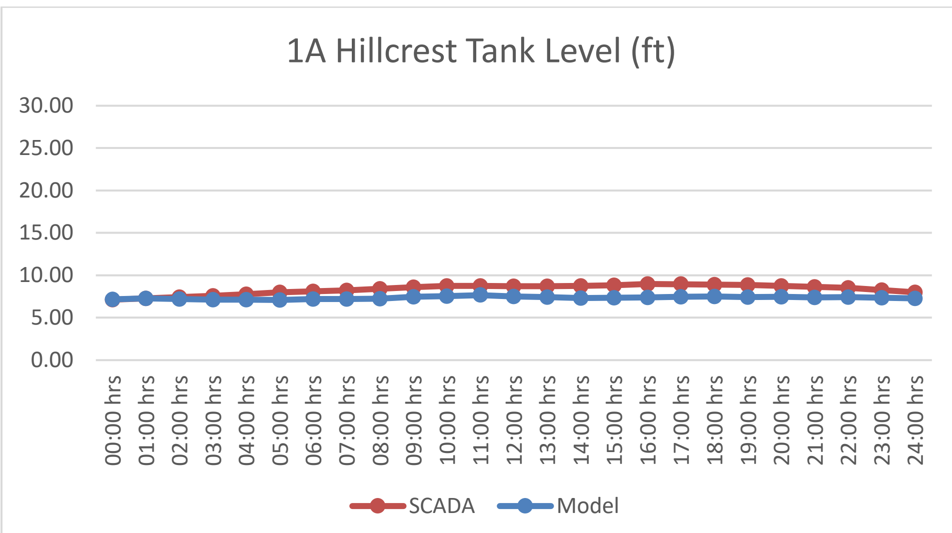
Zone 1 Booster Pump Stations

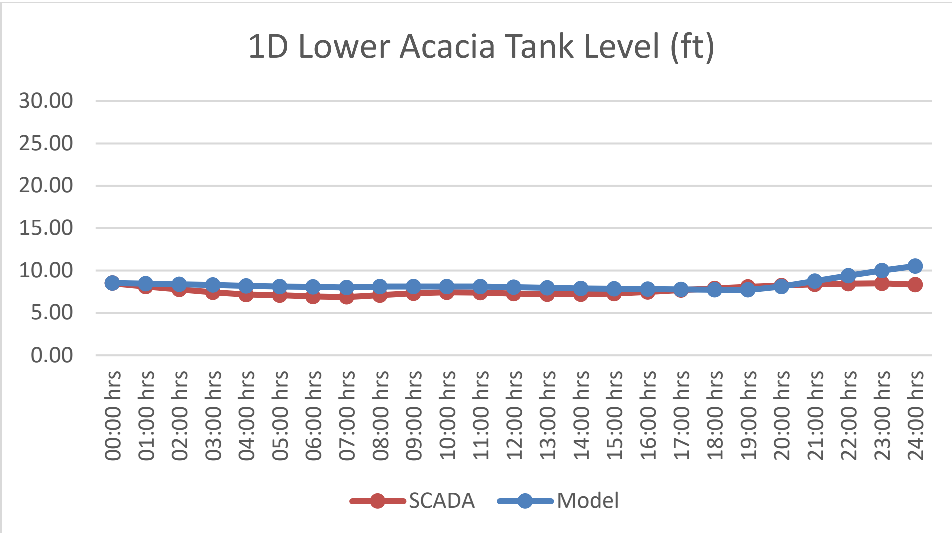




Zone 1 Reservoirs



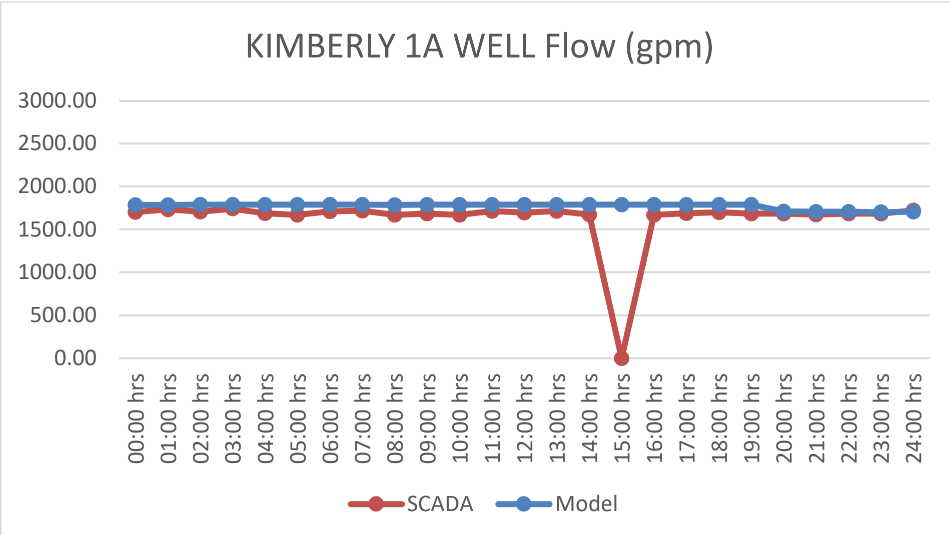


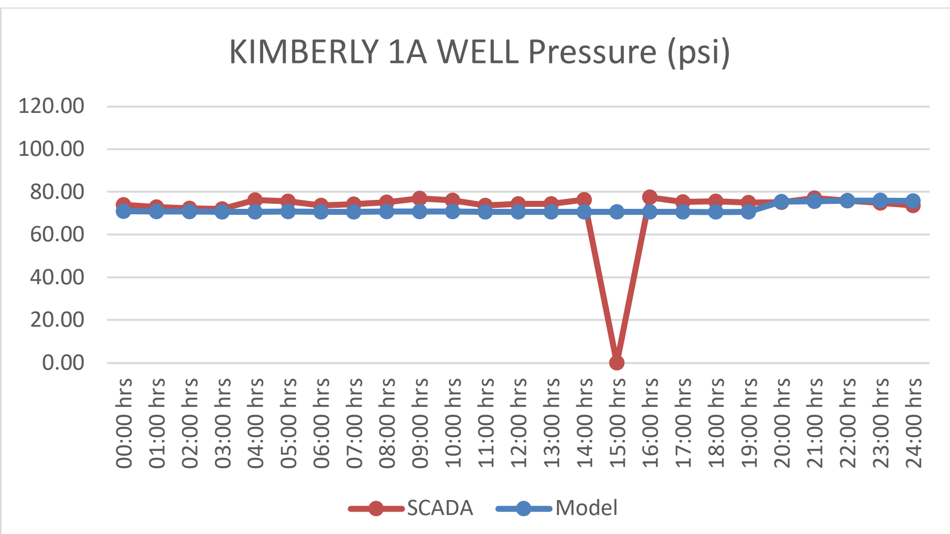


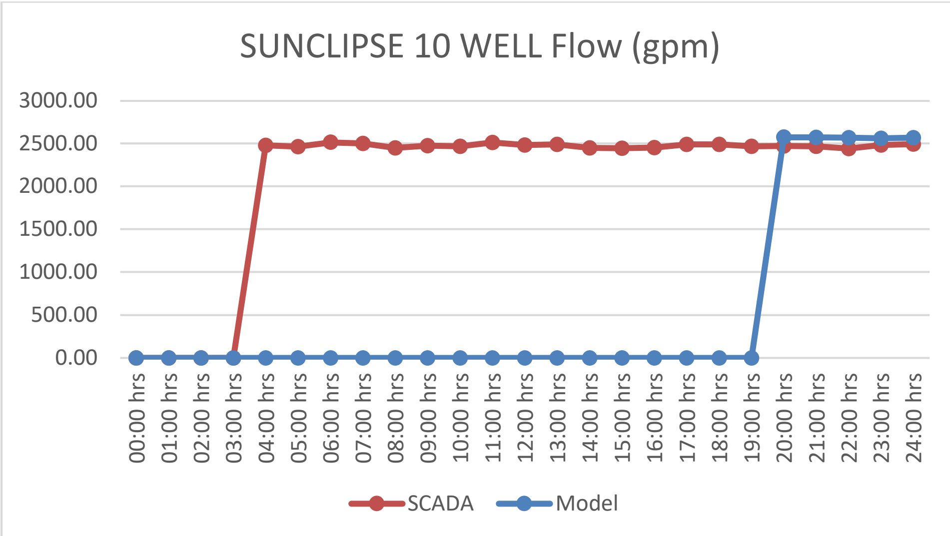
1D Lower Acacia Tank Level (ft)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

C.1.2 ZONE 1A EPS MODEL CALIBRATION VS SCADA CHARTS

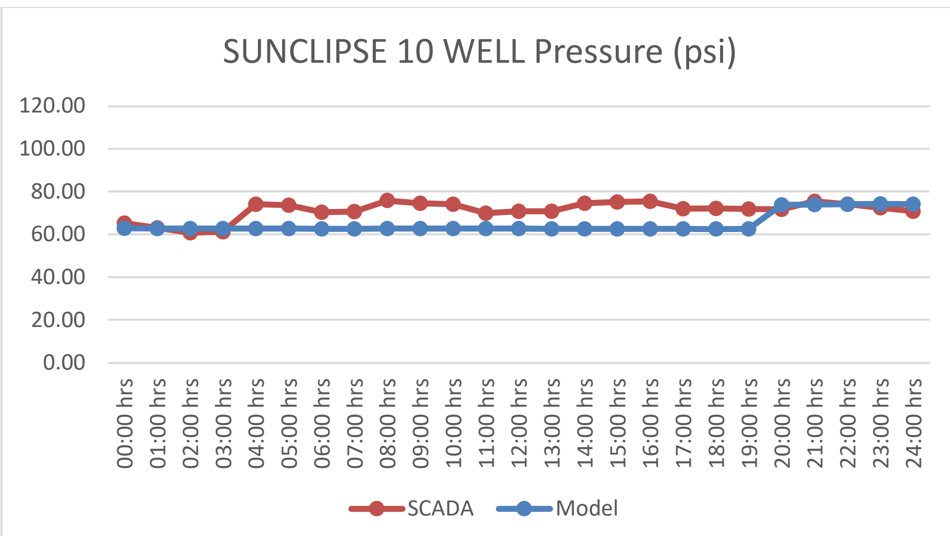
Zone 1A Wells





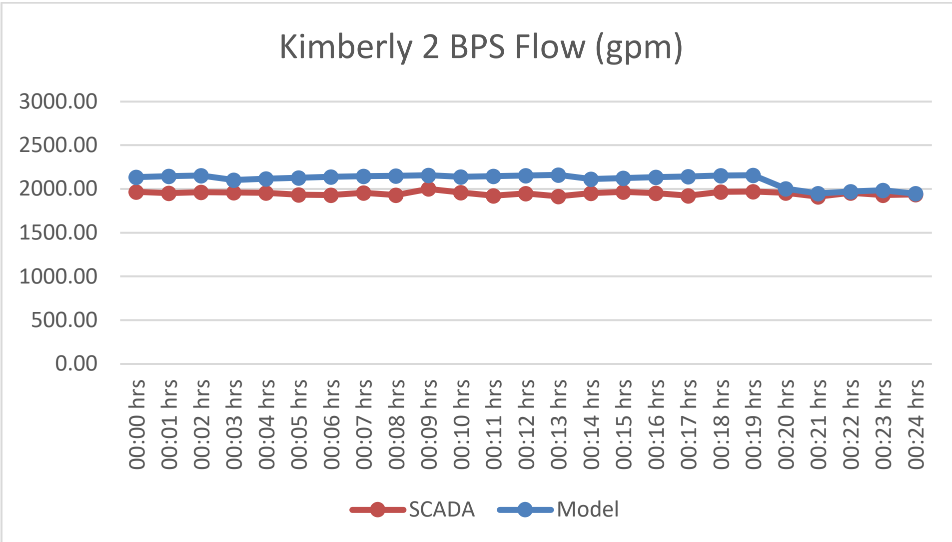


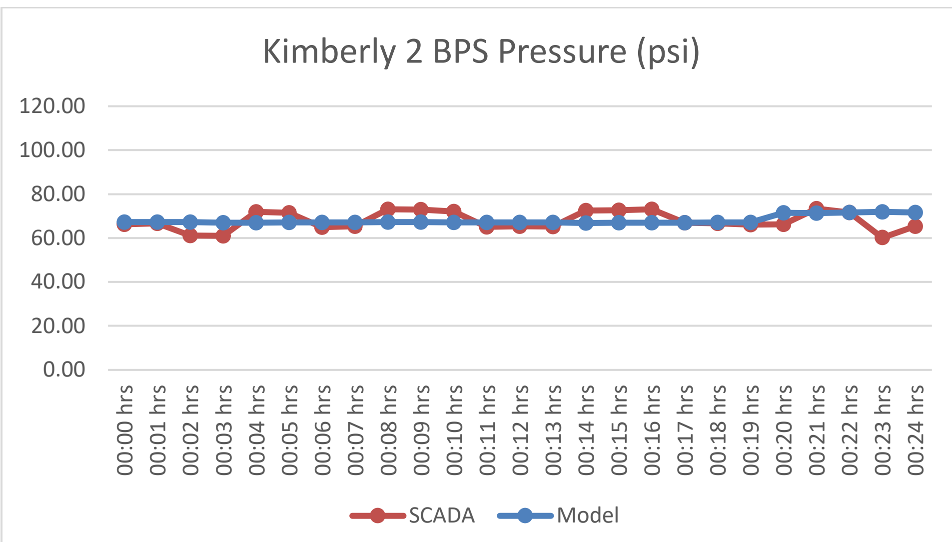
SUNCLIPSE 10 WELL Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model



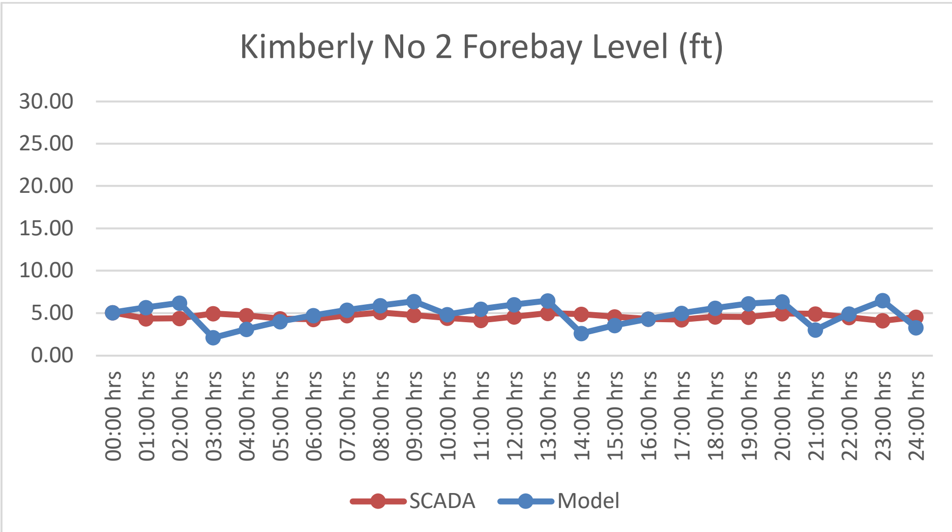
SUNCLIPSE 10 WELL Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

