BEFORE THE WASHINGTON

UTILITIES & TRANSPORTATION COMMISSION

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION,

Complainant,

v.

CASCADIA WATER, LLC

Respondent.

DOCKET UW-240151

CROSS-EXAMINATION EXHIBIT OF MATTHEW J. ROWELL AND CULLEY J. LEHMAN
ON BEHALF OF THE
WASHINGTON STATE OFFICE OF THE ATTORNEY GENERAL
PUBLIC COUNSEL UNIT

EXHIBIT MJR-CJL-__X

Cascadia Discovery Response to WCAW DR 47, Attachment 11
(CAL Waterworks Project Report)

February 6, 2025

CAL WATERWORKS
BOOSTER PUMPS AND RESERVOIR REPLACEMENT
PROJECT REPORT

CAL WATERWORKS: PWS ID #31040 6

July 2022

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CERTIFICATE OF ENGINEER

The technical material and data contained within this report has been prepared by or under the direction of the following registered professional engineer(s), licensed in accordance with the laws of the State of Washington to practice in the State of Washington.

QUICK REFERENCE PROJECT INFORMATION

General Project Information

Water System Name	CAL Waterworks
Water System ID Number	32140 6
System Owner	Cascadia Water, LLC
Project Description	Reservoir & Pumphouse Replacement
Reservoir, Pumphouse, and Treatment Site	Island County Parcel #: R22902-136-5260
System Owner/Operator	Culley Lehman (Manager)
System Engineer	Robert Bennion, P.E. - Davido Consulting Group, Inc.

Project Summary

Proposed Storage	79,400-gallon Reinforced Circular Concrete Reservoir (26' Diameter x 20' Tall)
System Design Values	Average Day Demand (ADD) = 250 gpd/ERU Maximum Day Demand (MDD) = 500 gpd/ERU Peak Hour Demand (PHD): [a]Max System Capacity (193 ERUs) = 178 gpm [b]Pressure Zone #1 Future Capacity (150 ERUs) = 148 gpm [b]Pressure Zone #2 Future Capacity (10 ERUs) = 28 gpm *[a]50-70-year forecast used for reservoir sizing* *[b]15-20-year forecast used for booster pump sizing*
Connections	DOH Approved Connections – 146 Active Residential Service Connections – 114 Active Nonresidential Service Connection – 1
Sources	Well #1 (S01), DOE Tag: AGA928, 45 gpm Well #1 (S01), DOE Tag: AGA927, 45 gpm Island County Parcel #: R22902-136-5260
Water Rights	**Water Right #1** Permit Number: G1-00032P Priority Date: December 23, 1971 Q_i = 55 gpm & V_a = 27.5 acre-ft/year **Water Right #2** Permit Number: G1-27478P Priority Date: June 1, 1994 Q_i = 35 gpm & V_a = 26.5 acre-ft/year **Total:** Q_i = 90 gpm & V_a = 54 acre-ft/year
Proposed Booster Pumps	(4) 10-hp Grundfos CR 32-3-2-3ph Centrifugal Booster Pumps (2) 3-hp Grundfos CR 5-9-3ph Centrifugal Booster Pumps

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1 PROJECT DESCRIPTION

This project report describes the proposed system improvements for the CAL Waterworks Water System (Public Water System Identification Number 310406). These improvements include replacing the pumphouse, booster pump system, hydropneumatic tanks, installing a larger concrete reservoir, and providing a loop in the distribution system

1.1 Background

CAL Waterworks (CAL) was first formed under the name Harbor Sands Distribution System (Harbor Sands) in 1963. The name of the system was changed from Harbor Sands to W&B Waterworks #2 and then changed to its current name of CAL Waterworks by 1996. Harbor Sands installed their first well (Well #1) in 1963 and the system was originally approved to serve 105 lots. In 1972, a 40,000-gallon concrete storage reservoir and booster pump station were installed. A second well (Well #2) was installed in 1985 and was approved as a source in 1996. Each well has an approved capacity of 45-gpm. A copy of CAL's Water Facility Inventory (WFI) form is included in Appendix A.

