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RDOS-23-UTL-09 | Engineering & Financial Assessment of the Sage Mesa Water System

Final Report

July 23, 2024 | Version 3 for RDOS Review

Submitted to: Regional District of Okanagan-Similkameen
Prepared by McElhanney

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Our file: 2422-20427-00

Your Challenge.
Our Passion.

July 23, 2024

Regional District of Okanagan-Similkameen
101 Martin Street
Penticton, B.C. V2A 5J9

Attention: Liisa Bloomfield, Manager of Utilities

Engineering & Financial Assessment of the Sage Mesa Water System – RDOS-23-UTL-09 -Technical Report - Final

An assessment of the Sage Mesa Water System is required so that the Regional District of Okanagan-Similkameen (RDOS) can understand source water characteristics, upgrades required for the treatment plant to meet current regulations and the current state of the waterworks system including distribution deficiencies, and capital and operating costs before considering taking over the system.

The engineering and financial assessments will give the RDOS a clear picture of how the system is currently operating, and the timing of future maintenance and upgrades based on the water source.

This Technical Report summarizes the infrastructure assessment, required upgrades and includes individual component or system cost estimates. The financial assessment reviews when funds related to future maintenance and upgrades will be required.

If you have any questions regarding this report, please do not hesitate to contact us.

Sincerely,

Lee Peltz, P.Eng., Project Manager
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Contents

APPENDICES

Executive Summary

Before taking over the Sage Mesa Water System, the Regional District of Okanagan-Similkameen (RDOS) needs to understand source water characteristics, upgrades required for the treatment plant to meet current regulations, and the current state of the waterworks system including distribution system deficiencies, and capital and operating costs.

RDOS has engaged McElhanney to provide engineering and financial assessments to give the RDOS a clear picture of how the system is currently operating, as well as what future maintenance and upgrades will be needed based on the water supply source. Two water supply options were considered:

- Okanagan Lake, which would require a new water treatment plant (WTP).

- The City of Penticton (CoP) operated West Bench System, which would require a hypochlorite top-up station to ensure disinfection residuals to the end of the system.

The evaluation also considered infrastructure (reservoir, pumping station, and pressure control stations) and pipe distribution system upgrades required for each scenario.

Regardless of how the water source and distribution system is improved, most of the Sage Mesa upgrades are needed now, to replace ageing infrastructure which is at the end of its life, and which does not provide sufficient fire storage, and in some instances sufficient hydrant coverage. The upgrades discussed below are needed to bring the system up to the minimum requirements based on guidelines and regulations.

The Distribution System

The existing system was first installed in the 1960’s with some of the infrastructure and piping being over 60 years old. A majority of the system was developed in the mid-1970 to mid-1990s. A desktop evaluation on the condition of the existing system was done.

In addition, the distribution system was modelled to determine the required upgrades to ensure design guidelines related to velocity, flow rate and pressure are met under average, max day and peak hour conditions. The system was also modeled to verify capacity under fire flow conditions.

These scenarios were modeled considering only one Upper Zone reservoir or two reservoirs (Upper Zone and Lower Zone) in use and supply of potable water either from a new water treatment plant (WTP) or from the West Bench system.

It was determined that most of the upgrades required to the distribution system were required regardless of the water supply source or number of reservoirs in service.

Reservoir Storage

Previous studies have concluded that both the existing Upper Zone and Lower Zone Reservoirs should be replaced, with the Upper Reservoir being the higher priority. In addition, based on required storage volumes, neither the Upper nor Lower Reservoirs has sufficient storage to supply their respective zones during fire flows.

Consequently, the cost and benefits of having one or two reservoirs was evaluated and discussed with the RDOS. Although having two reservoirs would provide additional fire flow storage due to the need to store fire flow in both reservoirs, it is more costly than having one reservoir and requires additional maintenance.

Based on discussions with the RDOS on Thursday November 23, 2023, RDOS gave the direction to consider one reservoir for the overall cost comparison of the two water supply scenarios.

Treated Water Supply

Two treated water supply options were evaluated. The first considered the water supply and treatment within Sage Mesa. As the existing treatment system does not meet current guidelines and there is insufficient space to expand the existing raw water pumphouse, cost estimates assume a new WTP would be located in the vicinity of the existing Lower Reservoir, at the edge of the Pine Hills Golf Course.

Four treatment system options were evaluated as follows:

1. Dissolved Air Flotation (DAF) with Rapid Sand Filtration
2. Hollow Fibre Nanofiltration (HNF)
3. Ballasted Flocculation and Rapid Sand Filtration
4. Pressure Filtration – Sand Media and Granular Activated Carbon and UV Disinfection

Based on capital and life-cycle costs, Option #4 – Pressure Filtration, was the least costly option.

The second option considered connecting to the West Bench distribution system. This option required a new watermain and flow control station to convey water from West Bench to the Lower Reservoir. It was assumed that a chlorine booster system would be required to ensure sufficient residual chlorine at the end of the Sage Mesa system. Pending confirmation that one of the two existing chlorine systems (raw water pumphouse or lower reservoir booster station) could be re-used, it was assumed that a new chlorination system would be required and could be housed in the lower reservoir booster station.

Cost Comparison Summary

The cost estimate for the two water supply options is summarized in the Table below. The common upgrades recommended for the system, regardless of the water supply source, are identified at the top of the table and the split comparison of the two water source options is included in the bottom half. Costs shown in the table have assumed that the single reservoir option and WTP option #4 – Pressure Filtration have been selected.