Zone 1A Booster Pump Stations



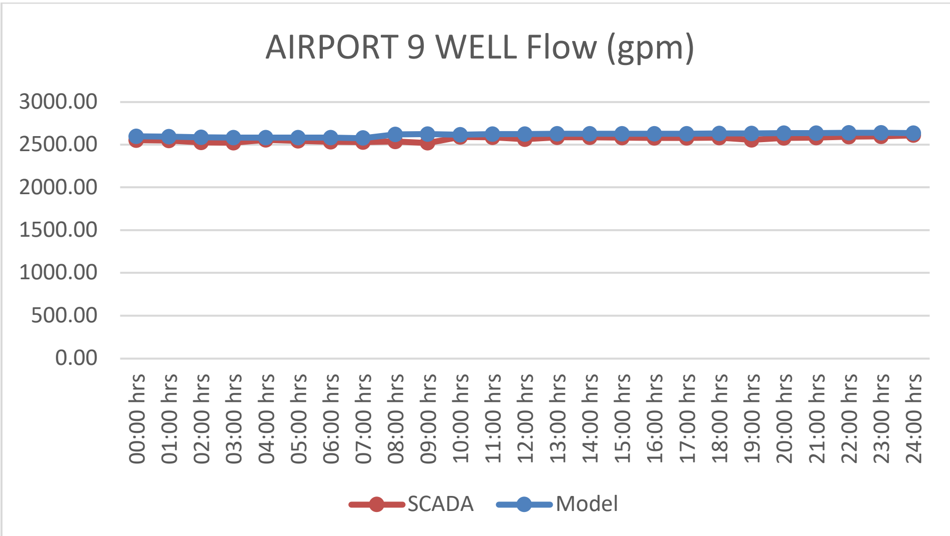


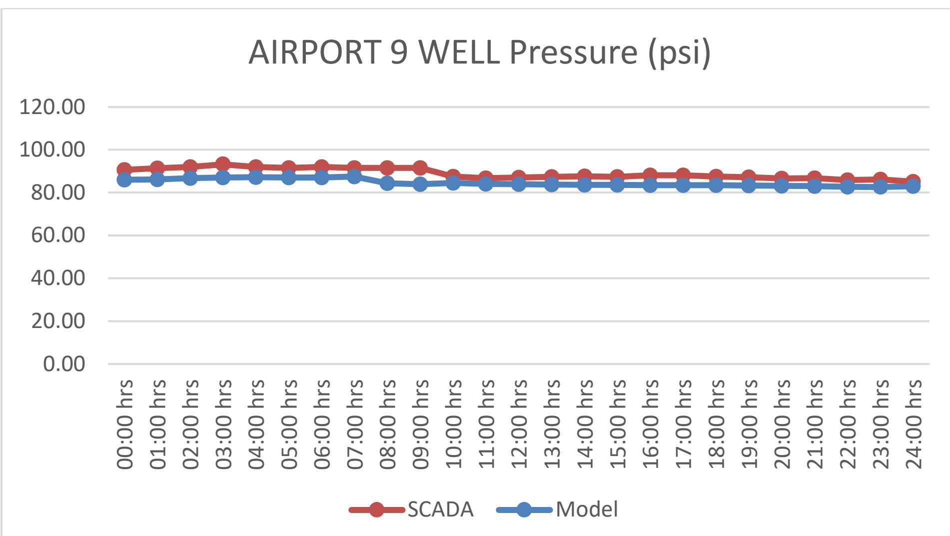
Zone 1A Reservoirs

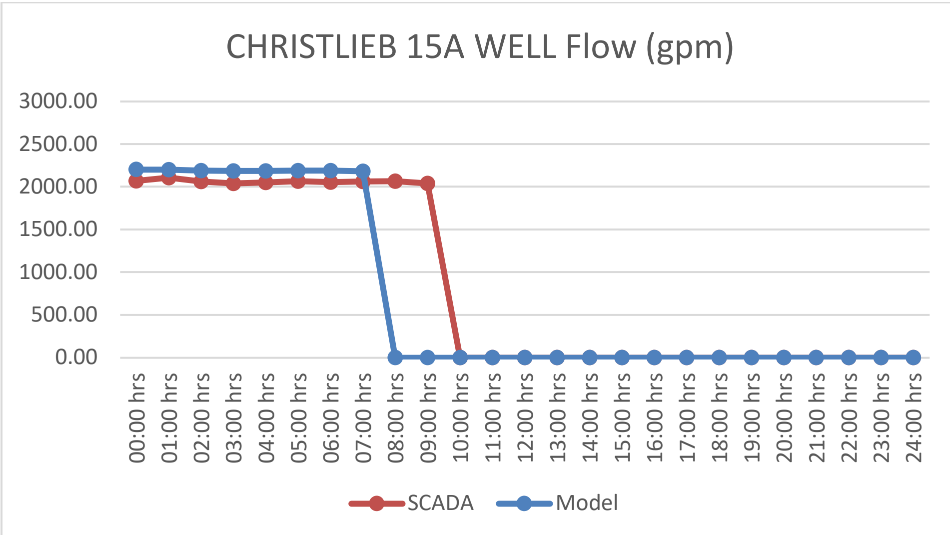


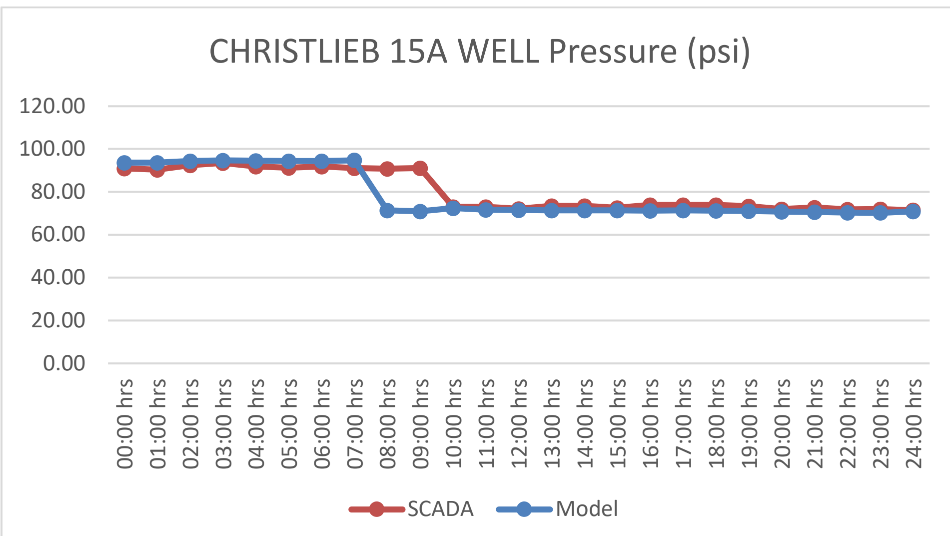
C.1.3 ZONE 1B EPS MODEL CALIBRATION VS SCADA CHARTS

Zone 1B Wells

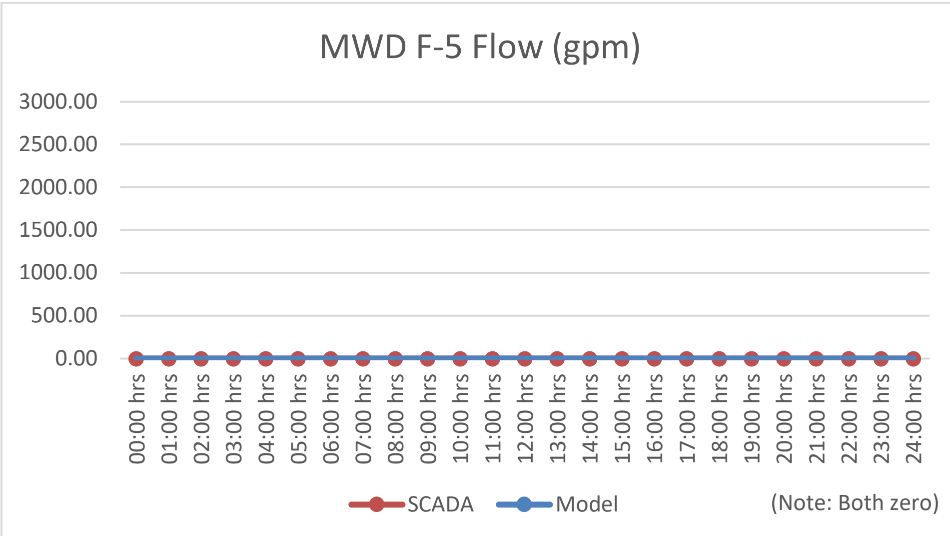


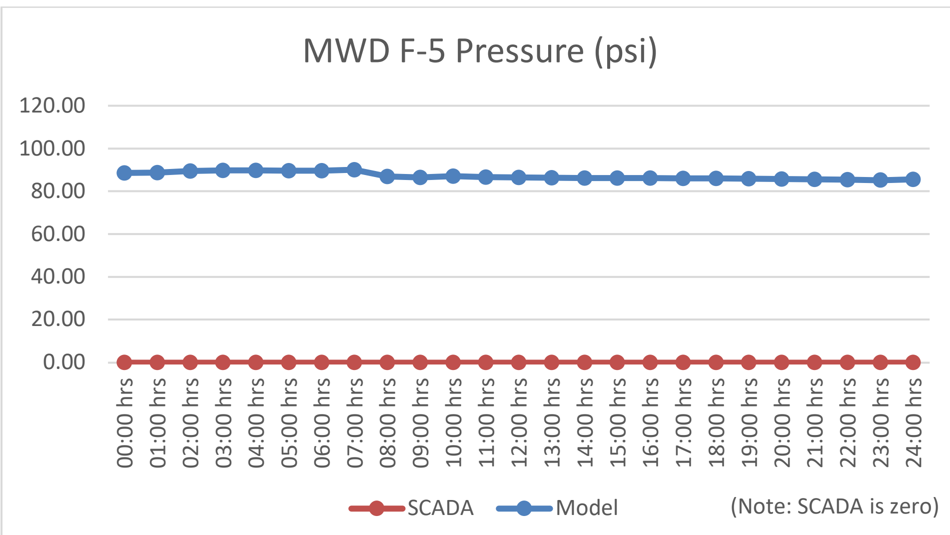



CHRISTLIEB 15A WELL Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

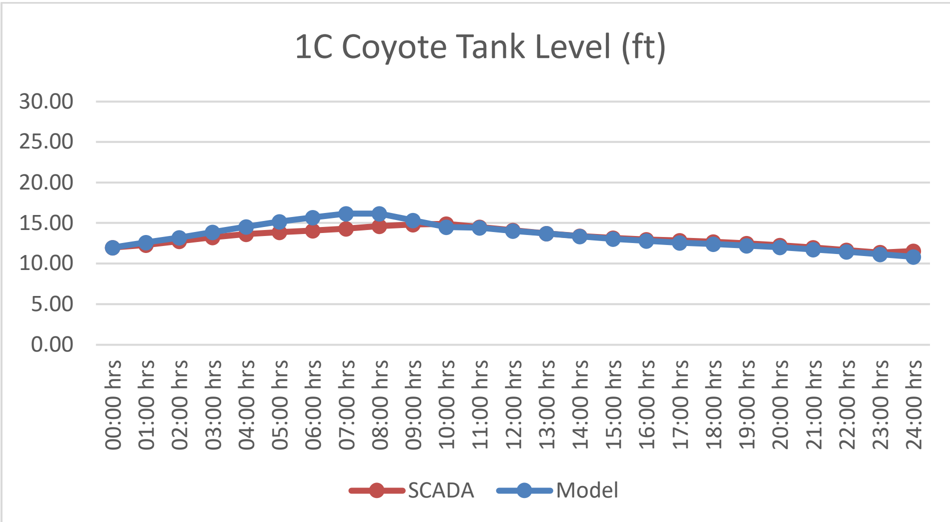

CHRISTLIEB 15A WELL Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

Zone 1B Import Turnouts



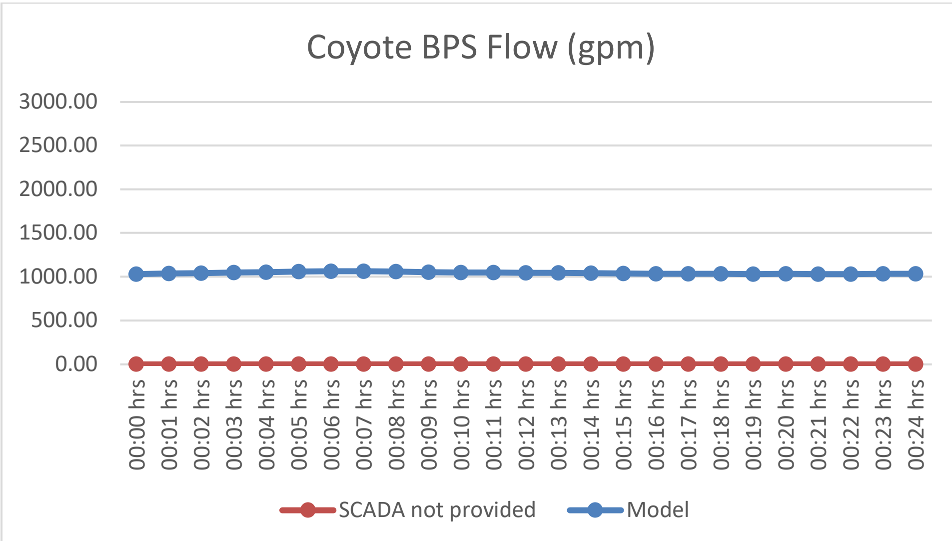


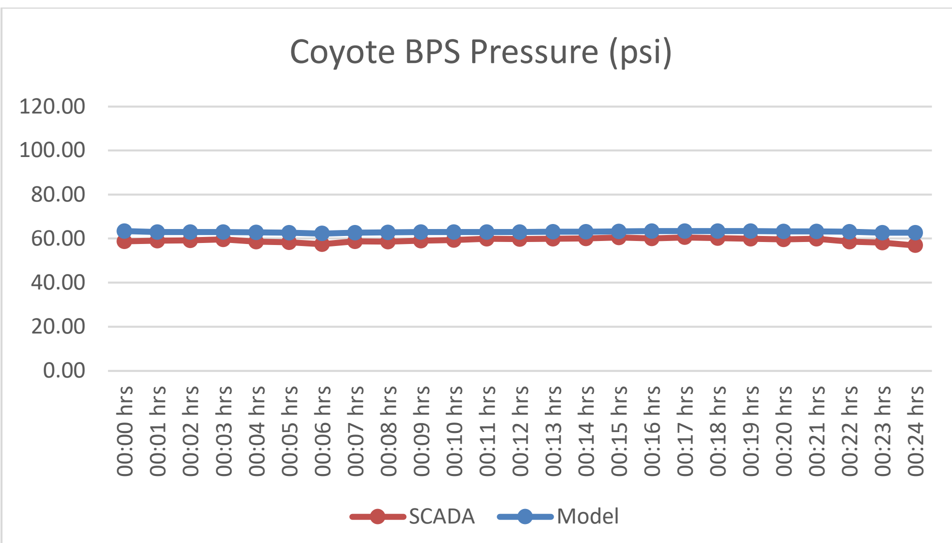
Zone 1B Reservoirs

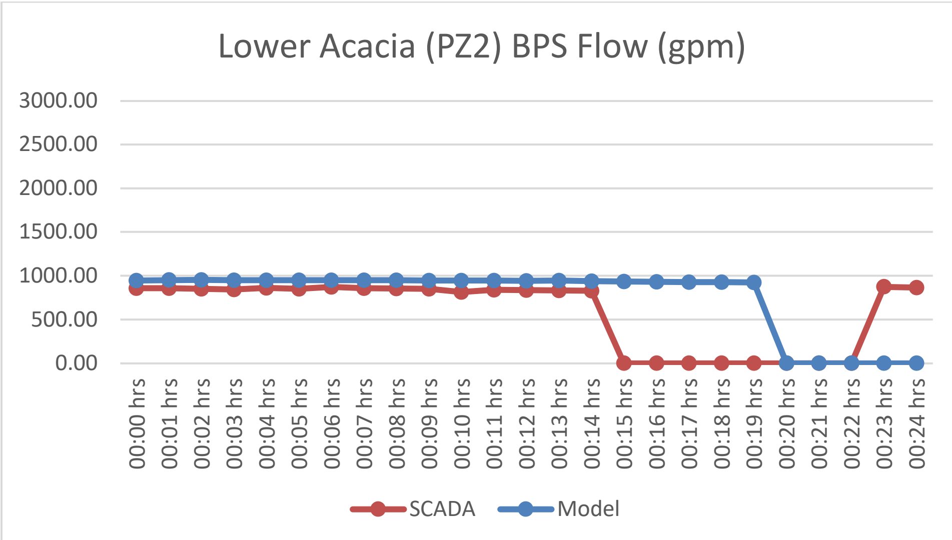


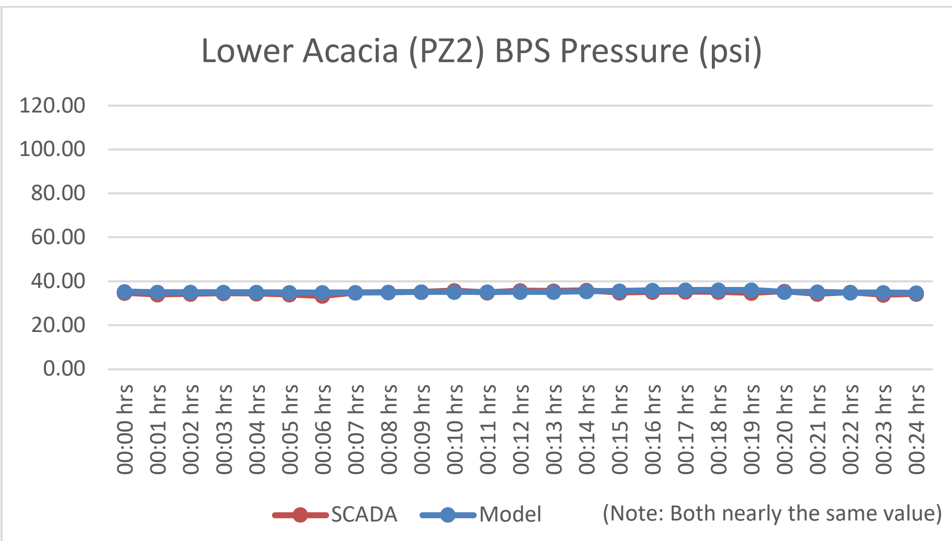
C.1.4 ZONE 2 EPS MODEL CALIBRATION VS SCADA CHARTS