CAL Waterworks (CAL) is currently owned and operated by Cascadia Water, LLC. The System is located off East Harbor Road north of Freeland, WA in the southern portion of Whidbey Island. The location of the service area is shown in Figure 1. CAL has a Washington State Department of Health (DOH) approved capacity of 146 connections, currently CAL has 99 single-family residential connections and one nonresidential connection. The non-residential connection is a wholesale water supply to Goss Lakeridge Acres Association (PWS ID # 220700). Goss Lakeridge Acres has 15 single family residences. Therefore, CAL is currently providing service to a total of 114 residences. A copy of Goss Lakeridge Acres Association WFI form is included in Appendix A. The Goss Lakeridge Acres Water System is located on the north end of the CAL distribution system along East Goodell Road. Goss Lakeridge Acres has its own booster pump system to provide adequate pressure within their distribution system.

The *Cascadia Unified Water System Plan* included the identification of capital improvement projects for the CAL Water System. This proposed project addresses the four (4) highest priority projects. The proposed work includes the following:

1. Waterline Installation – Installing approximately 150-feet of 6" water main to loop the water main along East Harbor Road between Beachwood Drive and Harbor Sands Lane. This project addresses the primary deficiency in the distribution system that limits capacity to the connection with Goss Lakeridge Acres.
2. Pumphouse Building with Booster Pump Station – Installation of a new building with sufficient size for the updated booster pumps, hydropneumatics tanks, and other appurtenances. Includes the design and installation of a booster pump station to maintain system pressures.
3. New storage reservoir – Installation of a new reservoir to provide adequate storage for anticipated future system needs. The existing reservoir will be demolished and replaced with a new storage tank.
4. System Security – Security fencing will be installed around the reservoir, pumphouse, and wells located off Pheasant Farm Lane.

Figure 1: Project Location

1.2 Existing System Configuration

CAL has two wells located on a system owned lot containing the storage reservoir and the pumphouse containing the booster pump stations (Island County Parcel R22902-136-5260). The two wells function in a lead/lag configuration which are controlled by reservoir levels. A well field was designated in 1994 for the purpose of water quality monitoring. The system has water right certificates with a combined withdrawal rate of 90-gpm and annual withdrawal of 54.0 acre-feet per year.

The system includes a single concrete reservoir with a total storage volume of 40,000-gallons (nominal volume). Four 5-hp pumps supply water to the primary (low pressure) service area. A second booster pump station, consisting of twin 1.5-hp pumps further increase the pressure from the discharge of the 5-hp pumps to properly supply the homes in the high elevation pressure zone. The high-elevation pressure zone is referred to as Pressure Zone #2 in this report, while the rest of the service area is referred to as Pressure Zone #1; pressure zones can be seen in Figure 2. Fire flow is not provided by the existing booster system. The four 5-hp booster pump motors are protected from frequent on-off cycling by three 315-gallon vertical hydropneumatic tanks. Two 220-gallon vertical hydropneumatic tanks provide pump protection to the twin 1.5-hp booster pump motors.

Hydraulic modeling indicates that while supplying Peak Hour Demands (PHD) there are portions of the distribution system that experience low service pressures along Ravenridge Drive, Harbor Sands Lane, and east along Goodell Road into Goss Lakeridge Acres. The low pressures are caused by distribution system constraints along East Harbor Road between Beachwood Drive and Harbor Sands Lane. The low-pressure regions are fed off 3-inch water mains. This system deficiency is addressed by this project (Item Section 1.3.1).

Figure 2: Pressure Zone Map

1.3 Recommended Improvements

The proposed improvements are designed to address the higher priority capital improvement projects for the system as identified by the Water System Plan. These projects involve replacement of aging infrastructure which limits distribution system reliability and capacity. In addition, the improvements cover distribution system piping, system storage, system pressure, and general facility security.

1.3.1 Distribution Piping

As noted previously, the *2020 Cascadia Unified Water System Plan* states that when supplying PHD, there are portions of the distribution system that experience low service pressures along Ravenridge Drive, Harbor Sands Lane, and east along Goodell Road into Goss Lakeridge Acres. In the hydraulic model discussed in Section 5.4, the low pressures in the distribution system are resolved by installing a small section of new water main along East Harbor Road between Beachwood Drive and Harbor Sands Lane. The new main will connect the existing 4-inch line on the intersection of East Harbor Road and Beachwood Drive to the existing 6-inch main located midway between Beachwood Drive and Harbor Sands Lane 150-feet to the North.

