TECHNICAL MEMORANDUM

# Pressure Zone Study
# Blue Lake Springs Mutual Water Company

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This technical memorandum presents Luhdorff and Scalmanini Consulting Engineers (LSCE) analysis of Blue Lake Springs Mutual Water Company's (BLSMWC) distribution system and pressure zones. The analysis is used to establish design parameters of the proposed pipeline replacements that are required to bring the distribution system into compliance with Waterworks Standards and the standards of Calaveras County Water District (CCWD). This work was completed to fulfill a recommendation of BLSMWC's Water Master Plan completed by LSCE in 2014. This memo was finalized after input from the BLSMWC on the Draft version Dated November 10, 2016.

## 1.0 Introduction

The existing distribution system is controlled by two 750,000 gallon bolted steel storage tanks (Tank 4 and Tank 6) situated in opposite sides of the system and hydraulically supply separate areas. Tank 6, on the eastern side, is supplied from BLSMWC's water treatment plant (WTP), which treats groundwater pumped from its White Pines well field (Wells 2 and 3) and the newly completed Well 4 (Lucia). Tank 4, on the western side, can be supplied by the WTP or by water purchased from CCWD and supplied by an intertie to Tank 4. Additionally, the WTP can directly feed the system in its immediate vicinity.

Due to the mountainous nature of system's setting, elevation is a driving factor in characterizing the system, particularly in regard to system pressure ranges. To control system pressure, forty-four (44) pressure reducing valves (PRVs) are installed throughout the system to limit high pressures.

The distribution system was expanded with growth of the Blue Lake Springs development. Supply pipeline were added as needed to supply houses as they were built. Original supply lines were small diameter (1.5-4 inches) PVC and were placed in the back of lots. 6-inch asbestos cement pipes were used as main transmission lines from the WTP to the tanks. Original development expansion occurred by unit, and each unit was supplied by its own individual redwood storage tank. This arrangement allowed each unit to be considered its own pressure zone, which is the basis of the current zone alignments and naming. Eventually the two current tanks were constructed in 1992, and the redwood tanks were abandoned. Upon construction of Tanks 4 and 6, the zones were consolidated into the current configuration and are delineated by zone meters to measure water usage for each zone. In the current arrangement, there are five (5) metered zones, but the actual number of pressure zones is twenty (20) as controlled by position of normally closed valves and PRVs.

BLSMWC conducted replacement of pipe mainlines in certain areas of the development from 2006 to 2009. The purpose of constructing new mainlines was to replace old and leaky lines, upsize the pipe to provide adequate fire flow, meet CCWD standards, and to move the pipes into the streets for easier access and maintenance. The new pipe is, at minimum, 6-inch PVC. New PRV stations were also added to control high pressures. Since new pipes were constructed in only certain areas, the system has mixed areas of old and new pipe. This has created a several small pressure zones where both new and old pipes exist and other inconsistencies with how the pressure zones are delineated.

## 2.0 Purpose of Pressure Zone Study

The purposes of this Pressure Zone Study, as recommended in the Water Master Plans are as follow:

A. Refine the accuracy of the computer model of the distribution system.
B. Evaluate the existing pressure zones and how to better delineate them.
C. Evaluate future water system configuration and pressure zones to improve balance between both tanks and minimize the number of pressure zones and PRVs.
D. Confirm planned piping sizes and system operation for future development.

## 3.0 Field Investigation

On June 2, 2016, LSCE conducted testing on the BLSMWC's distribution system. Tests were conducted by flowing a fire hydrant and measuring pressure drops in the system. Four hydrants were selected by LSCE to flow for the purpose of this investigation. The flow hydrants and static hydrants are listed in **Table 1**. Each test followed these procedures:

A. Take an initial pressure reading from test hydrant and one or two selected observation hydrants immediately upstream and downstream of test hydrant.
B. Fully open test hydrant and measure flowrate.
C. Once conditions stabilize (several minutes of flowing), record residual pressures of static hydrants.
D. Close test hydrant.

**Table 1. Test Hydrants (Lot-Unit)**

| | TEST HYDRANT | OBSERVATION HYDRANT 1 | OBSERVATION HYDRANT 2 |
|---|---|---|---|
| **TEST 1** | 56-10 | 29-10 | 38-10 |
| **TEST 2** | 243-2 | 139-10 | 250-2 |
| **TEST 3** | 122-10 | 128-10 | N/A |
| **TEST 4** | 857-7 | 178-8 | 188-8 |

In addition to measurements made at these hydrants during testing, pressure transducers with dataloggers were placed in the system prior to testing. The transducers logged a pressure reading every minute. These transducers were installed on service lines at 7-9, 41-12, and 75-13 (lot-unit).

During testing, the pump at the WTP was off. The levels in Tank 4 and Tank 6 were about 27 feet and 26 feet, respectively.

System demand on the day of testing, excluding water discharged due to flow testing, was an average of 74.5 gpm. This is roughly half of the average day demand determined in the Water Master Plan, i.e. the system in the low demand period at the time of testing. Overall usage, usage by zone, and water discharge for testing are in **Table 2** below. **Table 3** presents the data collected during testing.