Zone 2 Booster Pump Stations

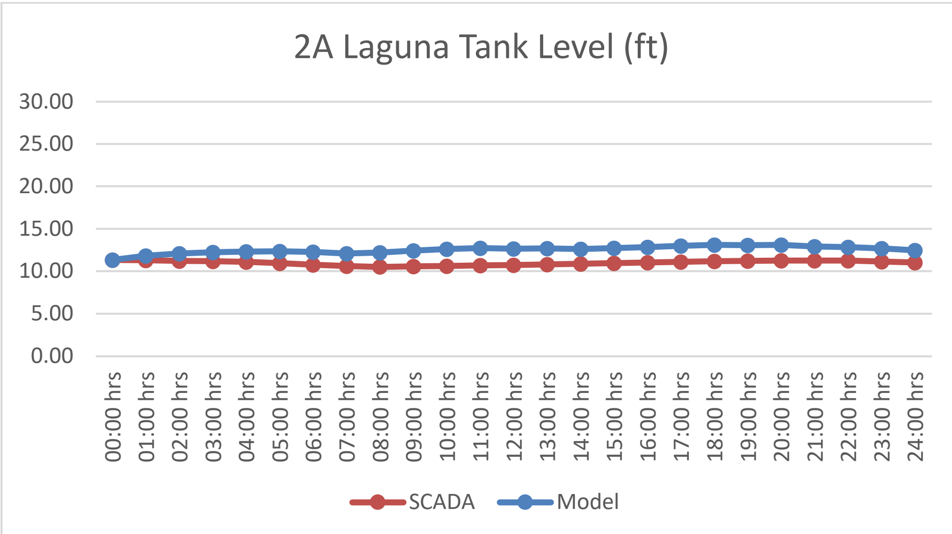


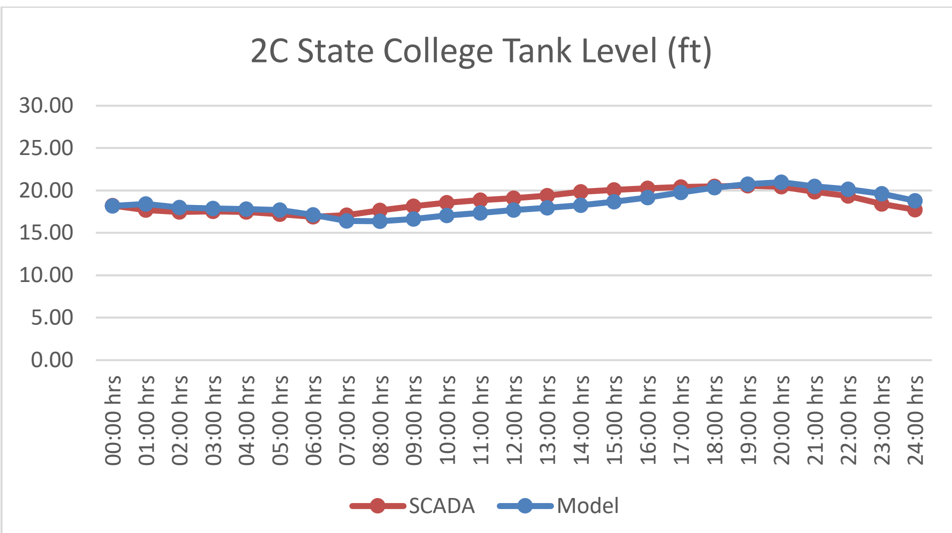


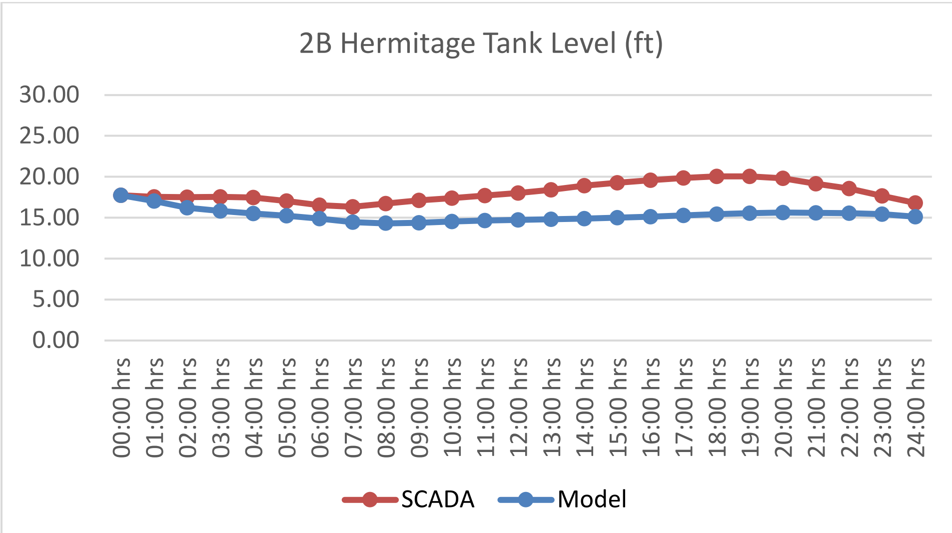

Lower Acacia (PZ2) BPS Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
00:01 hrs
00:02 hrs
00:03 hrs
00:04 hrs
00:05 hrs
00:06 hrs
00:07 hrs
00:08 hrs
00:09 hrs
00:10 hrs
00:11 hrs
00:12 hrs
00:13 hrs
00:14 hrs
00:15 hrs
00:16 hrs
00:17 hrs
00:18 hrs
00:19 hrs
00:20 hrs
00:21 hrs
00:22 hrs
00:23 hrs
00:24 hrs
SCADA
Model


Lower Acacia (PZ2) BPS Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
00:01 hrs
00:02 hrs
00:03 hrs
00:04 hrs
00:05 hrs
00:06 hrs
00:07 hrs
00:08 hrs
00:09 hrs
00:10 hrs
00:11 hrs
00:12 hrs
00:13 hrs
00:14 hrs
00:15 hrs
00:16 hrs
00:17 hrs
00:18 hrs
00:19 hrs
00:20 hrs
00:21 hrs
00:22 hrs
00:23 hrs
00:24 hrs
SCADA
Model
(Note: Both nearly the same value)

Zone 2 Reservoirs

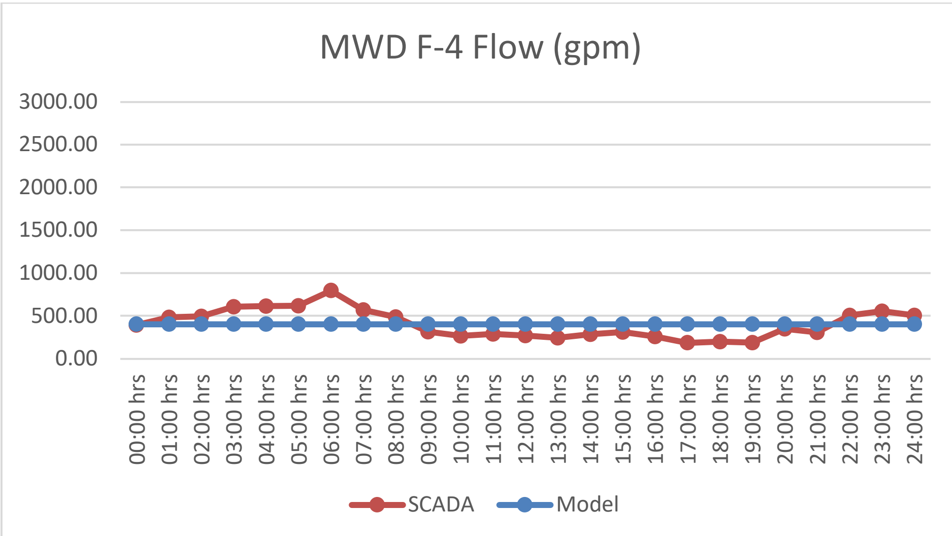


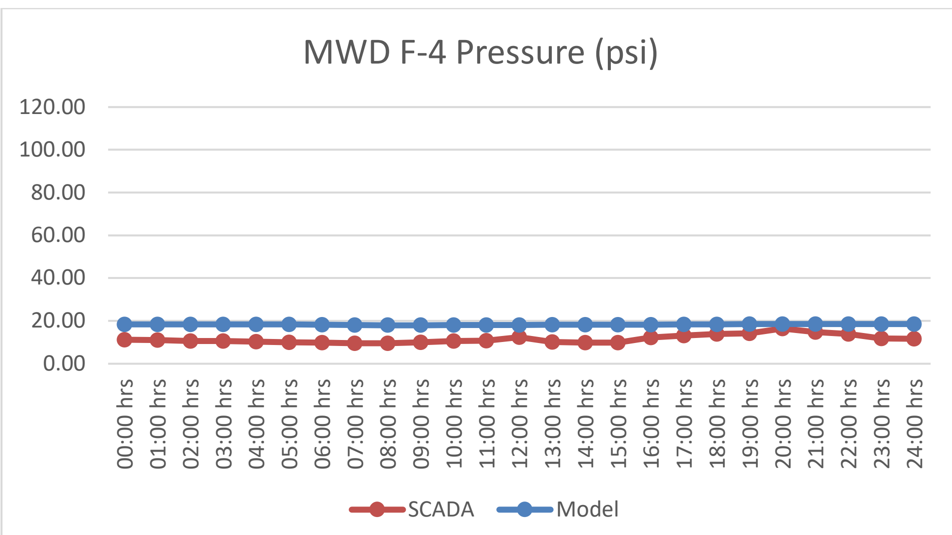


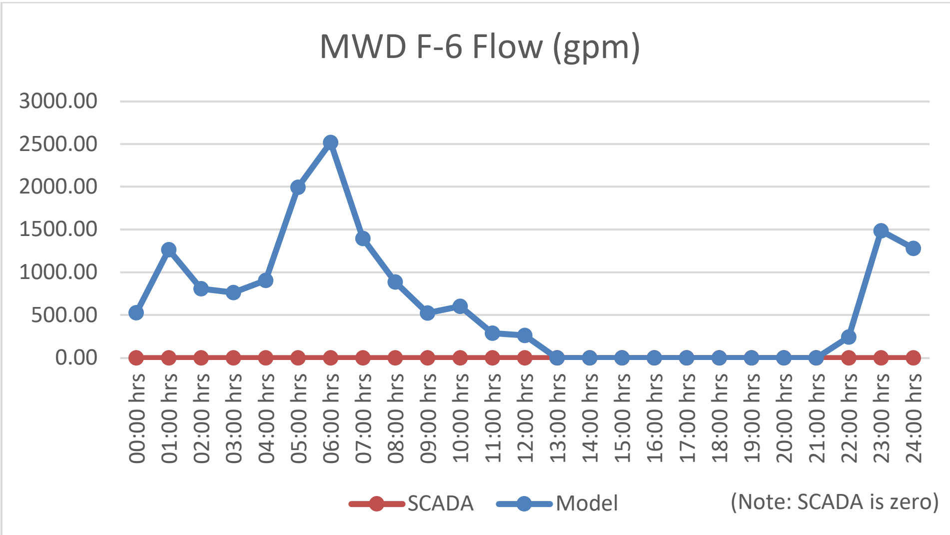

2B Hermitage Tank Level (ft)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

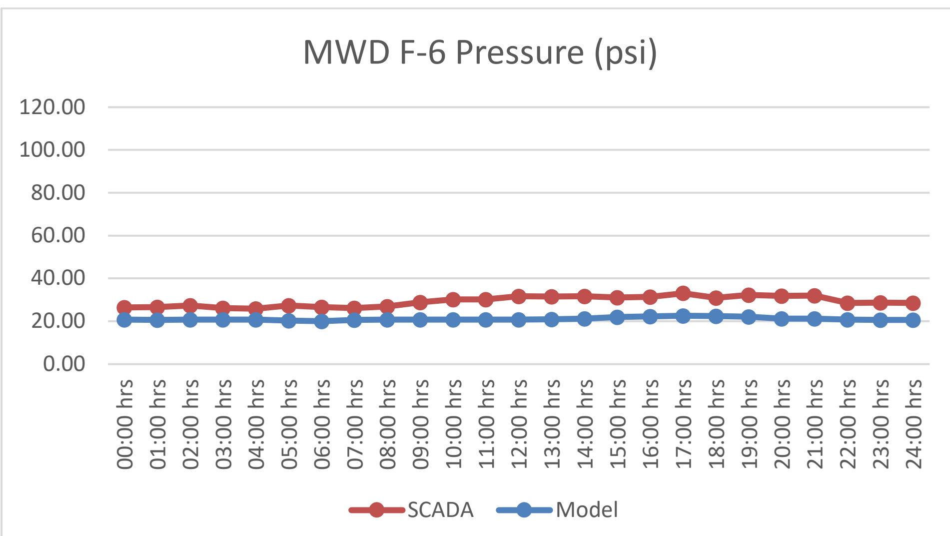
C.1.5 ZONE 3 EPS MODEL CALIBRATION VS SCADA CHARTS