In addition, an 8-inch watermain will be extended from the pumphouse down an existing easement between Island County parcels R22902-150-5110 and R22902-142-5030 to East Harbor Road. This line will extend approximately 350-feet northwest where it will cross under East Harbor Road and connect to the existing 4-inch water main located on the west side of this road. This section of pipe will replace an old 4-inch water main and is sized to support future system improvements, including fire flow capacity, if desired, at a later date.

1.3.2 System Storage

The existing reservoir is a 40,000-gallon octagonal concrete reservoir installed in 1972. This reservoir has reached its useful life expectancy and is leaking from the corners. The existing reservoir will be removed and replaced with a storage reservoir sized to provide for the system's anticipated future storage needs for a maximum capacity 193 Equivalent Residential Units (ERUs). The proposed reservoir has a storage capacity of 79,400-gallons with dimensions of 26-feet diameter by 20-feet of height.

During construction temporary storage will be installed to support system operations. Demolition of the old reservoir and construction of the new reservoir will be staged to reduce the timeframe for the temporary storage, and to allow for the temporary storage to be in use outside of the season where the system experiences peak demands. During reservoir replacement, consumers will be notified of the reduced storage capacity and they will be encouraged to limit water usage during construction.

1.3.3 Pumphouse and Booster Pump Replacement

The existing pumphouse is in poor condition and has an inadequate layout to properly service the installed equipment. The existing pumphouse will be demolished and replaced. The new pumphouse will be sized to locate the booster pump system(s), associated hydropneumatic tanks, and controls.

The current booster pumps and pressure tanks have exceeded their useful life and no longer provide reliable service to the system. New booster pump systems will be installed to support current and future anticipated system demands in accordance with growth expectations estimates provided in the Water System Plan. There are two separate booster pump systems, one for the lower pressure zone, Pressure Zone #1, which includes the majority of the system's connections, and a second for the upper pressure zone, Pressure Zone #2. Both systems are designed to meet the Peak Hour Demand (PHD) corresponding to the area and service connections that each system serves. The booster system for Pressure Zone #1 is also designed to provide adequate capacity to provide residential fire flow. The existing pumphouse and equipment will continue to operate throughout construction.

2 PLANNING CONSIDERATIONS

No additional management responsibilities will be necessary because the project is an in-kind replacement of an existing reservoir. Cascadia Water, the owner of CAL Waterworks, owns the parcel where the new reservoir and pumphouse will be constructed. There are no known legal considerations that would affect the proposal.

The proposed new reservoir and pumphouse will comply with the setbacks required by Island County. Per the Island County municipal code, a reservoir must be located with at least 0.5 feet of setback for every 1 foot of reservoir height above ground-level. The proposed 20-foot-tall reservoir results in a setback requirement of 10' feet. A building permit with Island County is required for the reservoir construction. A building permit will be obtained by the installation contractor prior to the start of construction activities. The building permit will require a site plan, tank and building construction details and supporting structural engineering calculations.

Construction of the project is proposed to start in Fall of 2022. Operational costs of the proposed change to the system are negligible. Maintenance should continue as usual and should consist of periodic cleaning and inspection of the reservoir.

The replaced reservoir has been sized to accommodate the system's maximum capacity of 193 connections, as noted in the 2020 Cascadia Water System Plan. No increase in system capacity is being requested with this project, however, the System is planning on expanding in the future, therefore, the reservoir has been designed to have the capacity for future expansion.

3 DESIGN CRITERIA

3.1 Water System Design Values

Water usage design values were taken from the latest approved capacity analysis for CAL Waterworks approved in 2018 (DOH Submittal No. 18-0101). The water usage data in that analysis was based on 3 years of data.

3.1.1 Average Day Demand

The annual average day demand (ADD) was 175 gpd/ERU for this period. The maximum summer (June-September) ADD value is approximately 250 gpd/ERU. For a conservative analysis, the maximum summer ADD of 250 gpd/ERU was used as the system ADD.