**Table 2. System Water Usage in Gallons for June 2, 2016**

| | ZONE 1 | ZONE 2/3 | ZONE 4/5 | ZONE 6/7 | ZONE 13 | TOTAL |
|---|---|---|---|---|---|---|
| **BACKGROUND USAGE** | 2,975 | 14,208 | 31,048 | 45,000 | 14,000 | 107,231 |
| **USAGE FOR FLOW TESTING** | 9,025 | 16,792 | 7,952 | 0 | 0 | 33,769 |
| **TOTAL USAGE*** | 12,000 | 31,000 | 39,000 | 45,000 | 14,000 | 141,000 |

* Values of total usage came from the BLSMWC daily zone meter reads. Flow testing usage was calculated from LSCE's field notes. Background usage was calculated.

**Table 3. Field Fire Flow Test Results**
**June 2, 2016**

| | TEST 1* | TEST 2 | TEST 3** | TEST 4 |
|---|---|---|---|---|
| **TEST FLOWRATE** | 475 gpm | 1062 gpm | 1022 gpm | 994 gpm |
| **TEST HYDRANT STATIC PRESSURE** | 79 psi | 116 psi | 95 psi | 121 psi |
| **OBSERVATION HYDRANT 1 STATIC PRESSURE** | 72 psi | 104 psi | 98 psi | 102 psi |
| **OBSERVATION HYDRANT 2 STATIC PRESSURE** | 93 psi | 98 psi | - | 112 psi |
| **TEST HYDRNAT FLOWING PRESSURE** | 0 psi | 40 psi | 37 psi | 35 psi |
| **OBSERVATION HYDRANT 1 FLOWING PRESSURE** | 54 psi | 78 psi | NA | 34 psi |
| **OBSERVATION HYDRANT 2 FLOWING PRESSURE** | 81 psi | 48 psi | - | 42 psi |

* Test 1 had restricted flow from discharge hose arrangement.
** Test 3 observation data was not recorded.

In some cases, hoses were used to divert water to site drainage areas through a dechlorinating diffuser. The hose caused significant head loss thereby reducing flow to levels too low for the test (see Test 1 in **Table 3**). Tests 2-4 were completed discharging directly from the test hydrant so that flowrates of about 1,000 gpm were achieved.

For Test 3, only one static hydrant was possible since the test hydrant was at the end of the line. Additionally, a reading from the static hydrant was not available to be read while flowing the test hydrant. Data from the pressure transducers in the system were used for analysis instead.

## 4.0 Model Calibration

As part of the Water Master Plan, a computer model of the BLSMWC's water system, originally created by HDR, was updated and used for analysis of the system. Particularly, the model was used to determine needed distribution pipe diameters necessary to provide adequate fire flows throughout the system, which fed into a prioritization model for the pipeline upgrades. Though the model was functional, model calibration was recommended in the Water Master Plan to ensure the accuracy of results.

Model calibration is the process where actual field data are compared against model output data to address predictive accuracy of the model. This process can lead to corrections to the model to reflect actual pipeline hydraulics. In the case of the BLSMWC, there are a mixture of older and newer distribution piping and the operators isolate areas of the system manually with normally closed valves, which creates complexities when analyzing the system. The current system contains PRVs on older or newer piping, but in some locations do not isolate a zone because of interties with the upper zones in other locations. In conducting the model calibration exercise, LSCE and the BLSMWC identified valves the operators typically have normally closed valves as a way to control the system and we identified current PRV settings, which ultimately improved predictive capability of the model for the areas tested.

Several meetings between BLSMWC and LSCE were conducted to review the system map and model to make corrections and review status of valves. Each meeting updated and corrected the map and model to represent the system accurately. Corrections included checking pressure reducing valve (PRV) settings, status of gate valves (open or closed), and location and connections of distribution pipes.

Currently, the model runs and has an acceptable level of accuracy for the areas tested. The predictive accuracy of the model in areas untested would mainly be driven by the working condition of PRVs and any unknown closed valves present. Additional testing can help bring the model into better calibration and illuminate other inaccuracies. However, the majority of areas untested will have new pipelines constructed, which can be assumed to have better control for model accuracy.

Ultimately, the model is needed to determine design parameters for replacing about half of the system. The future system model can dictate many variables as design parameters and therefore have better control of accuracy in consolation with the existing, newer portions of the system.

## 5.0 Defining and Evaluating System Zones

The BLSMWC system is currently parsed into "zones" which can be tracked by individual meters for water usage. However, these zones do not fit the definition of a pressure zone. LSCE analyzed the system and determined that there are about twenty (20) individual pressure zones due to the positioning of PRVs and connections of the distribution pipes.

There are two types of pressure-based zones: 1) gravity zones; and, 2) pressure zones. A gravity zone is the area that is directly fed from a supply tank with no restriction of pressure (i.e. PRV). In gravity zones, water is gravity fed from the tank within acceptable levels of pressure. A pressure zone is an area controlled by PRVs fed by an upper zone to maintain a certain range of pressure within the lower elevation areas.