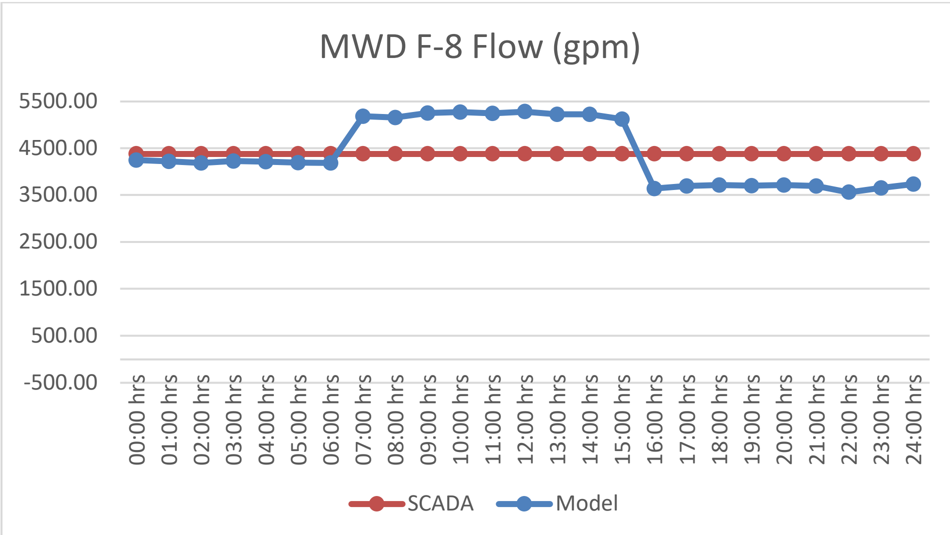
Zone 3 Import Turnouts

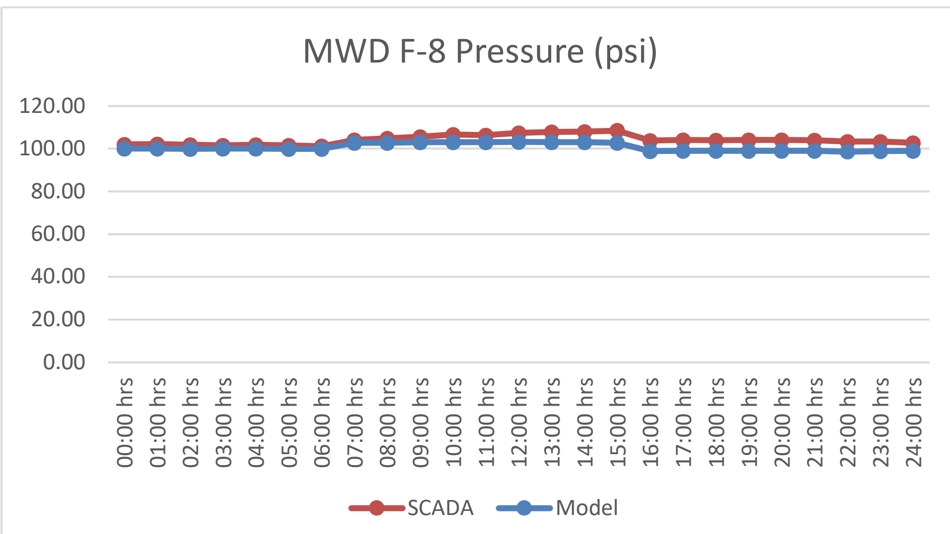


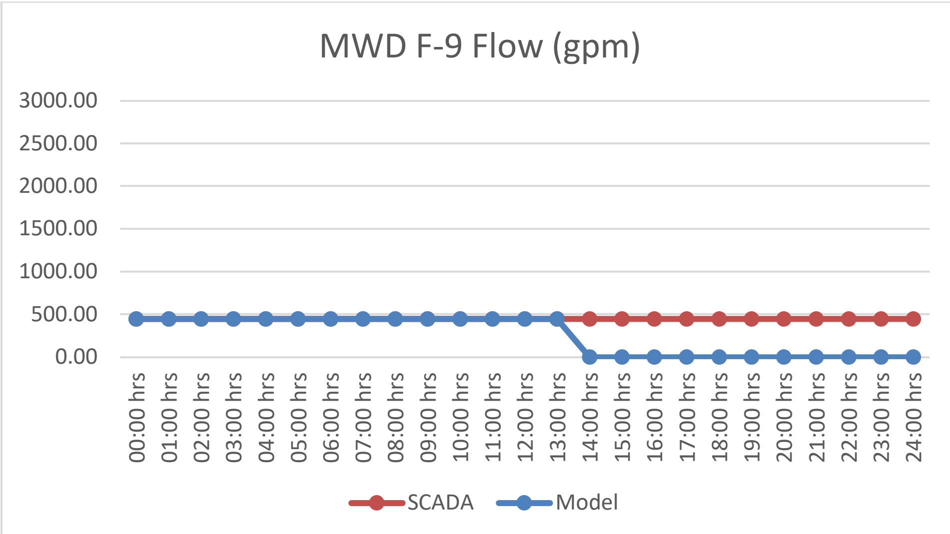


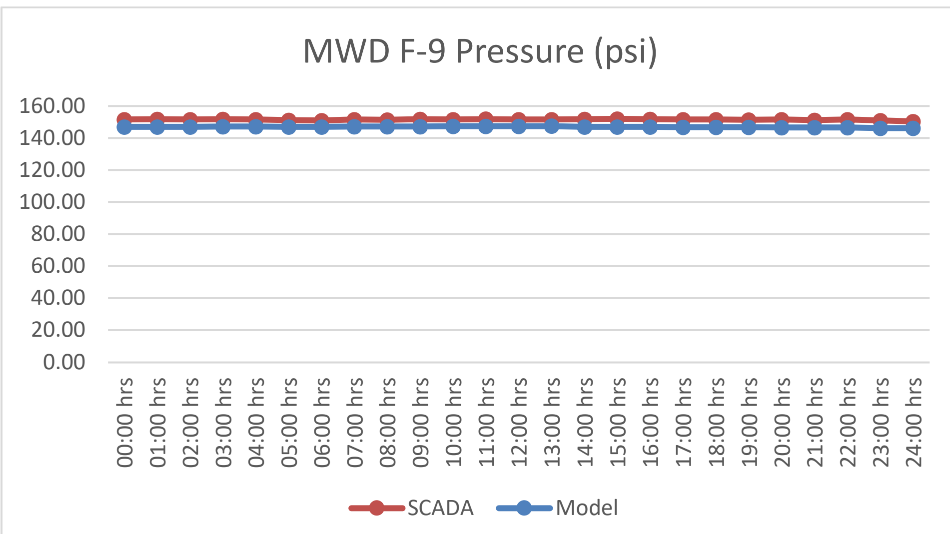

MWD F-6 Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model
(Note: SCADA is zero)


MWD F-6 Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

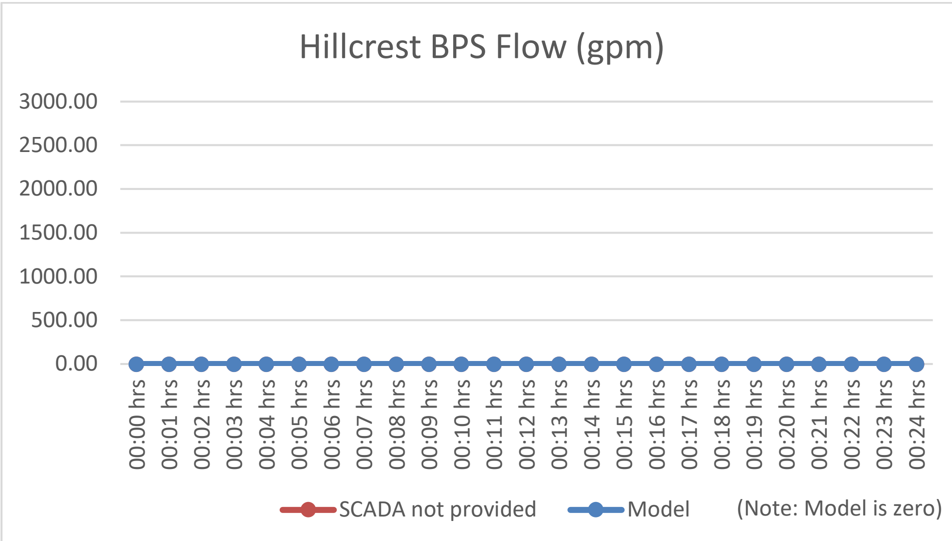

MWD F-8 Flow (gpm)
5500.00
4500.00
3500.00
2500.00
1500.00
500.00
-500.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

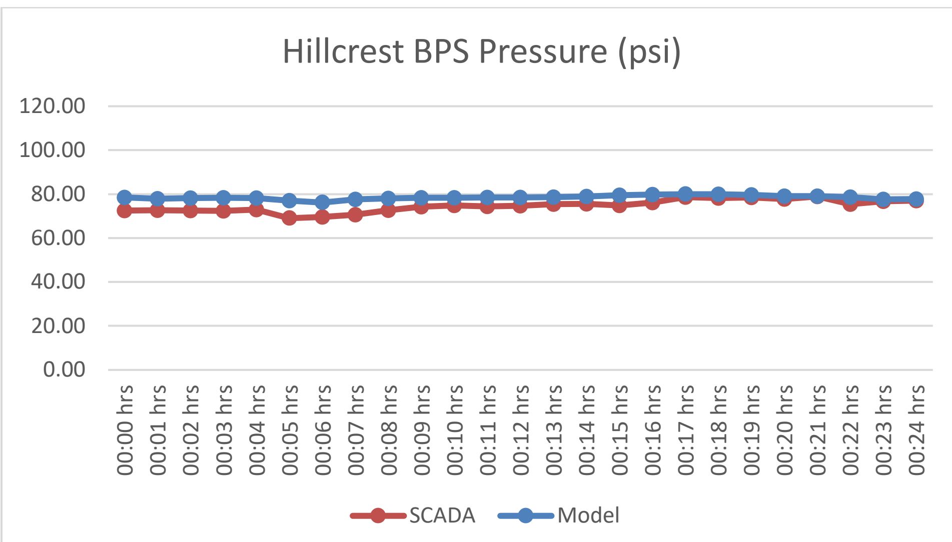

MWD F-8 Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

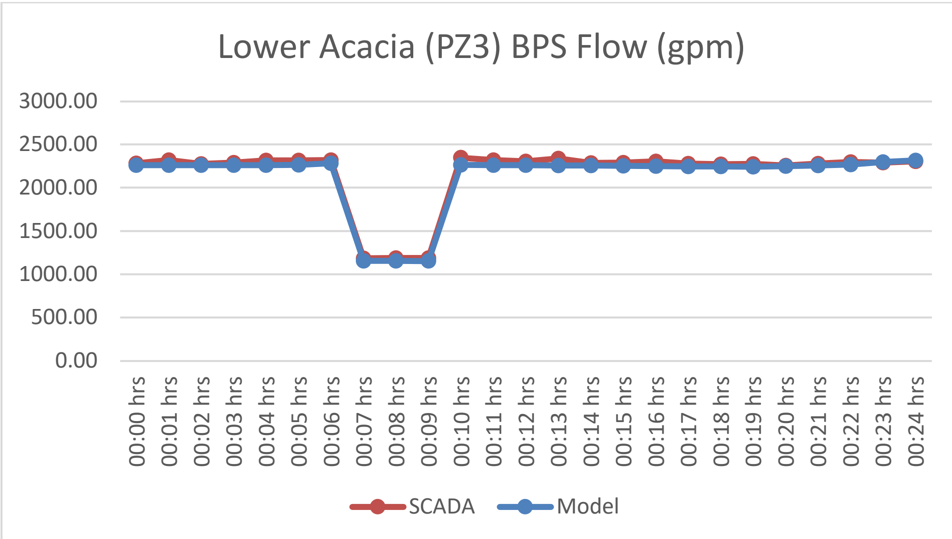

MWD F-9 Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model


MWD F-9 Pressure (psi)
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

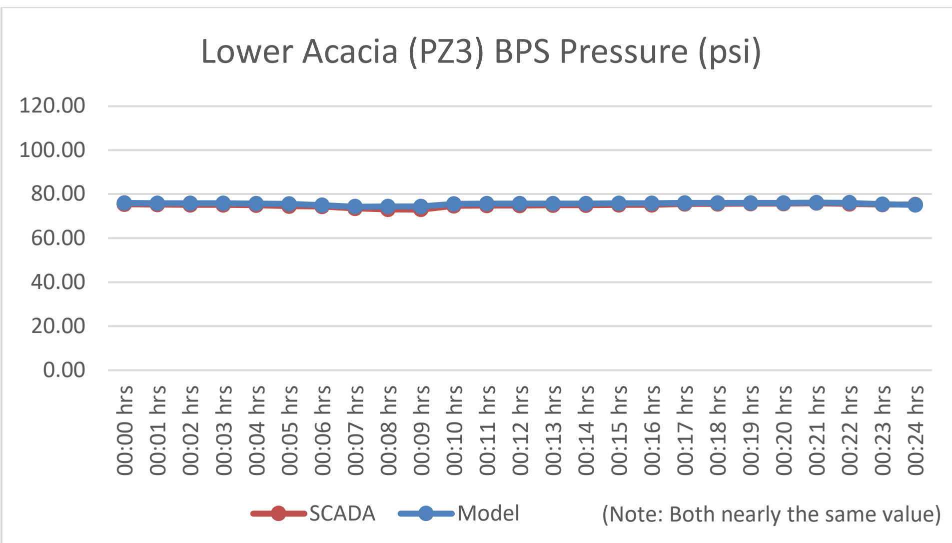
Zone 3 Booster Pump Stations



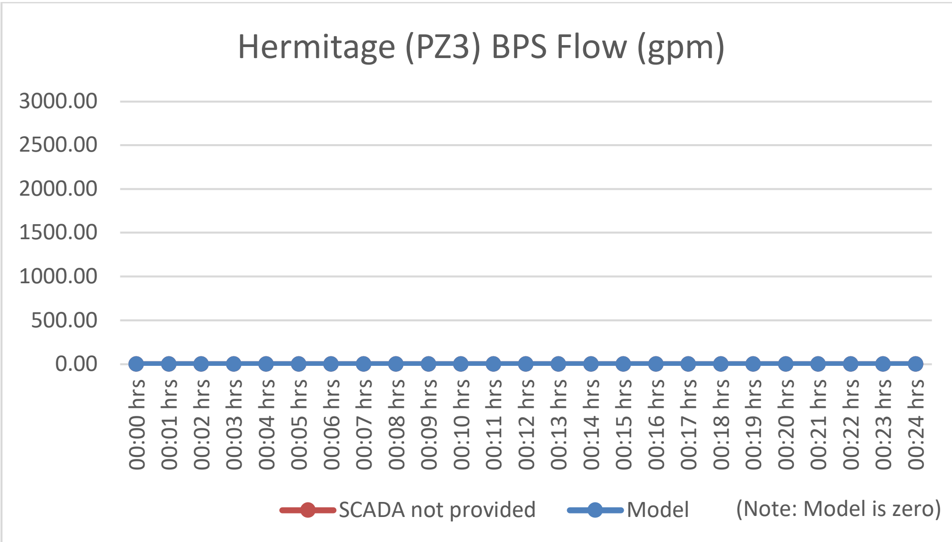


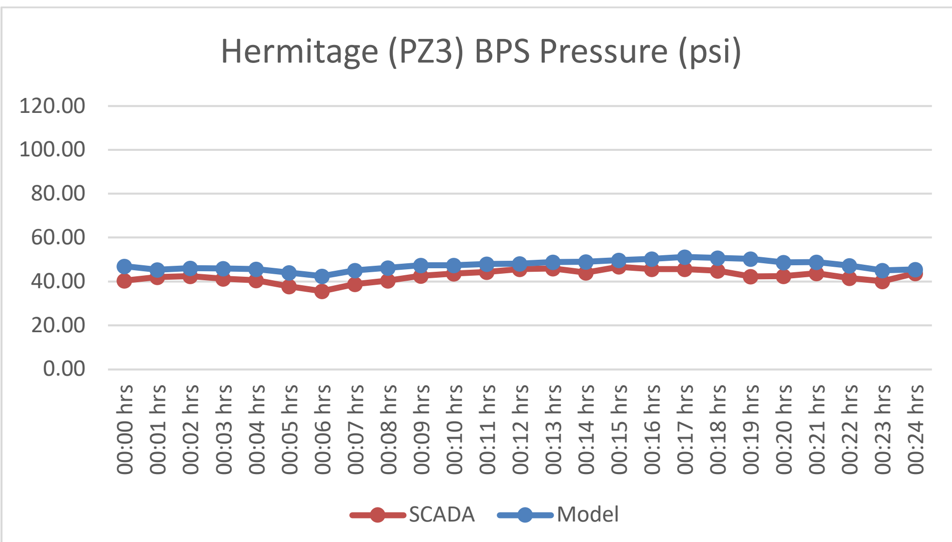


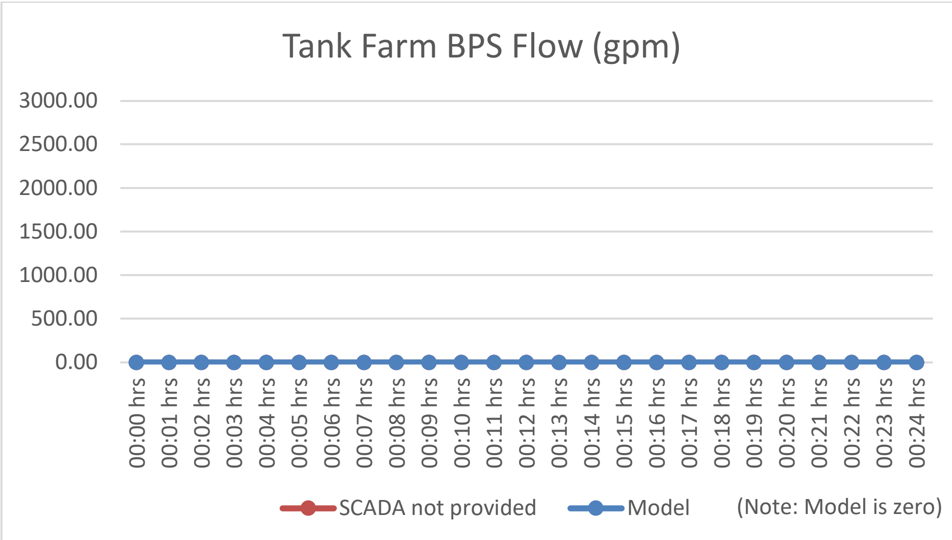
Lower Acacia (PZ3) BPS Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
00:01 hrs
00:02 hrs
00:03 hrs
00:04 hrs
00:05 hrs
00:06 hrs
00:07 hrs
00:08 hrs
00:09 hrs
00:10 hrs
00:11 hrs
00:12 hrs
00:13 hrs
00:14 hrs
00:15 hrs
00:16 hrs
00:17 hrs
00:18 hrs
00:19 hrs
00:20 hrs
00:21 hrs
00:22 hrs
00:23 hrs
00:24 hrs
SCADA
Model