3.1.2 Maximum Day Demand

Maximum day demand (MDD) is ideally determined by meter readings and is the largest single-day usage of water based upon production. The maximum day demand (MDD) could not be determined from actual water use data due to lack of daily source meter readings. Therefore, the meter readings for each system were analyzed to determine a maximum monthly average day demand (MMADD). The MMADD is then multiplied by a peaking factor to determine MDD per the DOH Water System Design Manual (Design Manual) Section 3.4.1. The highest (maximum) monthly average day demand (MADD) reading is 293 gpd/ERU. The MDD used in the analysis is determined from the MADD and equates to 500 gpd/ERU.

3.1.3 Peak Hour Demand

The Peak Hour Demand (PHD) was found using Equation 3-1 from the DOH *Water System Design Manual*, 2019 edition (referred to as the "Manual" throughout this report). The equation uses the MDD and the number of potential connections to determine the PHD flowrate.

$$\mathrm{PHD} = \frac{\mathrm{MDD}}{1440}((\mathrm{C})(\mathrm{N}) + \mathrm{F}) + 18$$

Where:
PHD = Peak Hour Demand (gpm)
MDD = 530 gpd/ERU
C = coefficient based on system size (see Table 1)
N = number of potential connections
F = coefficient based on system size (see Table 1)

The coefficients that are utilized in the above formula are dependent upon the number of connections served. The coefficients used are listed below in Table 1.

Table 1: Peak Hour Demand Calculation Coefficients

Range of ERUs	C	F
15 – 50	3.0	0
51 – 100	2.5	25
101 – 250	2.0	75
251 – 500	1.8	125
> 500	1.6	225

To properly assess source capacity, water right capacity, and storage levels the full system PHD was developed. However, booster pumps for the separate pressure zones are based on the PHD corresponding to the potential number of service connections in each zone. Therefore, the values for PHD that were used in the development of the proposed improvements are shown in Table 2.

Table 2: Peak Hour Demand Design Values

Area	ERUs	C	F	PHD (gpm)
Existing System [a]	114	2.0	75	123
Future System [b]	193	2.0	75	178
Future Pressure Zone 1 [c]	150	3.0	0	148
Future Pressure Zone 2 [d]	10	2.0	75	28

[a] Used for sizing of temporary storage requirements
[a] Used for sizing of the proposed reservoir
[a] Used for sizing of booster pumps for Pressure Zone 1
[a] Used for sizing of booster pumps for Pressure Zone 2

4 RESERVOIR DESIGN CALCULATIONS

4.1 Reservoir Sizing

The system design parameters from Section 3 were used to support the reservoir sizing. Reservoir sizing was completed according to DOH guidance in the *Water System Design Manual*, 2019 edition (Design Manual) to ensure that the system would have adequate storage capacity to meet the needs of currently approved connection as well as anticipated future needs. With limited space on the system owned parcel, it will be necessary to remove the existing reservoir to install the new one. During this process, temporary storage will need to be provided. Design calculations for the temporary storage, based on current connections, and the proposed reservoir, based on future projections are included in Appendix C. The five following storage components were considered in the design process:

1. Operational Storage (OS)
2. Equalizing Storage (ES)
3. Dead Storage (DS)
4. Standby Storage (SB)
5. Fire Suppression Storage (FSS)

The proposed reservoir consists of reinforced circular concrete with a diameter of 26 feet and a height of 20 feet. This results in a total storage capacity of approximately 79,400 gallons (V_R) and 3,970 gallons of storage per foot of reservoir height (V_f). Temporary storage will consist of two hydraulically connected 5,000 gallon polyethylene tanks with a total storage capacity of 10,000-gallons. Each of the temporary storage reservoirs is 10-feet in diameter and has an effective height of 8.66 feet.

4.1.1 Operational Storage

Operational storage (OS) is the height difference between the water levels in the reservoir where the well pumps are turned on and off. Adequate operational storage will prevent excess cycling of the well pumps by minimizing the number of times they need to start. 1-foot of elevation difference will be provided between the well pump on and off signals. Therefore, the operation storage is calculated as follows:

Proposed Reservoir:
$\text{OS} = 0.5\text{ ft} \cdot 3{,}970\ \text{gal/ft} = 1{,}990\ \text{gallons}$

Temporary Storage:
$\text{OS} = 0.5\text{ ft} \cdot 1{,}150\ \text{gal/ft} = 580\ \text{gallons}$

Each of the CAL sources alternates in filling the reservoir, unless levels fall continue to fall, at which point the lag pump is activated. In typical operations, at a fill rate of 45 gpm, the 1,990 gallons of OS will allow the well pumps to stay on for a minimum of 44 minutes during filling operations. This volume is adequate to provide the required pump protection.