LSCE analyzed the system, with assistance of the model, to delineate the existing pressure zones for the BLSMWC. These pressure zones are shown in **Plate 1**. Each zone is listed based upon which tank primarily feeds it and how it connects to the tank. For instance, the zone adjacent to Tank 6 (shown in green) is called “T6-Upper” since it is fed by Tank 6 and is gravity fed with no pressure restriction. The adjacent light pink zone is considered a “middle” zone since water supplied to it must first pass through the upper zone and is controlled by PRVs entering the zone. Continuing the trend creates lower zones, zones fed by middle zones. Unit 13, which is geographically distinct from direct tank feeds, is delineated into three (3) pressure zones and names upper, middle, and lower based on elevation. Additionally, a main zone is identified and is connected directly from the WTP.

Based on these delineated pressure zones, a vertical schematic (**Figure 1**) was created, which shows the high and low elevation of each zone, PRV set points, pipe connections, tanks, and hydraulic grade lines. The typical demands of the system are not high enough to cause significantly lower pressures relative to the static pressure induced by elevation and PRV settings. Therefore, elevation is the primary driver to system pressures within each zone. Many zones have comparable elevations. Ideally, these zones should be combined to simplify the system thereby minimizing the number of pressure zones. (Note: During LSCE’s meeting with the BLSMWC on October 4$^{th}$, corrections were made to the system map, which further delineated pressure zones resulting in the configuration shown in **Plate 1**. These divisions were not incorporated in **Figure 1** due to emphasis on analysis of the future system. **Figure 1** notes which zones were combined during LSCE’s analysis.)

## 6.0 Future System Objectives

LSCE met with the BLSMWC staff and discussed objectives to incorporate into the design of replacement pipelines throughout the system. These objectives were as follows:

A. Reduce the total number of pressure zones.
    i. Combine current Zone 1 into one zone.
    ii. Eliminate unnecessary PRVs.
    iii. Combine adjacent zones with similar elevations, where possible.
B. Maintain pressures between 50-125 psi, however high pressures could be specifically designed if merited by the tradeoff for improvements.
C. Feed current Zone 1 from the tanks instead of directly from the WTP.
D. Extend system coverage of Tank 4 for redundancy, turnover, and increased usage of CCWD water. Having overlapping coverage throughout the system also creates a larger capacity to meet fire flows.
E. Improve redundancy of both tanks. Currently, areas served by Tank 4 can also be served by Tank 6. However, some areas of Tank 6 cannot be served by Tank 4. This involves refurbishing the Cypress Point booster pump station to move water from Tank 4 to Tank 6.
F. Eliminate backlot pipelines, including the backlot mainline from Tank 6.

G. Minimize sizing of new distribution piping by improving “looping” through multiple feeds to the zones.

## 7.0 Future System Design Alternatives

Based on discussions with the BLSMWC, implementation of the above stated design objectives was discussed. The model of the future system was used to help inform these design goals. The following discussion considers implementation of these objectives, with some being outlined as alternatives for the BLSMWC to consider when moving forward with the design process. **Plate 2** shows the configuration of the future system, with pipe size recommendations to meet fire flows based on model runs.

Combine Pressure Zones and/or Reduce PRVs

Simplifying the system involves either combining pressure zones into larger controlled areas and/or reducing the number of PRVs required to maintain adequate pressure in the system. **Plate 2** shows the location of the future distribution pipe and PRVs. PRVs are positioned to combine areas with similar elevation into the same pressure zone as location and topography allows. A gravity zone is specified immediately around each tank, which has pressure uncontrolled by PRVs. In these zones, water flows freely up to a pressure of about 125 psi. When the pressure becomes too high (about 125 psi), PRVs are placed to bring pressures within reasonable levels for lower elevations. These new zones are considered “middle” zones since they are fed by upper or gravity fed zones. Once pressure becomes too high in the middle zones, PRVs break the pressure again to reasonable levels, thus creating lower zones. LSCE’s configuration of the new system in **Plate 2** has reduced the number of PRVs from thirty-eight (38) currently to thirty-four (34) in the future system and the number of pressure zones from twenty (20) to eleven (11).

Extending Coverage of Tank 4

Prior to CCWD water source, Tank 4 was normally operated to provide water to roughly a third of the system. However, the current practice to expand Tank 4 influence, and thus CCWD supply, to roughly 50% of the system is a normally closed transmission main valve (i.e. isolating downstream of Gloria PRV allows Tank 4 to supply Gloria PRV). The remaining system is supplied by Tank 6 and directly from the treatment plant. The zones proposed in the future system that are fed by Tank 4 are designed to be gravity fed by the tank rather than through a PRV off the transmission line (i.e. Gloria PRV). By expanding the coverage of Tank 4 on the gravity side, redundancy is created in the system for the occurrence of emergencies such as the treatment plant going down or Tank 6 needing repair or maintenance. This also extends the usage of CCWD water, which the BLSMWC desires to maximize usage under their purchase contract.