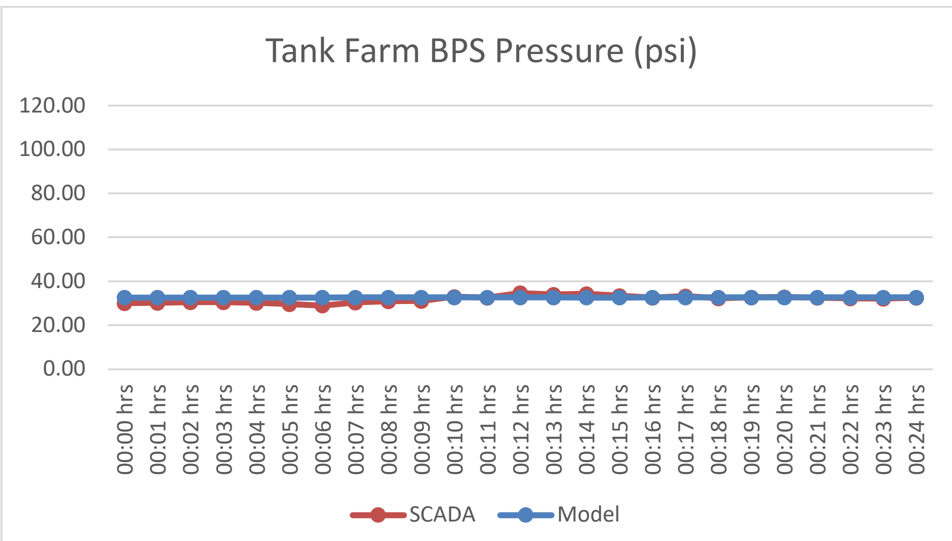


Lower Acacia (PZ3) BPS Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
00:01 hrs
00:02 hrs
00:03 hrs
00:04 hrs
00:05 hrs
00:06 hrs
00:07 hrs
00:08 hrs
00:09 hrs
00:10 hrs
00:11 hrs
00:12 hrs
00:13 hrs
00:14 hrs
00:15 hrs
00:16 hrs
00:17 hrs
00:18 hrs
00:19 hrs
00:20 hrs
00:21 hrs
00:22 hrs
00:23 hrs
00:24 hrs
SCADA
Model
(Note: Both nearly the same value)

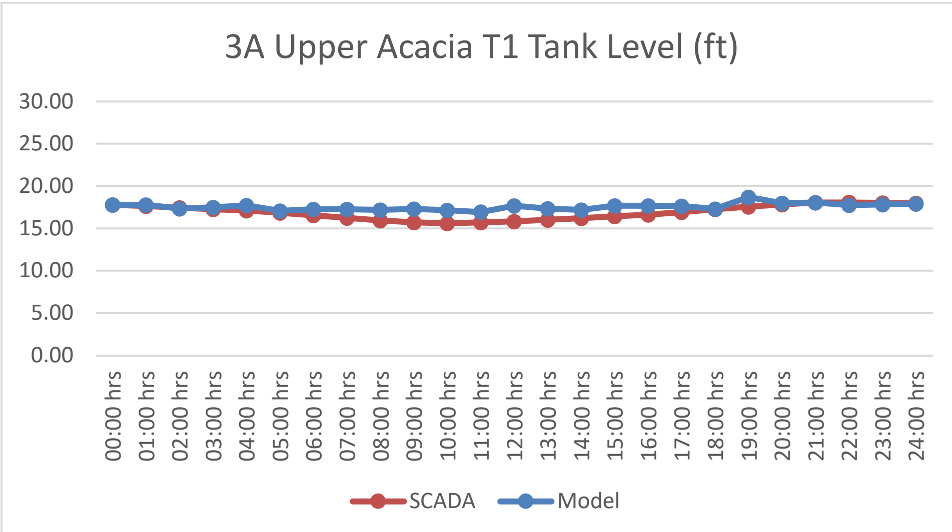

Hermitage (PZ3) BPS Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
00:01 hrs
00:02 hrs
00:03 hrs
00:04 hrs
00:05 hrs
00:06 hrs
00:07 hrs
00:08 hrs
00:09 hrs
00:10 hrs
00:11 hrs
00:12 hrs
00:13 hrs
00:14 hrs
00:15 hrs
00:16 hrs
00:17 hrs
00:18 hrs
00:19 hrs
00:20 hrs
00:21 hrs
00:22 hrs
00:23 hrs
00:24 hrs
SCADA not provided
Model
(Note: Model is zero)

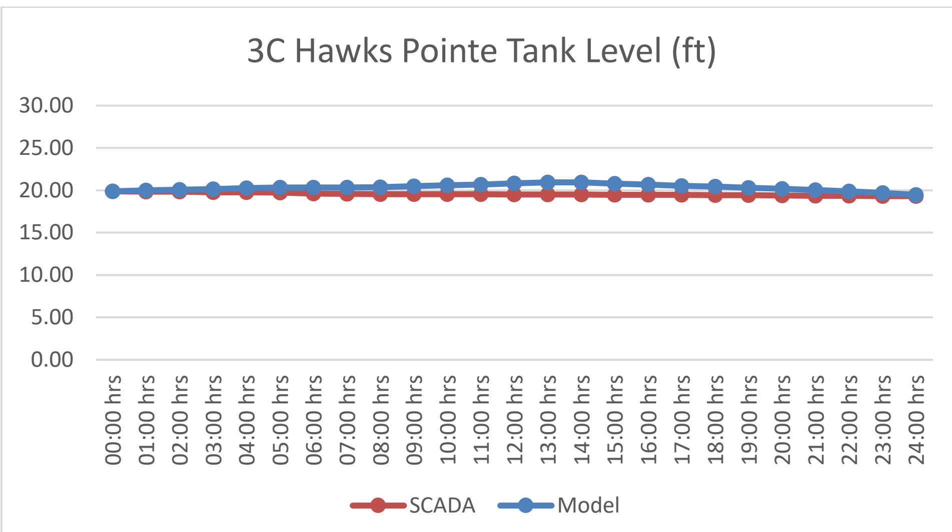

Hermitage (PZ3) BPS Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
00:01 hrs
00:02 hrs
00:03 hrs
00:04 hrs
00:05 hrs
00:06 hrs
00:07 hrs
00:08 hrs
00:09 hrs
00:10 hrs
00:11 hrs
00:12 hrs
00:13 hrs
00:14 hrs
00:15 hrs
00:16 hrs
00:17 hrs
00:18 hrs
00:19 hrs
00:20 hrs
00:21 hrs
00:22 hrs
00:23 hrs
00:24 hrs
SCADA
Model

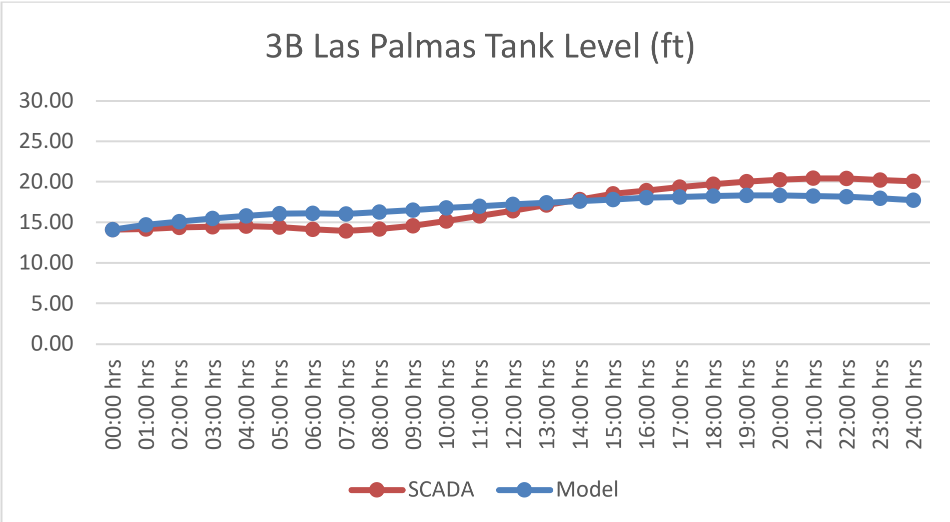

Tank Farm BPS Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
00:01 hrs
00:02 hrs
00:03 hrs
00:04 hrs
00:05 hrs
00:06 hrs
00:07 hrs
00:08 hrs
00:09 hrs
00:10 hrs
00:11 hrs
00:12 hrs
00:13 hrs
00:14 hrs
00:15 hrs
00:16 hrs
00:17 hrs
00:18 hrs
00:19 hrs
00:20 hrs
00:21 hrs
00:22 hrs
00:23 hrs
00:24 hrs
SCADA not provided
Model
(Note: Model is zero)

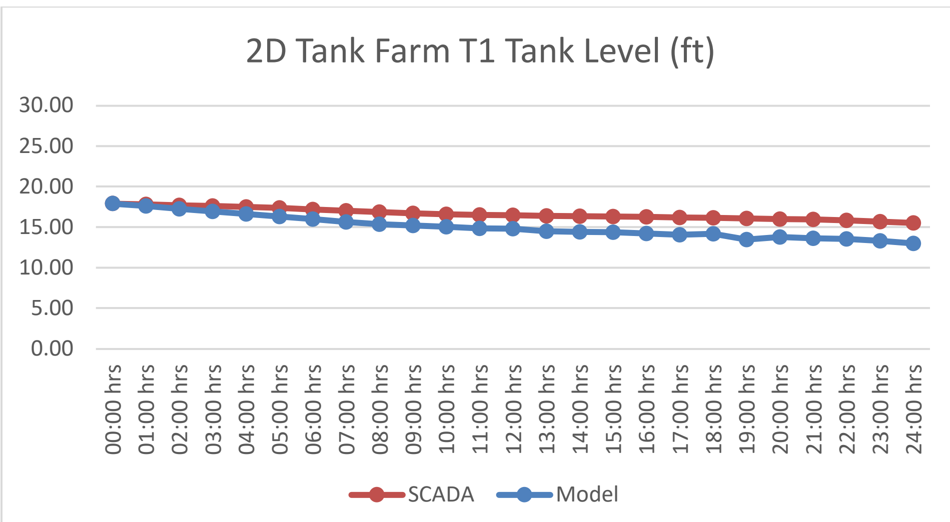

Tank Farm BPS Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
00:01 hrs
00:02 hrs
00:03 hrs
00:04 hrs
00:05 hrs
00:06 hrs
00:07 hrs
00:08 hrs
00:09 hrs
00:10 hrs
00:11 hrs
00:12 hrs
00:13 hrs
00:14 hrs
00:15 hrs
00:16 hrs
00:17 hrs
00:18 hrs
00:19 hrs
00:20 hrs
00:21 hrs
00:22 hrs
00:23 hrs
00:24 hrs
SCADA
Model

Zone 3 Reservoirs



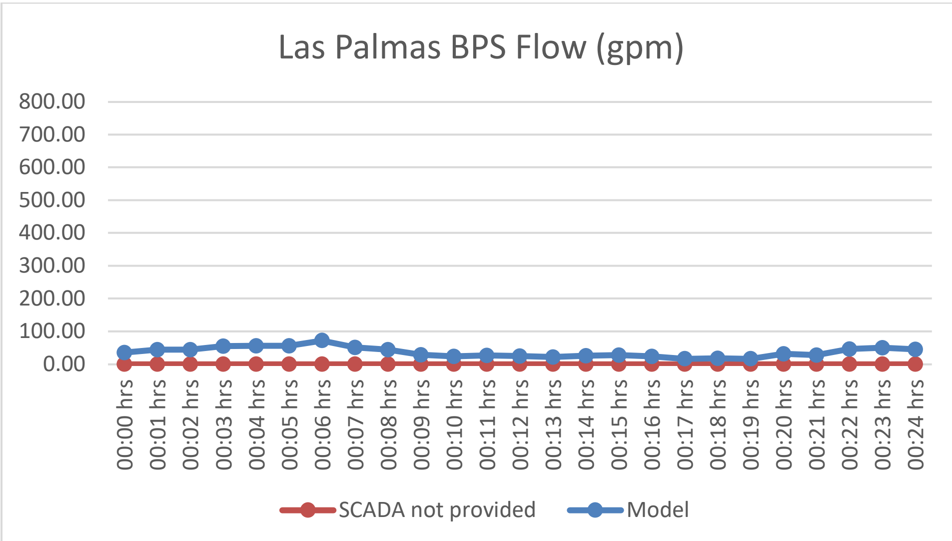


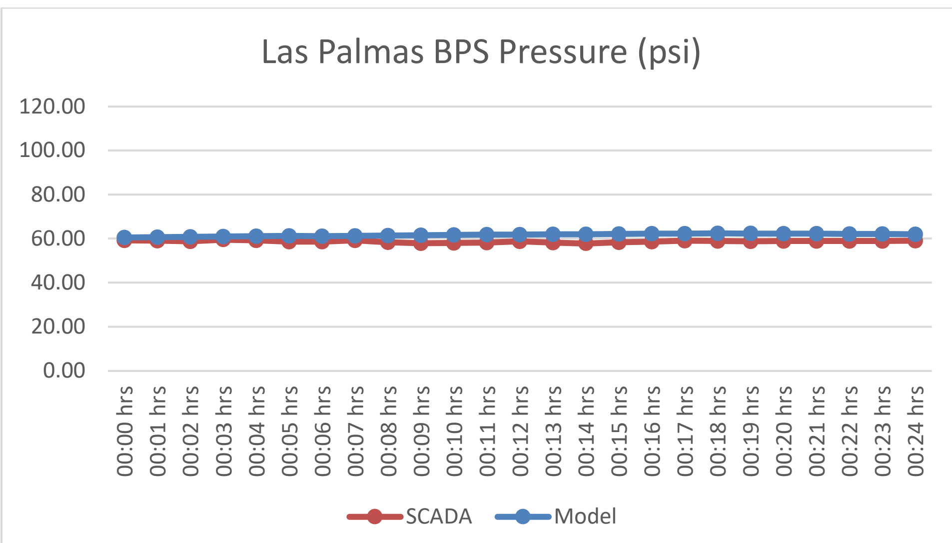

3B Las Palmas Tank Level (ft)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model


2D Tank Farm T1 Tank Level (ft)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

C.1.6 ZONE 4 EPS MODEL CALIBRATION VS SCADA CHARTS

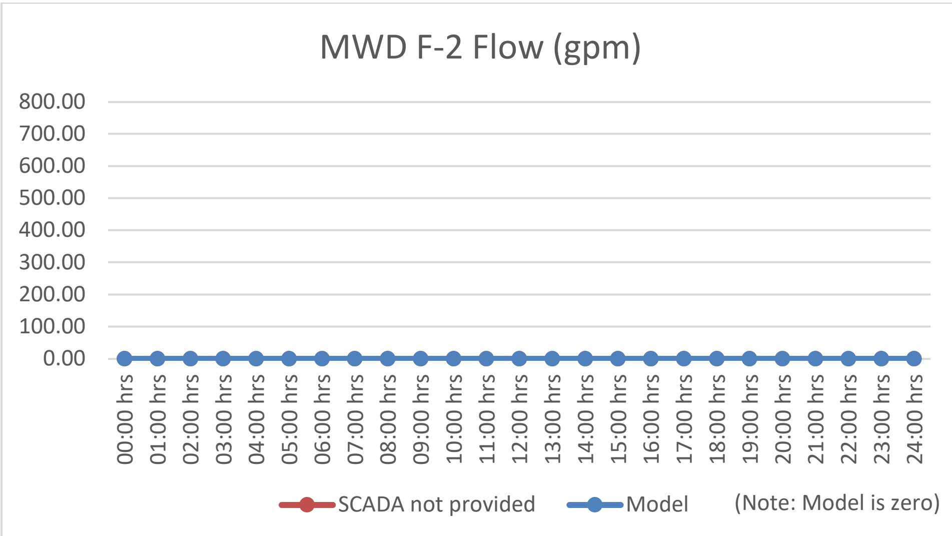
Zone 4 Booster Pump Stations

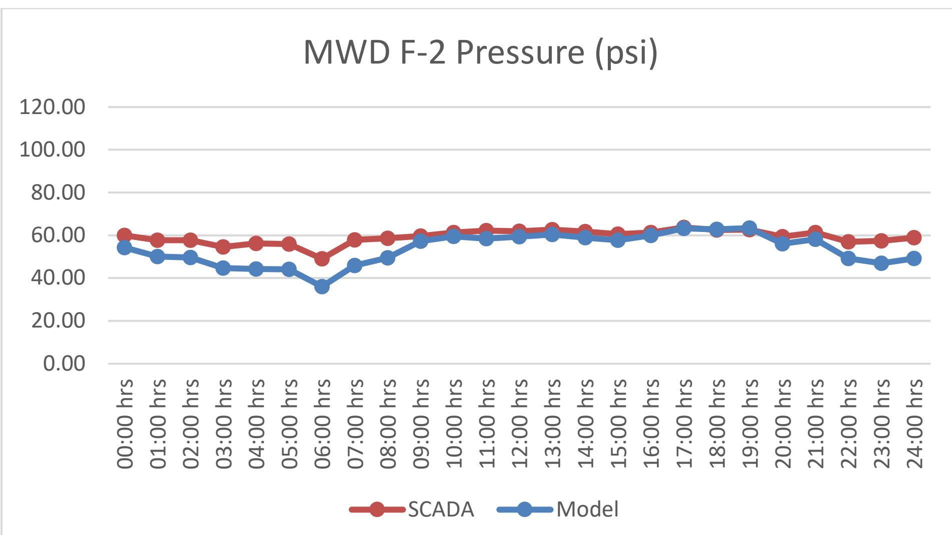




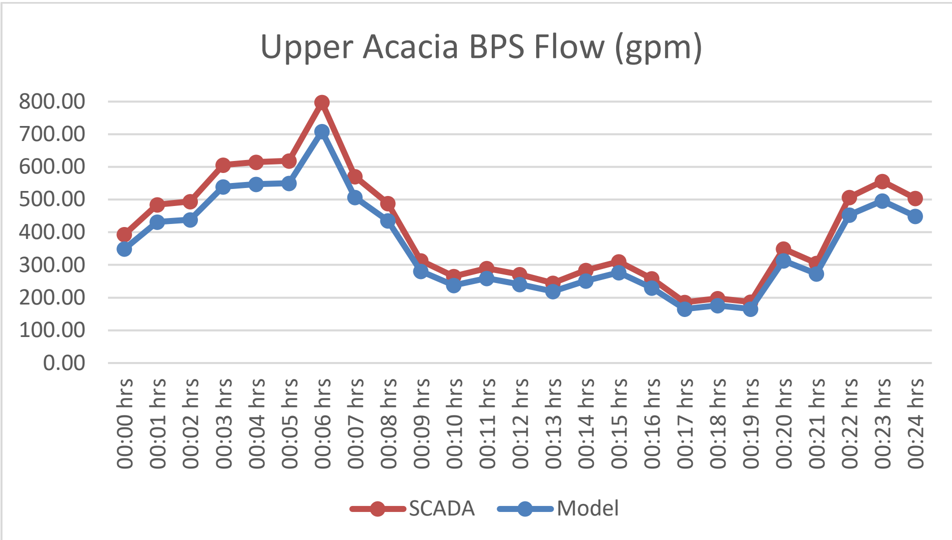
C.1.7 ZONE 4A EPS MODEL CALIBRATION VS SCADA CHARTS