With the temporary storage reservoirs, the 580 gallons of OS will create fill times of approximately 13 minutes which also provides adequate pump protection.

4.1.2 Equalizing Storage

Equalizing storage (ES) is the volume of water that is needed to meet the peak demand period for the water system. Equalizing storage was calculated using equation 7-1 from the DOH *Water System Design Manual*, 2019 edition as follows:

$$\text{ES} = (\text{PHD} - \text{Q}_s)(150\ \text{minutes})$$

Where:

PHD = Peak Hour Demand
Q_s = Downstream system limiting capacity (90 gpm)

The proposed reservoir is designed to have the sufficient storage to support the anticipated system maximum capacity of 193 ERUs. The ES for the temporary storage was based on the current number of system connection (114 ERUs) including those from the Goss Lakeridge Acres distribution system. The PHD values associated with each scenario are found in Table 2.

Proposed Reservoir:

$$\text{ES} = (178\ \text{gpm} - 90\ \text{gpm}) \cdot (150\ \text{minutes}) = 13{,}210\ \text{gallons (or 3.3 ft of storage)}$$

Temporary Storage:

$$\text{ES} = (123\ \text{gpm} - 90\ \text{gpm}) \cdot (150\ \text{minutes}) = 4{,}950\ \text{gallons (or 4.3 ft of storage)}$$

4.1.3 Dead Storage

Dead storage (DS) is the unusable volume at the top (TDS) and bottom (BDS) of the reservoir. 6 inches of freeboard will be provided at the top of the proposed temporary storage reservoir(s). The reservoir outlet will be raised 6 inches above the bottom of the reservoir to prevent silt and other material that may collect in the reservoir from entering the distribution system. In addition, the booster pump low-level shut off will be set an additional 6 inches above the reservoir outlet, resulting in 1 foot of BDS. Therefore, dead storage values can be calculated as follows:

Proposed Reservoir:

$$\text{TDS} = 0.5\ \text{ft} \times 3{,}970\ \text{gal/ft} = 1{,}985\ \text{gallons (or 0.5 ft of storage)}$$
$$\text{BDS} = 1.0\ \text{ft} \times 3{,}970\ \text{gal/ft} = 3{,}970\ \text{gallons (or 1.0 ft of storage)}$$
$$\text{DS} = \text{TDS} + \text{BDS} = 5{,}960\ \text{gal (or 1.5 ft of storage)}$$

Temporary Storage:

$$\text{TDS} = 1.0\ \text{ft} \times 1{,}150\ \text{gal/ft} = 1{,}150\ \text{gal (or 1.0 ft of storage)}$$
$$\text{BDS} = 1.0\ \text{ft} \times 1{,}150\ \text{gal/ft} = 1{,}150\ \text{gal (or 1.0 ft of storage)}$$
$$\text{DS} = \text{TDS} + \text{BDS} = 2{,}230\ \text{gal (or 2.0 ft of storage)}$$

4.1.4 Standby Storage

Standby storage (SB) is the volume of water available to supply the system in case of source supply issues. The minimum recommended standby storage volume is 200 gallons per ERU. This results in a recommended standby storage volume of 38,600 gallons based on the system's maximum capacity of 193 ERUs. The temporary storage will provide minimal standby storage volume. The timing for use the temporary storage will be outside of peak seasonal demands for the system.