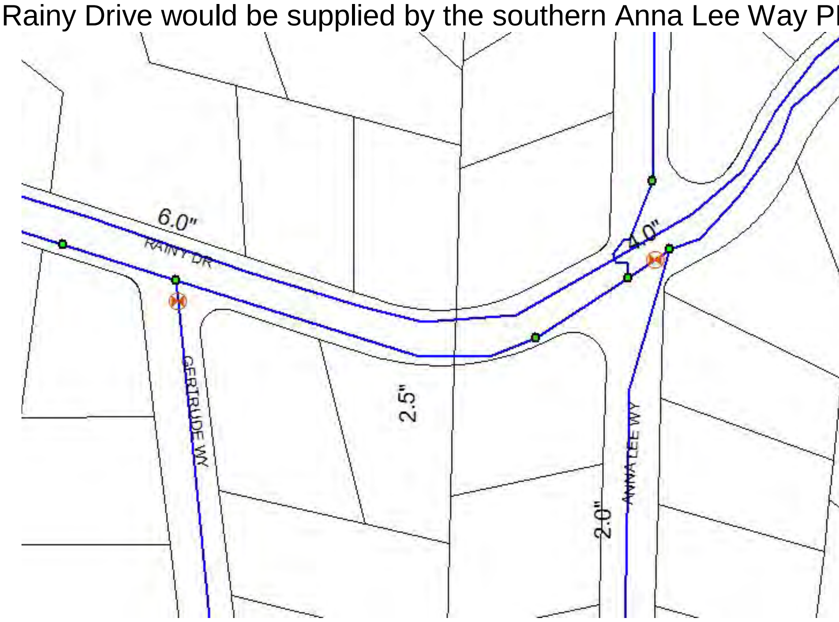
Cypress Point Booster Station for Redundancy

During periods where Tank 6 or the WTP may be offline, redundancy measures are needed to allow Tank 4 to feed the upper Tank 6 zones. Discussion with the BLSMWC determined that the most reasonable and economical way to extend Tank 4 coverage to Units 9, 11, and 12 is to refurbish the Cypress Point booster pump station. This station will allow for water from Tank 4 to be pumped into these areas and convey water from Tank 4 to Tank 6. The BLSMWC desires to abandon the backlot mainline from Tank 6 to Cypress Point due to maintenance and access problems. Therefore, water pumped from Cypress Point to Tank 6 will need to be conveyed through the distribution system in the streets unobstructed by PRVs. To accomplish this, a transmission line of about 900 feet will need to be maintained from the booster pump station to a connection at North Sierra View. Refurbishing the Cypress Point Booster Station will require protection for hydraulic surge during pump startup and shutdown. Possible design features to provide this protection are installation of a surge tank, a variable frequency drive (VFD) for the pump, a pump control valve, or a combination.

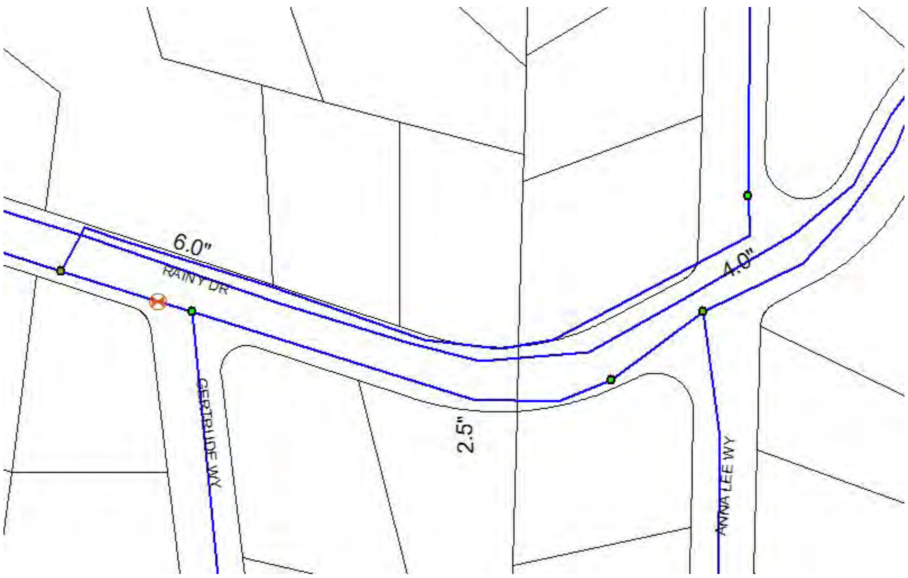
<u>Zone 1 Coverage and Pipeline Sizes</u>
Zone 1 is currently supplied from the WTP and Tank 6. In the future system, Zone 1 would be fed directly from the Tank 6 transmission main through a PRV on Linda Drive. Pipe sizing in the Water Master Plan (WMP) was based on meeting fire flows, which in Zone 1 resulted in 8- and 12-inch piping. In order to reduce Zone 1 pipe sizes, a secondary feed from the Tank 4 gravity zone was considered. To accomplish this, LSCE recommends installing a transmission line from Anna Lee Way to Dean Way via Nola Drive. Though this would cause pressures on Anna Lee Way to exceed 125 psi, this would give a direct gravity feed from Tank 4 to Zone 1. This would improve flow to the zone to meet fire flows. Additionally, due to this connection, pipe sizes determined in the WMP of 12 and 8 inch mainlines can be reduced while still meeting desired fire flow capacities (**see Plate 3**). In addition, Dean Way can be reduced to all 6-inch pipe and still meet the fire flow achieved with the 8- and 12-inch piping. As a result, the capital expenditure and required maintenance will be reduced with smaller pipe sizes.