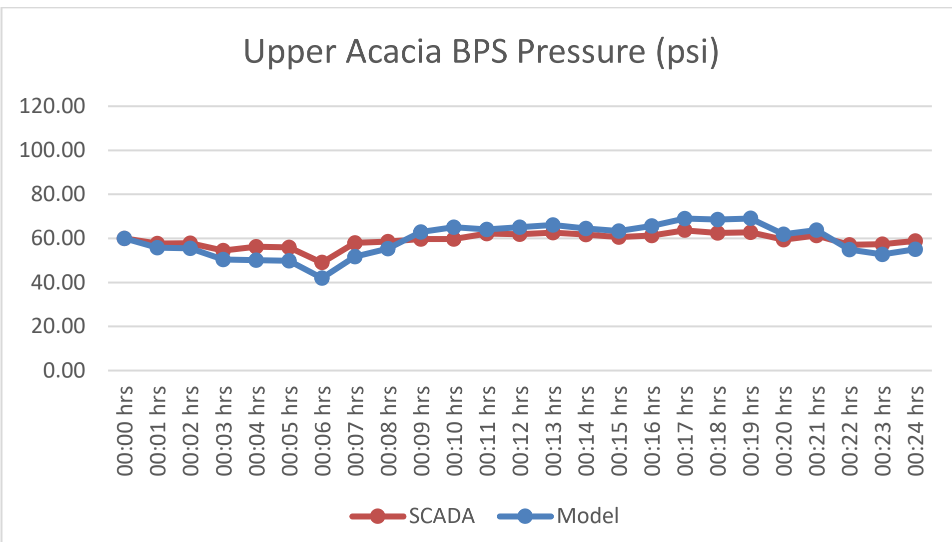
Zone 4A Import Turnouts





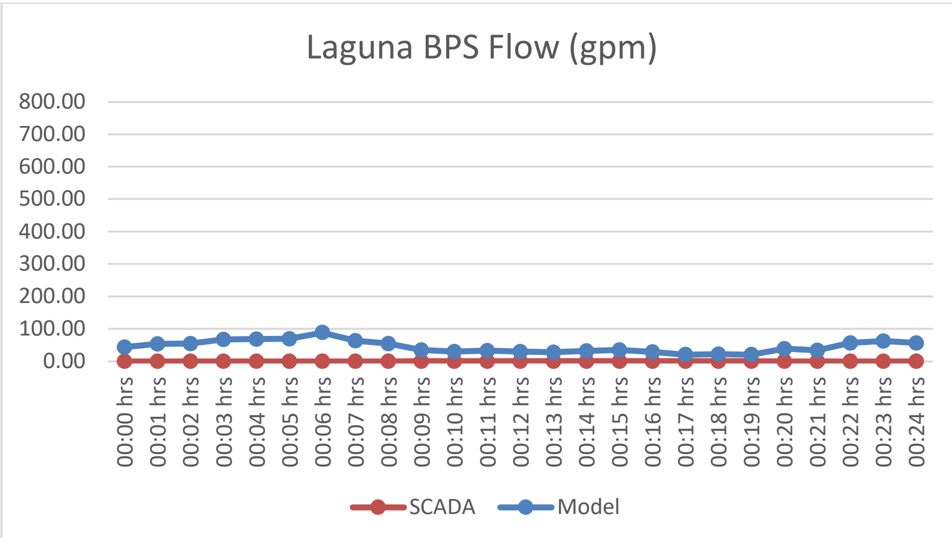
Zone 4A Booster Pump Stations

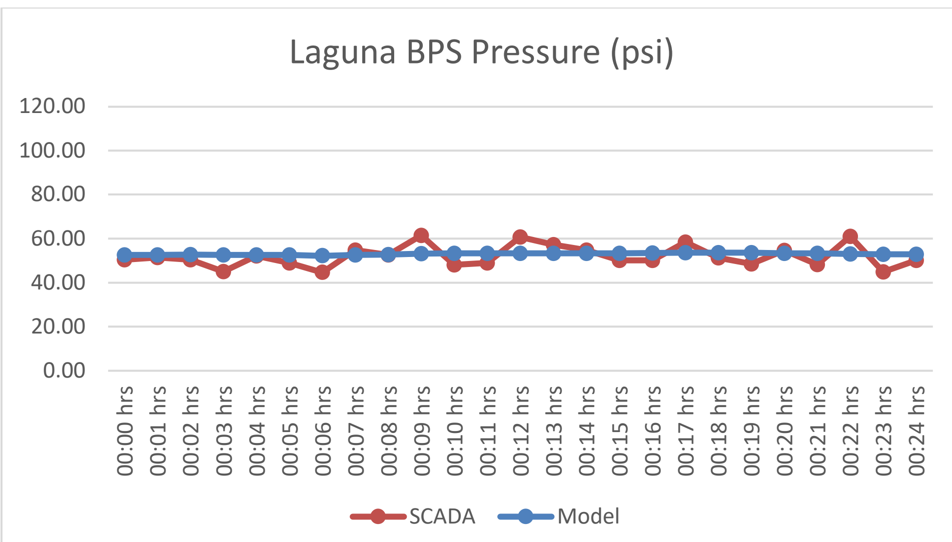




C.1.8 ZONE 4B EPS MODEL CALIBRATION VS SCADA CHARTS

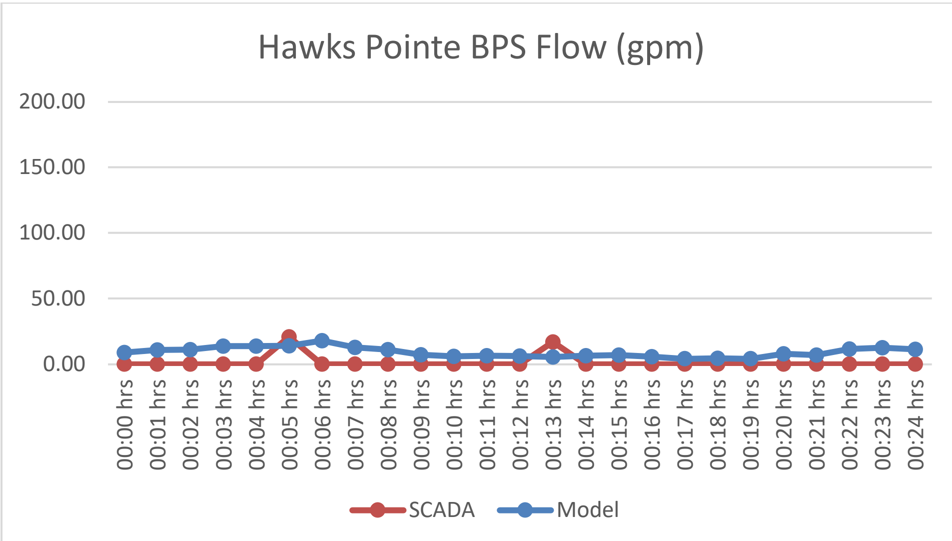
Zone 4B Booster Pump Stations

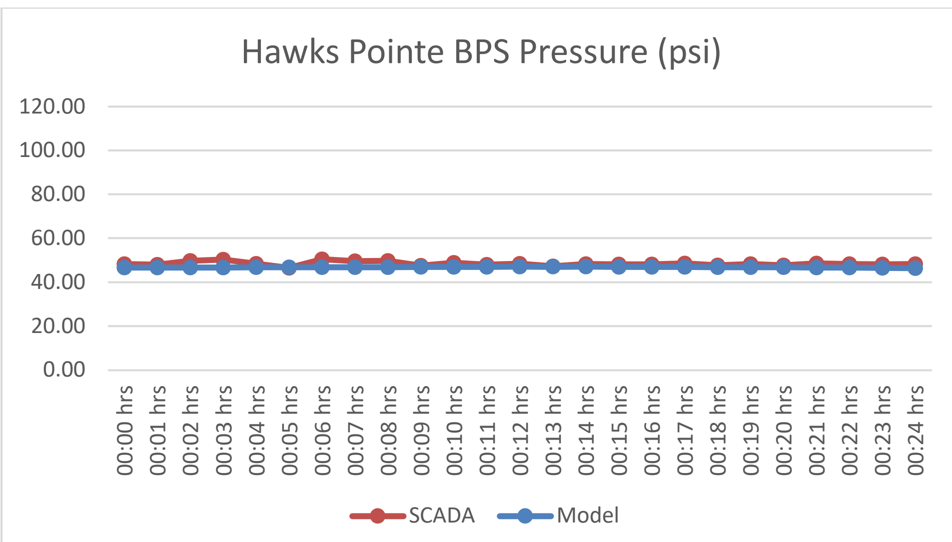




C.1.9 ZONE 4C WEST EPS MODEL CALIBRATION VS SCADA CHARTS

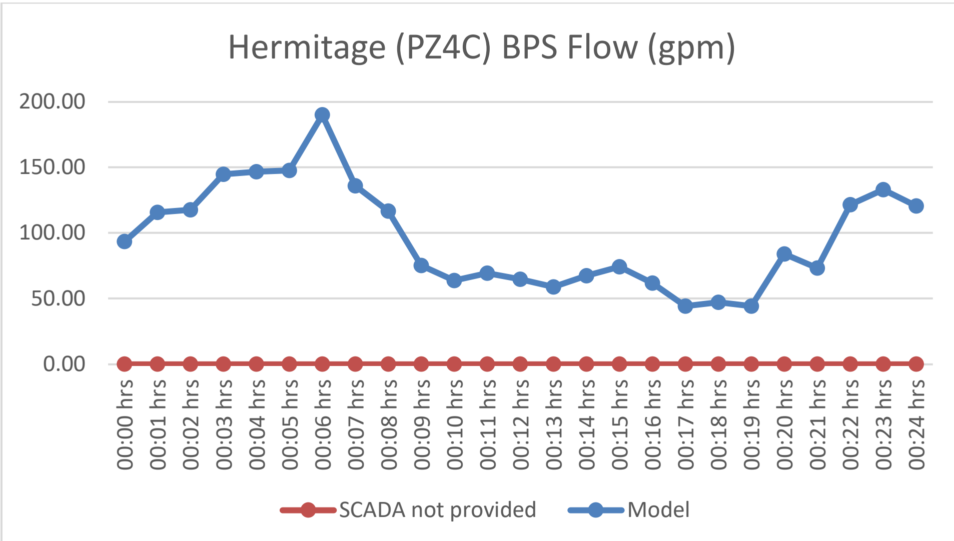
Zone 4C West Booster Pump Stations

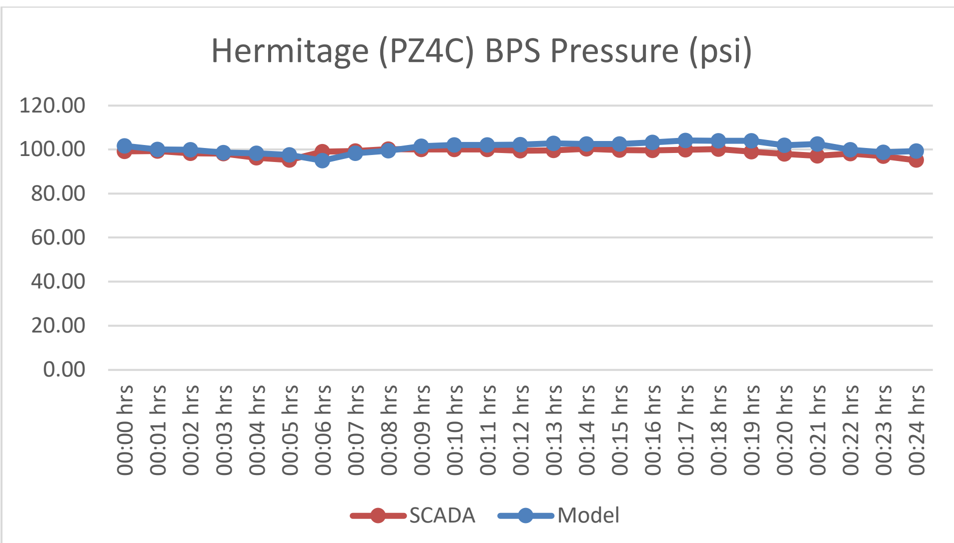




C.1.10 ZONE 4C EAST EPS MODEL CALIBRATION VS SCADA CHARTS

Zone 4C East Booster Pump Stations





C.2 List of Facilities with SCADA

Table C.2-1. List of Facilities with SCADA

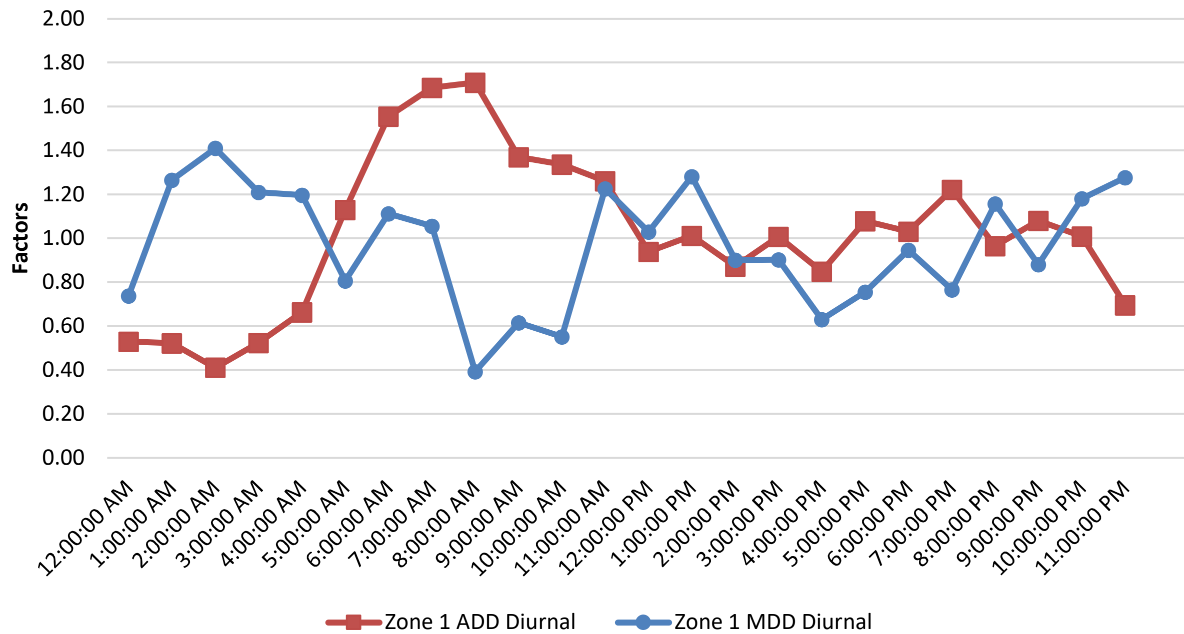
Site Name	Facility	Monitoring Capability
Airport	Well 9	Flowrate Discharge Pressure Pump Run Status Bypass Valve Status Valve Status
Christlieb	Well 15A	Flowrate Discharge Pressure Pump Run Status Bypass Valve Status
Kimberly 1	Well 1A	Flowrate Discharge Pressure Pump Run Status Bypass Valve Status Valve Status
Kimberly 2	Well 2, PS K2F-1A, & Kimberly Forebay	Flowrate Discharge Pressure Forebay Level Pump Run Status Valve Status
Main Plant[(a)]	Wells 3A, 4, 5, 6, 7, & 8	Flowrate
	PS MPF-1 & Main Plant Forebay	Discharge Pressure Forebay Level Pump Run Status Valve Status
Sunclipse	Well 10	Flowrate Discharge Pressure Pump Run Status Valve Status
F-02 & F-04	MWD Connection	Flowrate Discharge Pressure Upstream Pressure Valve Status
F-05	MWD Connection	Flowrate Discharge Pressure Upstream Pressure Valve Status
F-06	MWD Connection	Flowrate Discharge Pressure Upstream Pressure Valve Status
F-08	MWD Connection	Flowrate Discharge Pressure Upstream Pressure Valve Status
F-09	MWD Connection	Flowrate Discharge Pressure Upstream Pressure Valve Status