The standby storage provided by the both the proposed reservoir and temporary storage can be calculated as the remaining volume after operational storage, equalizing storage, and dead storage are accounted for. The provided standby storage is calculated as follows:

Proposed Reservoir:

$$\text{SB}_{\text{recommended}} = 200(\text{ERUs}) = 200(193) = 38{,}600\ \text{gallons}$$
$$\text{SB}_{\text{provided}} = \text{V}_{\text{R}} - (\text{OS} + \text{ES} + \text{DS}) = 79{,}430 - (1{,}990 + 13{,}210 + 5{,}960) = 58{,}480\ \text{gal}\textit{lons}$$

Temporary Storage:

$$\text{SB}_{\text{provided}} = \text{V}_{\text{R}} - (\text{OS} + \text{ES} + \text{DS}) = 10{,}000 - (580 + 4{,}950 + 2{,}230) = 2{,}250\ \text{gallons}$$

4.1.5 Fire Suppression Storage

Currently, CAL Waterworks is not required to provide fire flow. However, system improvements are being sized so that the system will be able to support fire flow in the future. Fire suppression storage

(FSS) requirements are set by Island County (IC). IC residential fire flow requirements are 500 gpm for 30 minutes, which equates to 15,000 gallons of required storage volume. Fire suppression storage may be nested with standby storage. The FSS storage requirements are satisfied, since the provided standby storage exceeds the fire flow requirements. The storage volumes provided by the proposed reservoirs are summarize in Table 3.

Table 3: Storage Components

	Proposed Reservoir		Temporary Storage	
Storage Component	**Volume (gallons)**	**Equivalent Height (feet)**	**Volume (gallons)**	**Equivalent Height (feet)**
Top Dead Storage	1,990	0.5	1,150	1.0
Operational Storage	1,990	0.5	580	0.5
Equalizing Storage	13,210	3.3	4,950	4.3
Standby Storage	58,480	14.7	2,250	1.9
Bottom Dead Storage	3,970	1.0	1,150	1.0
Total	**79,400**	**20.0**	**10,000**	**8.7**

4.2 Reservoir Floats and Piping Levels

The proposed reservoir will be constructed with a finished floor at the surrounding grade. The height of the proposed reservoir overflow, inlet, outlet, and drain lines are provided in Table 4, and are reported relative-to the finished floor of the proposed reservoir.

Table 4: Proposed Reservoir Piping Levels

	Proposed Reservoir	Temporary Storage
Piping Component	**Height* (feet)**	**Height* (feet)**
Inlet from Wells (Pipe Invert)	19.67	9.0
Overflow (Pipe Invert)	19.50	8.5
Outlet (Suction Line)	0.50	0.5
Drain	0	0

** All measurements occur from the floor of the proposed reservoir.*

Reservoir set points for lead and lag well pump on/off levels, low-level alarm, high-level alarm, and booster pump shut off levels are provided in Table 5.

Table 5: Reservoir Set Points

Reservoir Control Set Points	Proposed Reservoir Height* (feet)	Temporary Storage Height* (feet)
High Level Alarm	19.5	8.2
Well Pumps Off	19.0	8
Lead Well Pump On	18.5	7.5
Lag Well Pump On	18.0	7
Low Level Alarm	10.0	5.0
Booster Pump Shut Off	1.0	1.0

** All measurements occur from the floor of the proposed reservoir.*

4.3 Water Age

According to the DOH *Water System Design Manual*, 2019 edition on page 196, "long detention times in reservoirs can lead to loss of disinfectant residual, microbial growth, sediment accumulation, formation of disinfection byproducts, taste and odor problems, and other water quality issues." It is recommended that a complete turnover of water in a storage reservoir occur at least every three to five days to minimize these problems. The following calculation was used to estimate the average water age in the proposed reservoir. The calculation uses the existing number of connections of 115 ERUs (N) and the lowest ADD that the system has experienced (144 gpd/ERU).

$$\text{Water Age} = \frac{V_R - \text{TDS}}{\text{ADD} \cdot \text{N}} = \frac{79{,}400\ \text{gal} - 3{,}970\ \text{gal}}{144\ \text{gpd/ERU} \cdot 115\ \text{ERUs}} \cong 4.5\ \text{days}$$

The water age was estimated to be about 4.5 days which is acceptable. Water age is not expected to cause any complications with the proposed reservoir.

5 BOOSTER PUMP SYSTEM DESIGN CALCULATIONS

5.1 Booster Pump Design & Requirements

The guidelines for sizing a closed system booster pump station are described in section 8.1.2 of the Design Manual. The System's demands and flow rates are summarized in Section 3.1 of this report. System demands are calculated based on the approved number connections.