<u>Tank 4 to Zone 1 Transmission Alternatives</u>
In order to provide a gravity feed connection from Tank 4 to Dean Way, a mainline connection must be installed on Rainy Drive to the northern portion of Anna Lee Way without a PRV on the line. However, a PRV is needed to supply Gertrude Way, the southern portion of Anna Lee Way, and the lower part of Rainy Drive, which is the Tank 4 Middle zone, so that maximum pressures are not exceeded. Alternatives that were considered:

A. Connect Gertrude Way and the southern portion of Anna Lee Way to the fire flow main that runs north on Anna Lee Way to Zone 1. This keeps the number of concurrent pipes in Rainy drive to two: 1) transmission to/from Tank 4; and, 2) distribution mainline from Tank 4. However, a PRV will be needed for both Gertrude Way and the southern portion of Anna Lee Way. The lower portion of Rainy Drive would be supplied by the southern Anna Lee Way PRV:



B. Install a single PRV in the Rainy Drive distribution main upstream of Gertrude Way to supply the Tank 4 Middle zone. In order to maintain a Tank 4 gravity zone feed to Zone 1 via the northern portion of Anna Lee Way, a fire flow main will tap off the distribution main upstream of this new PRV and run from Gertrude way to the northern portion of Anna Lee Way. This configuration eliminates one PRV in Alternative A but requires three lines in Rainy Drive from Gertrude Way to Anna Lee Way:
   1. Existing transmission line to/from Tank 4
   2. New transmission line off of Tank 4 Upper that serves as fire flow supply to Zone 1 and distribution on northern Anna Lee Way (at higher than 125 psi)
   3. New distribution line to Tank 4 Middle zone




Alternative B is recommended due to lower cost and fewer PRV valves in the system though it does result in a section of higher pressures transmission piping between 150 and 170 psi. Alternative B is shown in **Plate 2**. These configurations allow the existing transmission main to be a dedicated Tank 4 transmission line. These also allow the Tank 4 upper gravity zone to serve a wider portion of the system under normal operating conditions.

<u>Russell Drive (Zone 1) Fire Flow Alternatives</u>
Even with the secondary feed to Zone 1 from the Tank 4 gravity zone discussed above, Russell Drive has limited fire flow capacity because of a long dead end main (no looping). Pipe size drives the availability of flow to meet demands. The new connection described in the previous section allows a reduction in pipe size and thus cost and maintenance. Two additional alternatives are considered to improve fire flow on Russell Drive:

A. Alternative A provides 930 gpm at the end of Russell Road
   i. 12-inch pipe from Blue Lake Springs Drive to Highway 4 – 1,275 feet
   ii. 8-inch pipe from Highway 4 to the northern end of David Lee Road – 580 feet
   iii. Russell south of the northern end of David Lee Road is 6-inch pipe – 2,230 feet
B. Alternative B provides 950 gpm to the end of Russell Road
   i. 12-inch pipe on Linda Drive – 825 feet

   ii. 8-inch pipe from Linda to the south end of David Lee Road – 2,060 feet
   iii. Russell south of the southern end of David Lee Road is 6-inch pipe – 1,250 feet

C. A third alternative is to obtain a new back-lot easement to run a transmission line from the intersection of Dean Way and Nola Drive to the end of Russell to create a looped connection and a connection to Tank 4. This would enable further reduction of pipe size and possibly reduce the 12-inch main from Linda Drive to an 8-inch line.

Neither Alternatives A nor B will meet the fire flow requirements, regardless of the quantity of large pipe in the system. Alternative A is recommended over B because of tradeoff of larger pipe and only a marginal increase in fire flow in Alternative B. Alternative C (looping through backlot easements), if feasible, would be the only way to achieve fire flow objectives and further investigation would be required to define backlot easements. Alternative A is recommended and shown in **Plate 2**.

## 8.0 Future System Recommendations

Based on the analysis above, the recommendations for a Future system are shown on **Plate 2**, which provides the PRV locations and settings of the future system. The set points of PRV stations from the model are shown in Plate 2, and are only initial settings that should be evaluated and updated to manage the feeds into each zone, which can be done on a site-specific basis during design of the improvements. Based on our evaluation, the proposed settings as shown in **Plate 2** would maintain adequate pressures in each zone. Most of the zones would be maintained between 40-140 psi, though pressures at the service lines will be mostly below 125 psi. There are specific transmission feeds as indicated in the discussion that would operate at pressures exceeding 150 psi in order to provide hydraulic performance.