Site Name	Facility	Monitoring Capability
Coyote[(b)]	PS 1C-2, Reservoir 1C, & Well 12A[(c)]	Discharge Pressure Reservoir Level Pump Run Status Valve Status
Hawks Pointe[(b)]	PS 3C-4C & Reservoir 3C	Discharge Pressure Reservoir Level Pump Run Status Valve Status
Hermitage[(b)]	PS 2B-3, PS 2B-4C, & Reservoir 2B	Discharge Pressure Reservoir Level Bypass Flowrate Pump Run Status Valve Status
Hillcrest[(b)]	PS 1A-3 & Reservoir 1A	Discharge Pressure Reservoir Level Pump Run Status Valve Status
Las Palmas[(b)]	PS 3B-4 & Reservoir 3B	Discharge Pressure Reservoir Level Pump Run Status Valve Status
Lower Acacia	PS 1D-2, PS 1D-3, & Reservoir 1D	Flowrate Discharge Pressure Reservoir Level Pump Run Status Valve Status
Laguna[(b)]	PS 2A-4B & Reservoir 2A	Discharge Pressure Reservoir Level Pump Run Status Valve Status
State College[(b)]	PS 2C-3 & Reservoir 2C	Discharge Pressure Reservoir Level Pump Run Status Valve Status
Tank Farm[(b)]	PS 2D-3 & Tank Farm T1-T5	Discharge Pressure Reservoir Level Pump Run Status Valve Status Valve Percent Open
Upper Acacia	PS 3A-4A, Reservoir 3A Repeater Station	Flowrate Discharge Pressure Reservoir Level Pump Run Status Valve Status

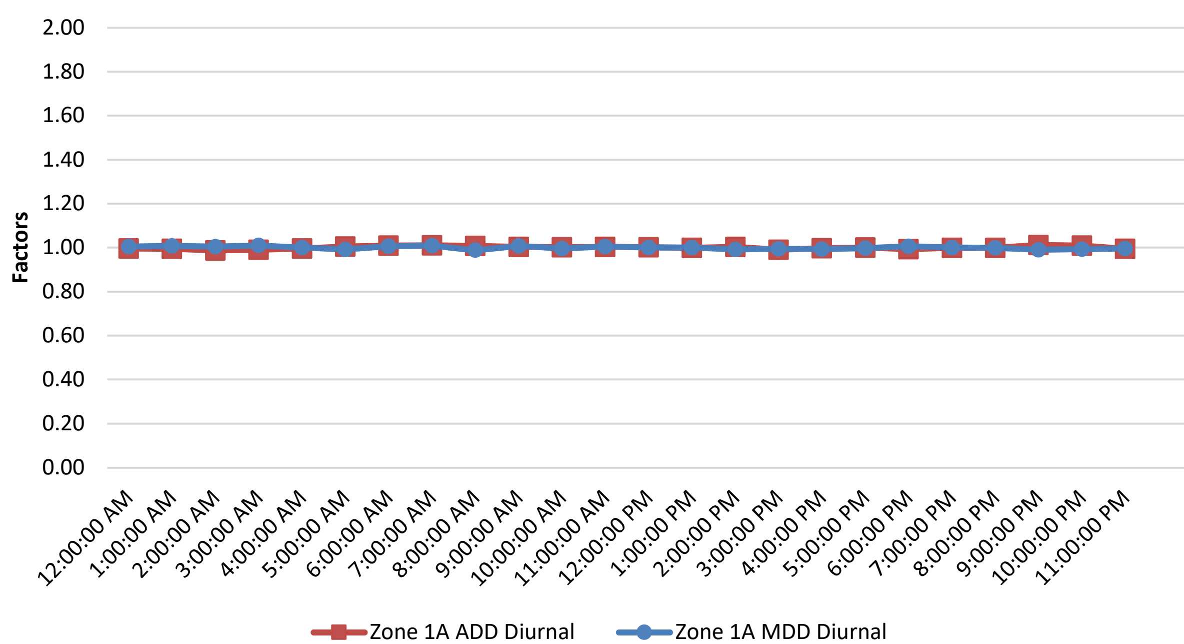
(a) Main Plant BPS does not have a flow meter but is capable of being monitored and connected to SCADA.
(b) Coyote BPS, Hawks Pointe BPS, Hermitage BPS, Hillcrest BPS, Las Palmas BPS, Laguna BPS, State College BPS, and Tank Farm BPS have a flow meter but are not connected to SCADA.
(c) Well 12A has been abandoned and has no SCADA monitoring capabilities.

C.3 Diurnal Patterns

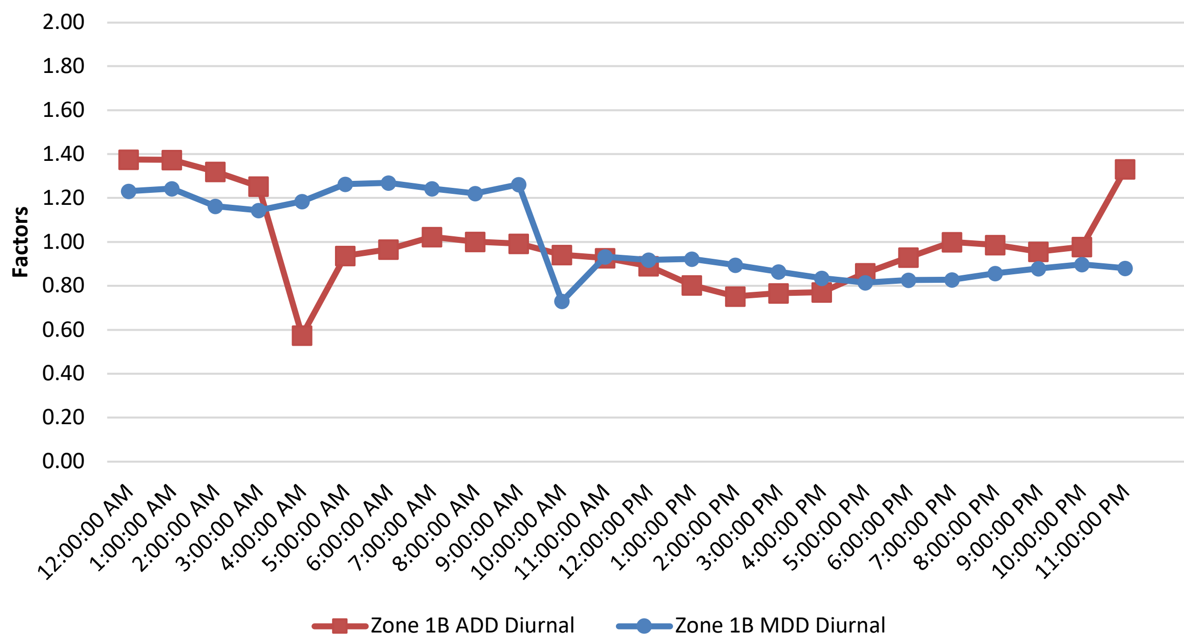
Zone 1 Diurnal Pattern



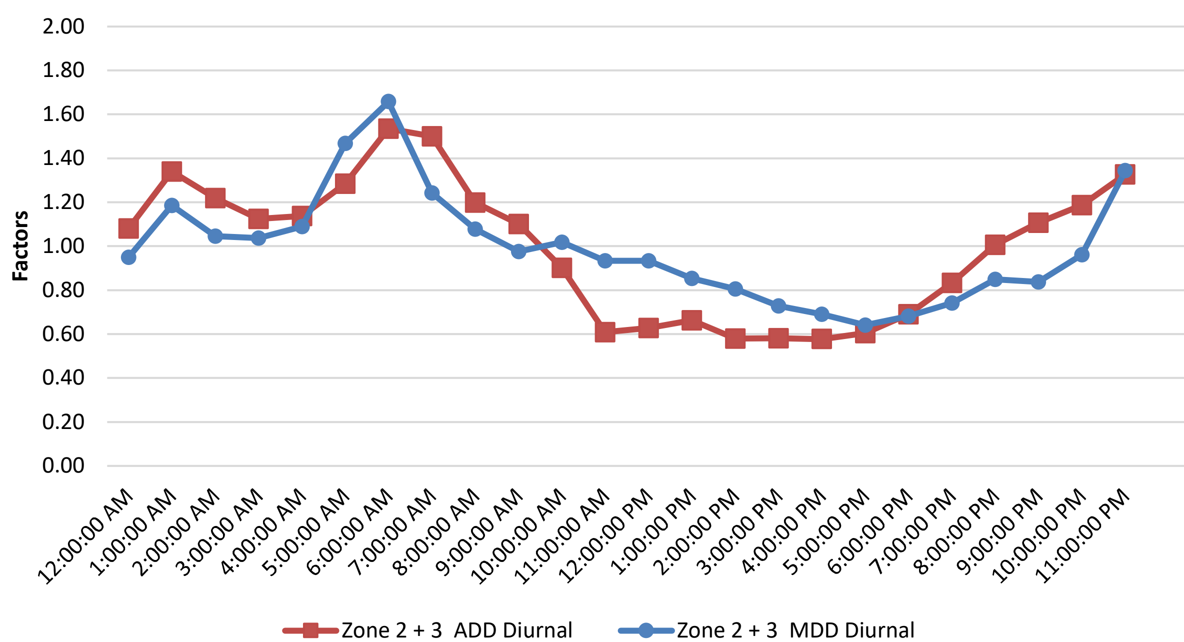
Zone 1A Diurnal Pattern



Zone 1B Diurnal Pattern

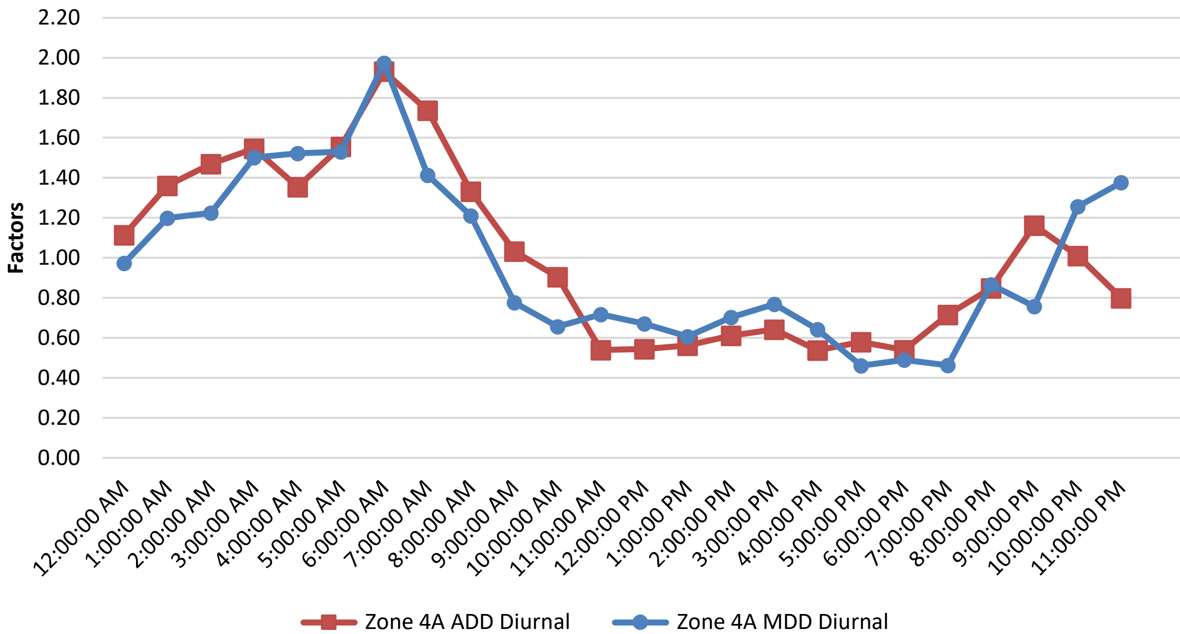


Zone 2 and 3 Diurnal Pattern



Zone 4A Diurnal Pattern

(Zone 4A Diurnal Pattern also used for Zones 1C, 2A, 3A, 4, 4B, and 4C)



Appendix D Pump Capacity Comparison

BOOSTER PUMP STATION PUMP CAPACITY COMPARISON

Pump Station Name	Pump Number	Design Capacity (gpm)	Design Operating Range Flow (gpm) [1]	Model Flow Range (gpm)	Pressure (spi)	
					Suction	Discharge
Main Plant	4	1,500	1,492 - 1,838	0	-4	77
	5	1,500	1,276 - 1,582	1,541 - 1,587	-4	77
	6	1,500	1,512 - 1,877	1,835 - 1,888	-4	77
	7	Unknown	1,456 - 1,695	0	-4	77
	8	1,600	1,455 - 1,680	0	-4	77
Kimberly No. 2	1	1,000	Unknown	0	1	71
	2	1,000	Unknown	1,937 - 2,122	1	72
	3	1,000	Unknown	0	1	71
Hillcrest	1	1,000	798 - 968	0	4	75
	2	1,000	719 - 958	0	4	75
Coyote	1	900	701 - 927	979 - 1,021	2	65
	2	900	705 - 887	962 - 1,005	2	65
	3	900	599 - 925	0	2	65
Lower Acadia Zone 2	1	850	Unknown	921 - 958	-3	36
	2	850	Unknown	0	-3	36
	3	850	Unknown	0	-3	36
Lower Acadia Zone 3	1	1,150	Unknown	0	-3	76
	2	1,150	Unknown	1,112 - 1,160	-3	76
	3	1,150	Unknown	0 - 1,143	-3	76
Laguna	1	300	95 - 453	31 - 101	-3	51
	2	1,500	350 - 2175	0	-3	51
Hermitage Zone 3	1	500	121 - 406	0	7	46
	2	1,000	877 - 1,059	0	7	46
Hermitage Zone 4C [2]	1	300	179 - 246	0	6	99
	2	300	176 - 212	942 - 1,076	6	99
	3	2,500	Unknown	0	6	99
Tank Farm	1	Unknown	1,238 - 1,644	0	6	33
	2	Unknown	1,135 - 1,688	0	6	33
Upper Acacia	1	350	Unknown	0	6	54
	2	700	Unknown	0	8	55
	3	1,000	Unknown	1,077 - 1,403	7	55
	4	1,000	Unknown	0	8	55
Las Palmas	1	600	300 - 850	0	7	60
	2	600	300 - 850	25 - 82	7	60
Hawks Point	1	150	Unknown	0	9	47
	2	150	Unknown	6 - 20	9	47

[1] Design operating flow range is based on available pump curves and SCE tests with multiple data points

[2] Hermitage Zone 4C Pump Station includes a hydropneumatic tank, as such, the pumps had to be modeled to take this into account and may not fall within the design operaing flow range

GROUNDWATER WELL PUMP CAPACITY COMPARISON

Well Name	Well Number	Design Capacity (gpm)	Design Operating Range Flow (gpm) [1]	Model Flow Range (gpm)	Pressure (spi)	
					Suction	Discharge
Kimberly	1A	2,800	Unknown	1,706 - 1,777	-77	75
	2	1,875	596 - 2,591	2,492 - 2,582	-3	2
Main Plant	3A	2,400	865 - 2,400	0	-78	78
	5	1,500	650 - 2,000	0 - 1,965	-48	-2
	6	1,500	Unknown	0	-46	-2
	8	2,000	750 - 2,600	1,692 - 1,704	-47	-2
Airport	9	2,500	750 - 3,245	2,547 - 2,618	-89	87
Sunclipse	10	2,000	2,217 - 2,477	0 - 2,598	-80	72
Christlieb	15A	2,000	1,771 - 1,978	0 - 2,220	-49	73