Per section 8.1.2 of the Design Manual, the booster stations are required satisfy to meet the following scenarios:

1. Supply the system Peak Hour Demand (PHD) while providing at least 30-psi to all service connections.
2. While not currently required to provide fire flow, the pumps have been designed to meet future fire flow demands. The Design Manual requires Fire Flow (FF) during Maximum Day Demand (MDD) while supplying at least 20-psi to all service locations within the distribution system. In this scenario, the largest pump supplying the supplying pressure zone of the distribution system is assumed to be out of service. This is discussed in further detail in Section 5.4.3 of this report.

5.2 Pump Settings and & System Pressures

The booster pumps for Pressure Zone #1 will be replaced with four (4) 10 hp Grundfos CR 32-2 A-G-A-E-HQQE booster pumps. The pumps have been sized to provide for existing PHD while having some flexibility to provide for future demands on the system. Cumulatively, the four pumps would be capable of providing residential fire flow requirements and MDD with the largest pump out of service. The four booster pumps will operate on an alternating lead/lag/lag/lag configuration where the starting and lag pumps will alternate with each pump-start. The proposed pressure settings are summarized in Table 6 and pump curves are included in Appendix D.

The booster pumps for Pressure Zone #2 will be replaced with two (2) 3 hp Grundfos CR 5-9-3ph booster pumps. Each pump provides a flow rate of 31 gpm at 95 psi and 39 gpm at 85 psi. These pumps will also operate on an alternating lead/lag configuration.

The pressure settings for each booster pump station were analyzed in a hydraulic model discussed in Section 5.4. The proposed pressure settings are summarized in Table 6 and pump curves are included in Appendix D.

Table 6: Booster Pump Pressure Settings

Pressure Zone #1 (4) 10 hp Grundfos CR 32-3-2-3ph	
Pump Position	**On/Off Pressure Setting**
Lead Pump	60/75 psi
Lag #1	55/70 psi
Lag #2	50/65 psi
Lag #3	45/60 psi
Pressure Zone #2 (2) 3 hp Grundfos CR 5-9-3ph	
Pump Position	**On/Off Pressure Setting**
Lead Pump	85/95 psi
Lag	75/85 psi

5.3 Pressure Tanks

New bladder tanks will be provided for each pressure zone. The minimum pressure tank storage for each booster pump system was found using Equation 9-1 from the Design Manual:

Design Manual Equation 9-1:

$$T \geq \frac{(R)(Q_p)}{(N_C)(V_B)}$$

Where:

$R = \dfrac{15(P_1 + 14.7)(P_2 + 14.7)}{(P_1 - P_2)/(P_2 + 9.7)}$

T = Total number of pressure tanks (gallons)

P_1 = Pump-Off pressure for water system operation (psi)

P_2 = Pump-On pressure for water system operation (psi)

N_c = Number of pump operating cycles per hour (6 cycles per alternating pump)

Q_p = Pump delivery capacity at the midpoint of the selected pressure range (gpm)

The lead pump for Pressure Zone #1 has on/off pressure settings of 60-psi and 75-psi. Q_P was found to be 135 gpm at 67.5 psi. The number of pump cycles per hour, N_C,was found to be 24 total cycles per hour, or 6 cycles per hour per alternating pump. Using 317-gallon Amtrol WX-454C bladder tanks, the minimum number of bladder tanks is 2. The pressure tanks should have an acceptance volume of 158 gallons which would equate to minimum pump run time of 1 minute. This meets minimum run time recommendations form pump manufacturers.

The lead pump for Pressure Zone #2 has on/off pressure settings of 85-psi and 95-psi. Q_P was found to be 34 gpm at 90 psi. The number of pump cycles per hour N_C was found to be 12 total cycles per hour, or 6 cycles per hour per alternating pump. Also using 264-gallon Amtrol WX-453C bladder tanks, the minimum number of bladder tanks is 2. The pressure tanks should have an acceptance volume of 158 gallons which would equate to minimum pump run time of 1 minute. This meets minimum run time recommendations form pump manufacturers.