The proposed pressure zone configuration resulted in a reduction of the size of a majority of the eight (8) and twelve (12) inch pipe proposed in the WMP to six (6) inch. This reduces capital costs for the system improvements.

LSCE recommends that these future system improvements be considered with the District in a pre-engineering design phase of the pipeline projects to identify the connection points and changes proposed to the existing system within this memorandum as reflected in the accompanied Plates and the existing water system model.

**Enclosures**

**Figure 1 – Existing Vertical System Schematic**

**Plate 1 – Existing System Map and Pressure Zones**

**Plate 2 – Future System Model and Pressure Zones**

**Plate 3 – Fire Flow Capacity on Maximum Day Demand**

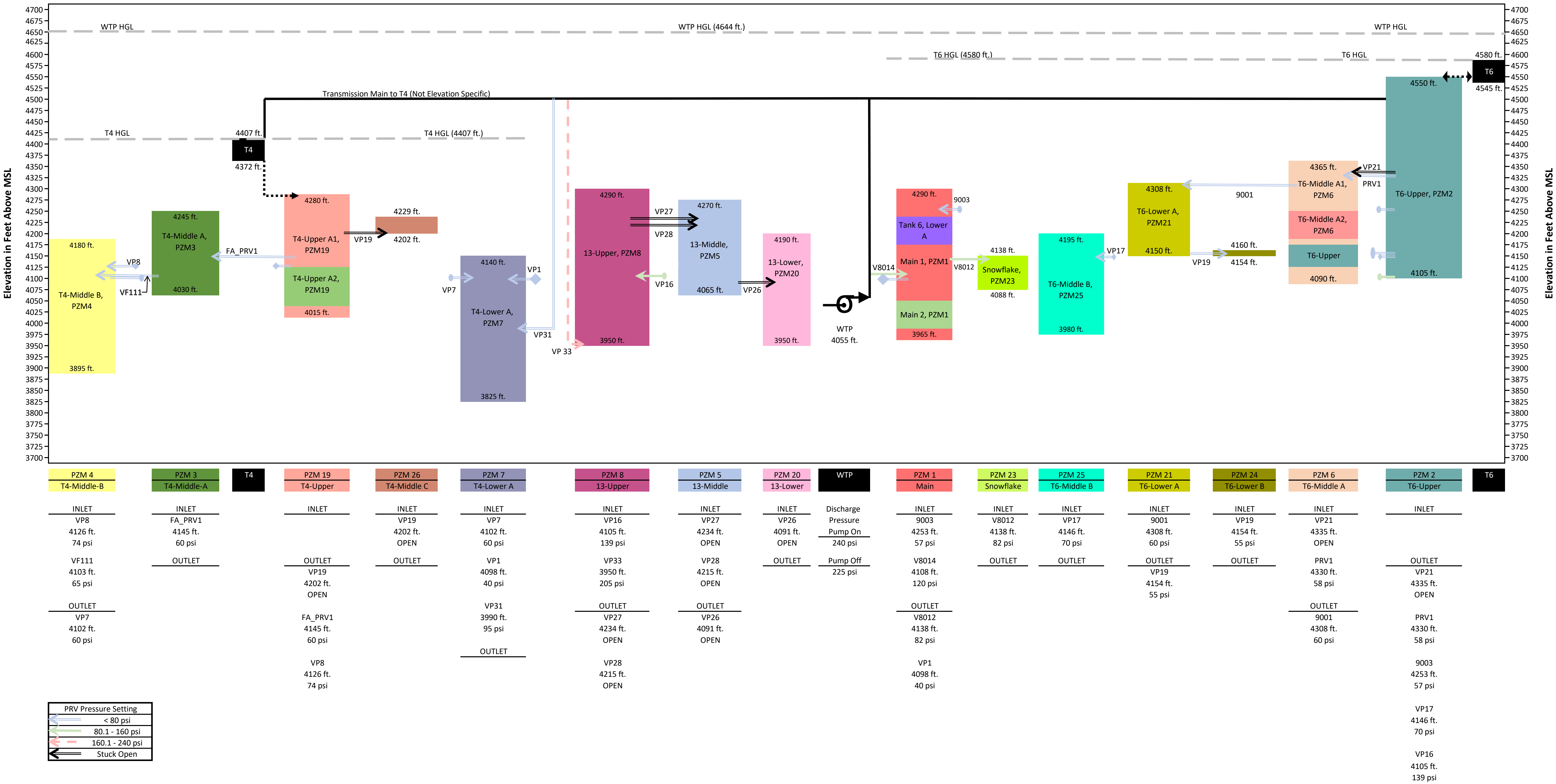



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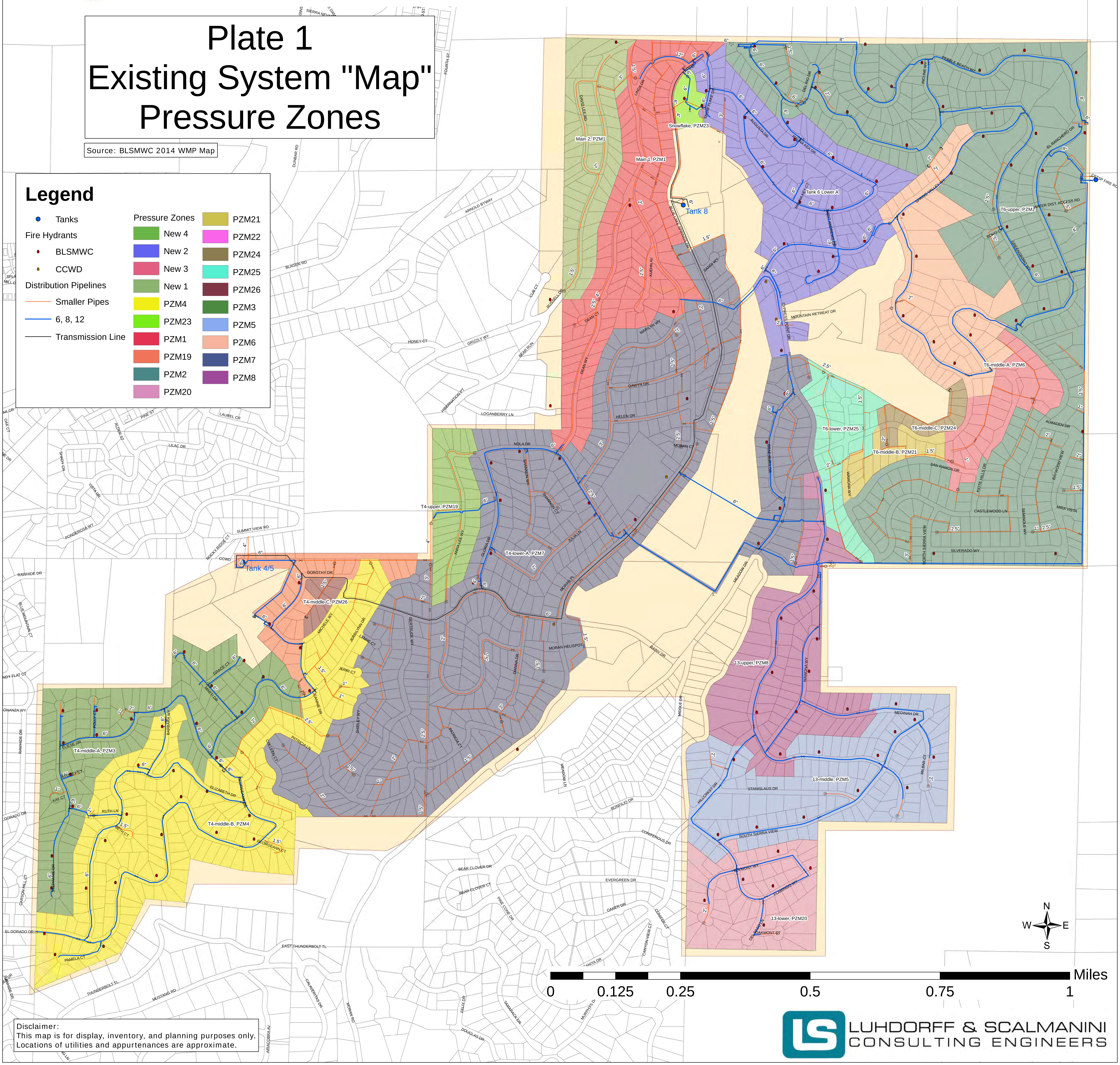
**Figure 1**
**Existing Vertical System Schematic**
**BLUE LAKE SPRINGS MUTUAL WATER COMPANY**

# BLUE LAKE SPRINGS UNITS NO. 1 - 13




Disclaimer:
This map is for display, inventory, and planning purposes only.
Locations of utilities and appurtenances are approximate.

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# BLUE LAKE SPRINGS UNITS NO. 1 - 13