Appendix E Proposed Pipeline Improvements

PROPOSED PIPELINE IMPROVEMENTS BASED ON EXISTING FIRE FLOW ANALYSIS

Recommended Project Description	Proposed Dia (in)	Quantity	Unit
Zone 1			
Replace existing 4" and 6" with 8" pipe, located between S Brookhurst Rd and S Pacific Dr, from W Orangethorpe Ave to north dead-end	8	235	LF
Replace existing 4" with 8" pipe located west of S Harbor Blvd between W Southgate Ave and W Hill Ave	8	275	LF
Replace existing 4" with 8" pipe on N Marie Ave from W Amerige Ave to north dead-end	8	204	LF
Replace existing 4" with 8" pipe on N Michael Ave from W Amerige Ave to north dead-end	8	187	LF
Replace existing 4" with 8" pipe on Russell Ave from W Amerige Ave to north dead-end	8	225	LF
Install new 6" pipe for looping at N Euclid St and W Wilshire Ave	6	9	LF
Replace existing 4" with 8" pipe for pipe loop between N Wayne Ave and N Lee Ave	8	284	LF
Replace existing 4" and 6" with 8" pipe on N Lee Ave from W Chapman Ave to loop at north end	8	444	LF
Replace existing 4" with 8" pipe on N Wayne Ave from W Chapman Ave to loop at north end	8	460	LF
Replace existing 6" with 8" pipe on E Truslow Ave from S Balcom Ave to east dead-end	8	454	LF
Replace existing 6" with 8" pipe on Patterson Way from S Balcom Ave to east dead-end	8	607	LF
Install new 12" pipe for looping on N Harbor Blvd from E Union Ave to E Glenwood Ave	12	473	LF
Replace existing 6" with 12" pipe on Eugene Dr from E Valley View Dr to 75-ft south	12	75	LF
Replace existing 6" with 8" pipe on Eugene Dr from proposed 12-in pipeline to south dead-end	8	503	LF
Install new 8" pipe for looping on E College Pl from N Lincoln Ave to N Cornell Ave	8	320	LF
Reconnect existing fire hydrant at W Orangethorpe Ave and S Citrus Ave from existing 6" pipe to existing 10" parallel pipe	-	1	EA
Zone 1A			
Replace existing 8" with 12" pipe on Via Burton from N Acacia St to east dead-end	12	1,023	LF
Replace existing 8" with 12" pipe on on E Walnut Ave from S Acacia Ave to S Hale Ave	12	1,053	LF
Replace existing 6" with 12" pipe on E Chapman Ave from Ladera Vista Dr to N State College Blvd	12	1,209	LF
Replace existing 6" with 8" pipe E Chapman Ave from N State College Blvd to Clarke Ave	8	1,149	LF
Replace existing 6" with 8" pipe for residential looping located south of E Chapman Ave between Ladera Vista Dr and N State College Blvd	8	1,466	LF
Replace existing 6" with 8" pipe on San Carlos Dr from Clarke Ave to N State College Blvd	8	732	LF
Replace existing 6" with 8" pipe on Concord Ave from Nutwood Ave to Sycamore Ave	8	1,043	LF
Replace existing 6" with 8" pipe on Nutwood Ave from Wilson Ave to N State College Blvd	8	957	LF
Replace existing 6" with 8" pipe on Sycamore Ave from Nutwood Ave to Concord Ave	8	1,027	LF
Replace existing 6" with 8" pipe on N Raymond Ave and E Glenwood Ave	8	44	LF
Replace existing 6" with 8" pipe on N Lincoln Ave from E Glenwood Ave to Dorothy Ln	8	681	LF
Replace existing 6" with 8" pipe on N Yale Ave from E Glenwood Ave to north dead-end	8	418	LF

Recommended Project Description	Proposed Dia (in)	Quantity	Unit
Zone 1B			
Replace existing 6" with 8" pipe on W Porter Ave from Magnolia Ave to east dead-end	8	876	LF
Install new 8" pipe for looping south of S Vine Ave and W Orangethorpe Ave	8	517	LF
Replace existing 6" with 8" pipe on S Vine Ave from W Orangethorpe Ave to new 8" pipe loop	8	463	LF
Replace existing 6" with 8" pipe on Peckham St from W Orangethorpe Ave to south dead-end	8	793	LF
Replace existing 6" with 8" pipe on W Roberta Ave from Carbon Creek to S Gilbert St	8	593	LF
Replace existing 6" with 8" pipe, located between W Southgate Ave and W Orangethorpe Ave, from S Brookhurst Rd to west dead-end	8	580	LF
Install new 8" pipe for looping from west dead-end of existing 6" pipe (replaced with 8" pipe) to W Orangethorpe Ave, located east of S Cedar Ave	8	805	LF
Replace existing 6" with 8" pipe on S Pine Dr from W Roberta Ave to W Houston Ave	8	377	LF
Replace existing 8" with 12" pipe on on W Houston Ave from S Courtney Ave 640-ft east to the east dead-end	10	610	LF
Replace existing 6" with 8" pipe on W Houston Ave from W Roberta Ave to W Maxzim Ave	8	1,054	LF
Install new 8" pipe for looping on W Roberta Ave from S Courtney Ave 350-ft east to S Brookhurst Rd	8	1,314	LF
Replace existing 6" with 8" pipe on W Roberta Ave from S Pine Dr to W Maxzim Ave	6	280	LF
Replace existing 6" with 8" pipe on Franklin Ave from Olin St to west dead-end	8	627	LF
Replace existing 6" with 8" pipe on Olin St from W Valencia Dr to Franklin Ave	8	510	LF
Replace existing 6" with 8" pipe on Carol Dr from Edward Ave to west dead-end	8	526	LF
Replace existing 6" with 8" pipe on Commonwealth Ave from Edward Ave to west dead-end	8	1,144	LF
Remove and replace existing 6" pipe segment on Artesia Ave east of Dale Pl	6	630	LF
Install new 18" pipe for looping on Dale Pl from Artesia Ave to existing 8" pipe on Dale Pl	18	467	LF
Remove and replace existing 6" pipe on N Pritchard Ave from Artesia Ave to W Commonwealth Ave	6	1,142	LF
Install new 8" pipe for looping on N Pritchard Ave at the intersection of Artesia Ave	8	9	LF
Replace existing 4" with 8" pipe on Plaza de Vista from Carmel Cir to west dead-end	8	194	LF
Zone 1C			
Replace existing 6" with 8" pipe, located between W Porter Ave and Auto Center Dr, from Maxwell Ave to west dead-end	8	283	LF
Zone 2			
Replace existing 6" with 8" pipe on Madison Ave from N Placentia Ave to Cameo Ln	8	542	LF
Replace existing 4" with 8" pipe, located north of Madison Ave, from Deerpark Dr to N Placentia Ave	8	629	LF
Replace existing 6" with 8" pipe for residential looping located north of Yorba Linda Blvd between N Deerpark Dr to N Placentia Ave	8	1,333	LF
Remove and replace existing 8" pipe on E Palm Dr from Sapphire Rd to N Bradford Ave	8	1,334	LF
Remove and replace existing 8" pipe on Yorba Linda Blvd from Sapphire Rd to N Bradford Ave	8	1,288	LF
Remove and replace existing 8" pipe located northeast of Topaz Ln between E Palm Dr and N Bradford Ave	8	1,287	LF
Remove and replace existing 8" pipe on N Bradford Ave from E Palm Dr to Topaz Ln	8	1,092	LF
Install new 8" pipe for looping on N Bradford Ave near Topaz Ln	8	352	LF
Replace existing 6" with 8" pipe on N Sapphire Rd from Topaz Ln to Quartz Ln	8	1,021	LF
Remove and replace existing 6" pipe from Topaz Ln to Quartz Ln	6	672	LF
Remove and replace existing 8" pipe on Quartz Ln from N Sapphire Rd to 710-ft southeast	8	713	LF
Remove and replace existing 8" pipe on Topaz Ln from N Sapphire Rd to 710-ft southeast	8	710	LF

Recommended Project Description	Proposed Dia (in)	Quantity	Unit
Replace existing 6" with 8" pipe on Hartford Ave from E Bastanchury Rd to Sherwood Ave	8	1,235	LF
Replace existing 6" with 8" pipe on Sherwood Ave from Deerpark Dr to Hartford Ave	8	1,671	LF
Replace existing 6" with 8" pipe on Hollydale Dr from Melody Ln to Dorothy Ln	8	572	LF
Replace existing 6" with 8" pipe on Kensington Dr from Hollydale Dr to Melody Ln	8	953	LF
Replace existing 6" with 8" pipe on Melody Ln from Kensington Dr to Acacia Ave	8	1,617	LF
Replace existing 6" with 8" pipe on Valvwood Dr from Panorama Rd to Lautrec Dr	8	672	LF
Replace existing 6" with 8" pipe on Dorothy Dr from Hornet Way to Sheppard Dr	8	257	LF
Replace existing 4" and 6" with 8" pipe on Sheppard Dr from Dorothy Dr to Virginia Rd	8	2,021	LF
Replace existing 6" with 8" pipe on Sheppard Dr from Virginia Rd to north dead-end	8	468	LF
Replace existing 4" with 8" pipe on Cristine Pl from W Valencia Mesa Dr to southeast dead-end	8	186	LF
Replace existing 4" and 6" with 8" pipe on N Johnston Knls from Sunny Crest Dr to east dead-end	8	313	LF
Replace existing 4" and 6" with 8" pipe on N Harbor Blvd from Brea Blvd to 1,150-ft northwest	8	1,228	LF
Realign pipelines from Zone 1 to Zone 2 near the intersection of Vista Verde Drive & West Union Avenue	-	1	LS
Install New Zone 3 to 2 PRV at E Bastanchury & Hartford Ave	-	1	EA
Reconnect existing fire hydrant at Brea Blvd and Longview Dr from Zone 2 existing 8" pipe to Zone 3 existing 12" parallel pipe	-	1	EA
Zone 3			
Replace existing 6" with 8" pipe on Sunny Knl from Sunny Crest Dr to northeast dead-end	8	503	LF
Replace existing 6" with 8" pipe on Sheffield Pl from Beacon St to west dead-end	8	314	LF
Replace existing 4" and 6" with 8" pipe on Salem Pl and Middlesex Pl as well as existing pipe loop between the streets, located north of Mystic Ave	8	1,143	LF
Replace existing 6" with 8" pipe on Hartford Ave from Winchester St to north dead-end	8	468	LF
Install new 8" pipe for looping from Hartford Ave dead-end to Cambridge Ave dead-end	8	276	LF
Replace existing 6" with 8" pipe on Thorn Pl from Winchester St to north dead-end	8	458	LF
Replace existing 6" with 8" pipe on Blackpine Ct from Cedarbrook Cir to east dead-end	8	158	LF
Replace existing 8" with 12" pipe on Associated Rd from Rolling Hills Dr to Gingerwood Cir	12	1,755	LF
Replace existing 6" with 8" pipe on Private St with Associated Rd to the west and Rolling Hills Dr to the south	8	1,929	LF
Replace existing 4" with 8" pipe, located east of Merlin Ave, from Mimosa Pl to Beechwood Ave	8	255	LF
Replace existing 6" with 8" pipe on Edgecliff Dr from N Raymond Ave to Kroeger Ave	8	418	LF
Replace existing 6" with 8" pipe on Kroeger Ave from Edgecliff Dr to Melody Ln	8	1,659	LF
Replace existing 4" and 6" with 8" pipe on Linda Ln from Skyline Dr to east dead-end	8	445	LF
Replace existing 6" with 8" pipe on N Norman Pl from N Raymond Ave to east dead-end	8	408	LF
Replace existing 6", 8", and 10" with 12" pipe on N Raymond Ave from Edgecliff Dr to Miramar Pl	12	1,103	LF
Replace existing 6" with 8" pipe on N Raymond Ave from Miramar Pl to Melody Ln	8	725	LF
Replace existing 6" with 8" pipe on N Raymond Ave from Skyline Dr to Kenwood Pl	8	951	LF
Replace existing 4" with 8" pipe on N Lemon St from Hillcrest Dr to Cannon Ln	8	314	LF
Replace existing 6" with 8" pipe on Beechwood Ave from Puente St to west dead-end	8	187	LF
Replace existing 6" with 8" pipe on Altivo Pl from Arbolado Dr to north dead-end	8	472	LF
Replace existing 6" with 8" pipe on Arbolado Dr from Madonna Dr to Altivo Pl	8	346	LF

Recommended Project Description	Proposed Dia (in)	Quantity	Unit
Replace existing 6" with 8" pipe on Madonna Dr from Arbolado Dr to Elinor Dr	8	562	LF
Replace existing 6" with 8" pipe on Balboa Rd from E Bastanchury Rd to north dead-end	8	377	LF
Replace existing 6" with 8" pipe on N Harbor Blvd from Coronado Dr to Miguel Pl	8	984	LF
Replace existing 6" with 8" pipe for residential looping located south of Imperial Hwy between N Palm St and S Puente St	8	1,529	LF
Replace existing 6" with 8" pipe on Via Codo from Via Codo to south dead-end	8	268	LF
Replace existing 6" with 8" pipe on Lakeside Dr from W Hermosa Dr to Terraza Pl	8	1,105	LF
Replace existing 6" with 8" pipe on Juanita Pl from Clarion Dr to southwest dead-end	8	629	LF
Replace existing 6" with 8" pipe on Anacapa Pl from Domingo Rd to Santa Barbara Ave	8	1,153	LF
Replace existing 6" with 8" pipe on Miguel Pl from Domingo Rd to northwest dead-end	8	550	LF
Replace existing 6" with 8" pipe on Rancho Cir from Terraza Pl to east dead-end	8	543	LF
Replace existing 6" with 8" pipe on Verona Dr from Rancho Cir to 685-ft west	8	685	LF
Replace existing 6" with 8" pipe on Yuma Way from Laguna Rd to southwest dead-end	8	872	LF
Replace existing 6" with 8" pipe on Avenida del Corto from Nicolas Dr to west dead-end	8	547	LF
Replace existing 6" with 8" pipe on Paseo Grande from Grissom Park Dr to Manzanita Dr	8	906	LF
Replace existing 6" with 8" pipe on Paseo Grande from Manzanita Dr to east dead-end	8	230	LF
Replace existing 6" with 8" pipe Ave del Norte from Parks Rd to west dead-end	8	412	LF
Replace existing 6" with 8" pipe on Ride Out Way from W Las Palmas Dr to southeast dead-end	8	729	LF
Zone 3A			
Replace existing 6" with 8" pipe on Avenida Selva from Calle Candela to Camino Recondito	8	220	LF
Replace existing 6" with 8" pipe on Calle Candela from El Rancho Vis to Ave Selva	8	561	LF
Replace existing 6" with 8" pipe on Camino Escondido from Calle Candela to east dead-end	8	409	LF
Zone 4			
Replace existing 6" with 8" pipe on Flintridge Dr from W Las Palmas Dr to 546-ft south	8	546	LF
Replace existing 6" with 8" pipe on La Sombra Way from W Las Palmas Dr to south dead-end	8	320	LF
Zone 4A			
Replace existing 6" with 8" pipe on Panorama Rd from Palisades Dr to Skyline Dr	8	837	LF
Replace existing 4" and 6" with 8" pipe on Skycrest Dr from Skyline Dr to Skyline Way	8	765	LF
Replace existing 6" with 8" pipe on Skyline Dr from Linda Vista Cir to N Raymond Ave	8	735	LF
Replace existing 6" with 8" pipe on Skyline Dr from Skyline Way to N Raymond Ave	8	883	LF
Replace existing 4" and 6" with 8" pipe on Skyline Way from Skyline Dr to Skycrest Dr	8	240	LF
Replace existing 6" with 8" pipe on Stanford Ave from Melody Ln to Virginia Rd	8	366	LF
Zone 4C			
Realign pipelines from Zone 3 to Zone 4C near the intersection of Applewood Cir & Hermitage Dr and Camino del Sol & Atherton Cir	-	1	LS
	Total	**83,770**	**LF**

Appendix F Condition Assessment Technical Memorandum

(Confidential)

Confidential Information is only available in the “Risk and Resiliency Assessment (SRR) Report”.

Access must be approved in advance by the Director of Public Works.

Appendix G Risk Assessment Technical Memorandum

(Confidential)

Confidential Information is only available in the “Risk and Resiliency Assessment (SRR) Report”.

Access must be approved in advance by the Director of Public Works.