5.4 Hydraulic Modeling

A hydraulic model was created using the software EPA-NET to simulate the proposed system to ensure adequate flow and pressure during operation and to verify that the proposed booster pumps meet the estimate demands. The following three scenarios were simulated using the hydraulic model:

1. PHD scenario (see scenario 1 in Table 7);
2. MDD plus FF scenario (see scenario 2 in Table 7), and
3. A static water pressure scenario with high pressure settings and no demand.

The criteria that were used to size the booster pump systems and the assumptions made in each modeling scenario are described in Table 7. All scenarios model the system with the improvements proposed in this project, including the proposed loop in the distribution system discuss in Section 1.3.1 and the proposed reservoir.

Table 7: Hydraulic Modeling Scenarios, Requirements, and Assumptions

Scenario	Demand Condition	Pressure Requirements	Scenario Assumptions
1	Peak Hour Demand	> 30 psi	• Equalizing Storage Depleted • Pressure Tanks at the Lead Pump "On" setting
2	Fire Flow + Maximum Day Demand	> 20 psi	• Largest Pump Out of Service • Equalizing & Fire Suppression Storage Depleted • Pressure Tanks at the 2nd Lag Pump "On" setting
3	Static Water Pressure	< 80 psi*	• All pumps off • Reservoir at bottom of Top Dead Storage • Pressure tanks at Lead Pump "Off" setting

5.4.1 Scenario #1: Peak Hour Demand

The PHD scenario was modelled to verify whether the proposed booster pumps systems and pressure settings can provide the PHD and a minimum pressure 30 psi at all service locations. For this scenario, the storage reservoir is assumed to have the equalizing storage depleted and the pressure tanks are assumed to be at the Lead Pump "On" setting for both pressure zones, or 55 psi and 85 psi for Pressure Zones #1 and #2 respectively. A single pump is adequate to supply PHD for each zone, so lead pump settings are used. The System's two pressure zones operate independently in the proposed configuration; therefore, each pressure zone was assumed to be at its estimate peak hour demand of 148 gpm and 29 gpm, respectively, as summarized in Section 3.1.3.

In the PHD modelling scenario, it was found that the pressure at all locations throughout the distribution system meet the minimum required pressure of 30 psi. In Pressure Zone #1, the lowest resulting service pressure was found to be 34 psi. In Pressure Zone #2, the lowest resulting pressure was found to be 40 psi.

5.4.2 Scenario #2: Static Water Pressure

For scenario 2, the static water pressure scenario, the pumps were turned off, and the reservoir and pressure tanks were set to their maximum levels. In Pressure Zones #1 and #2, the maximum pressure on the distribution system was found to be 80 psi and 95 psi. With the maximum water pressure within the Pressure Zone #2 exceeding 80-psi, it is recommended that the identified service connections with elevated pressures be provided with an individual pressure reducing valve.

5.4.3 Scenario #3: Fire-Flow

In order for the distribution system to provide fire flow in the future, it will be necessary to perform additional improvements to the system consisting of water main replacement along East Harbor Road. However, the currently proposed improvements have been sized to be capable of providing fire flow in the future. Scenario 3, the fire-flow scenario, the MDD of 58 gpm was distributed across the entire system. The fire-flow (FF) of 500 gpm was applied to one node in the distribution system. The Equalizing Storage and Fire Suppression Storage was assumed to be depleted, resulting in water level of 11 ft in the proposed reservoir.

As noted previously, the replacement of 4-inch water mains along East Harbor Road with minimum 6-inch water mains will be required for these future improvements. These improvements are noted in the Capital Improvement Project in the *2020 Cascadia Unified Water System Plan* for the medium to long term and are not proposed as a part of this project.

6 OPERATION AND MAINTENANCE CONSIDERATIONS

The system is owned and operated by Cascadia Water. The proposed work is replacement of existing equipment and features, so the changes to the system operation and maintenance is not significantly affected. No or minimal water quality changes are expected from the replacement of the reservoir. The system’s Operation and Maintenance (O&M) plan should be updated to include the manufacturer’s recommended procedures for the new booster pumps, bladder tanks, floats, controls, and other new equipment. Maintenance should continue as usual and should consist of periodic cleaning and inspection of the reservoir and line flushing. Operational costs of the reservoir are not expected to change significantly.