## Plate 2
## Future System "Model" Pressure Zones

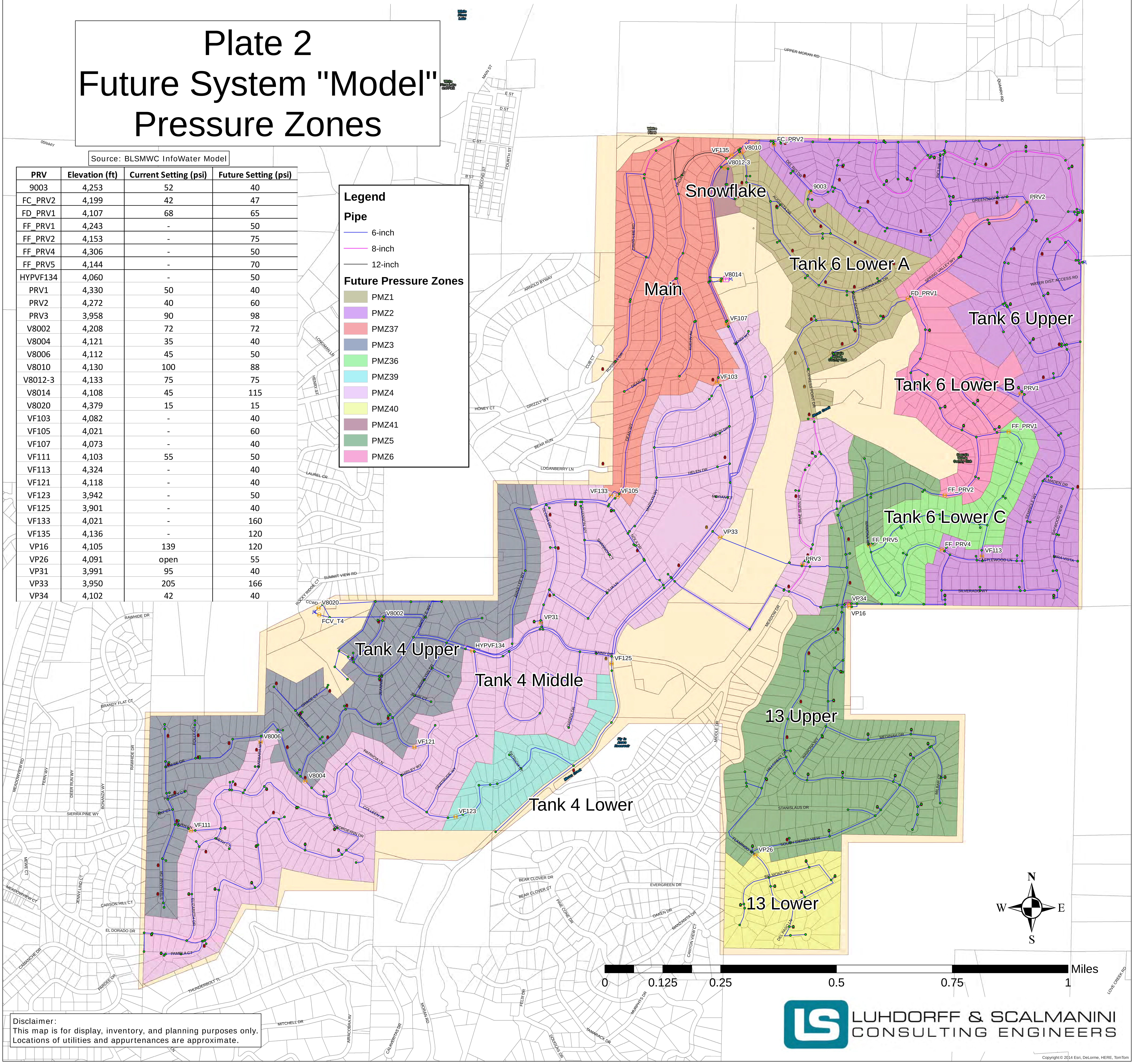
Source: BLSMWC InfoWater Model

| PRV | Elevation (ft) | Current Setting (psi) | Future Setting (psi) |
|---|---|---|---|
| 9003 | 4,253 | 52 | 40 |
| FC_PRV2 | 4,199 | 42 | 47 |
| FD_PRV1 | 4,107 | 68 | 65 |
| FF_PRV1 | 4,243 | - | 50 |
| FF_PRV2 | 4,153 | - | 75 |
| FF_PRV4 | 4,306 | - | 50 |
| FF_PRV5 | 4,144 | - | 70 |
| HYPVF134 | 4,060 | - | 50 |
| PRV1 | 4,330 | 50 | 40 |
| PRV2 | 4,272 | 40 | 60 |
| PRV3 | 3,958 | 90 | 98 |
| V8002 | 4,208 | 72 | 72 |
| V8004 | 4,121 | 35 | 40 |
| V8006 | 4,112 | 45 | 50 |
| V8010 | 4,130 | 100 | 88 |
| V8012-3 | 4,133 | 75 | 75 |
| V8014 | 4,108 | 45 | 115 |
| V8020 | 4,379 | 15 | 15 |
| VF103 | 4,082 | - | 40 |
| VF105 | 4,021 | - | 60 |
| VF107 | 4,073 | - | 40 |
| VF111 | 4,103 | 55 | 50 |
| VF113 | 4,324 | - | 40 |
| VF121 | 4,118 | - | 40 |
| VF123 | 3,942 | - | 50 |
| VF125 | 3,901 | - | 40 |
| VF133 | 4,021 | - | 160 |
| VF135 | 4,136 | - | 120 |
| VP16 | 4,105 | 139 | 120 |
| VP26 | 4,091 | open | 55 |
| VP31 | 3,991 | 95 | 40 |
| VP33 | 3,950 | 205 | 166 |
| VP34 | 4,102 | 42 | 40 |

**Legend**

**Pipe**
- 6-inch
- 8-inch
- 12-inch

**Future Pressure Zones**
- PMZ1
- PMZ2
- PMZ37
- PMZ3
- PMZ36
- PMZ39
- PMZ4
- PMZ40
- PMZ41
- PMZ5
- PMZ6

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