Table 1:Comparison of Cost Estimate for the Treatment Option vs. the Connection to Penticton Option

Description	New WTP Option	West Bench Supply - Option
Recommended for Both Options		
1. Distribution Upgrade - Forsyth Main, Hydrants, & Existing PRV Station	$2,720,000	
2. Distribution Upgrade - WOW Golf to Solana Main & Hydrants	$560,000	
3. Distribution Upgrade - Solana & Sage Mesa Main & Hydrants	$510,000	
4. Distribution Upgrade - Verano Main, Hydrant, and PRV	$600,000	
5. Distribution Upgrade - Sage Mesa North Hydrant	$30,000	
6. New Upper Reservoir. Includes connection and PRV/FCV kiosk to bypass Booster Station & Lower Reservoir	$2,950,000	
7. Demolition of Existing Upper and Lower Reservoirs	$200,000	
8. Addition/Replacement of Water Meters to all properties (incl. new meter and meter vault)	$850,000	
9. Replacement of remaining existing PRV station in Upper Zone	$250,000	
10. Booster Station Upgrades Incl. Backup Power	$200,000	
Sub-Total including 40% Contingency	**$8,870,000**	
Engineering Allowance (15%)	$1,300,000	
TOTAL	**$10,170,000**	
Water Source / Treatment Options	**New WTP Option**	**West Bench Supply Option**
11. Raw Water Pumphouse Upgrades, incl. intake	$1,860,000	-
12. Treatment Plant	$4,704,000	-
13. WTP Connection to Existing Distribution	$540,000	-
14. Connection to West Bench system incl. PRV/FCV kiosk and water meter kiosk	-	$1,970,000
15. Wet Well / Sump for Suction Side of Booster Station Pumps	-	$105,000
16. Hypochlorite Top-Up System	-	$60,000
17. Pumphouse Decommissioning Incl. Intake Capping	-	$100,000

18. Approximate City of Penticton DCCs (based on bulk water purchase agreement with the City)	-	$3,353,000
Sub-Total including 40% Contingency	**$7,104,000**	**$5,588,000**
Engineering Allowance (15%)	$1,100,000	$800,000
TOTAL	**$8,204,000**	**$6,388,000**
TOTAL INCLUDING DISTRIBUTION UPGRADES	**$18,374,000**	**$16,558,000**
ADDITIONAL COST TO REPLACE THE REST OF THE SAGE MESA SYSTEM (INCL. ENGINEERING ALLOWANCE)	**$14,600,000**	

As there is less than a 22% cost difference between the two water supply options, excluding the required system upgrades to address deficiencies, and the estimate is based on a Class D estimate with a 40% contingency, it is recommended that the RDOS consider tying into the West Bench System.

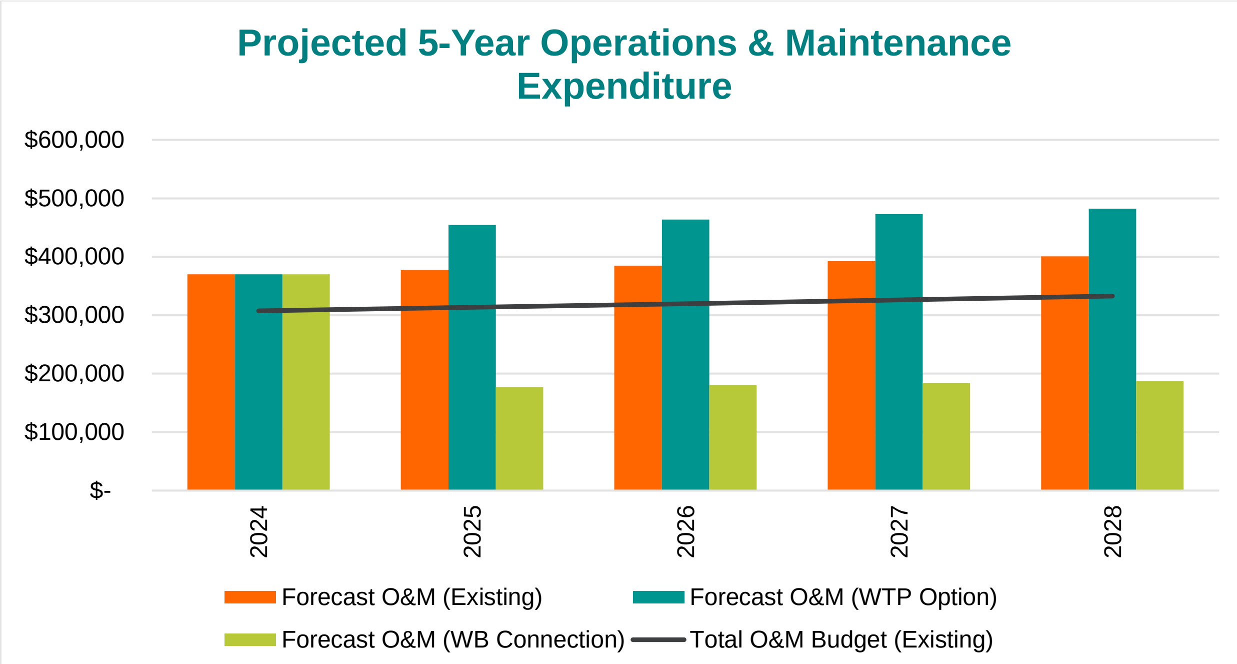
The cost associated with replacing the rest of the ageing Sage Mesa water distribution network beyond the upgrades summarized above is estimated at approx. $14,600,000.

A new WTP for Sage Mesa alone is likely not viable based on the cost estimate provided herein. The rate payer base is relatively small and fixed due to limited expansion opportunities based on topography, boundaries, and geology.

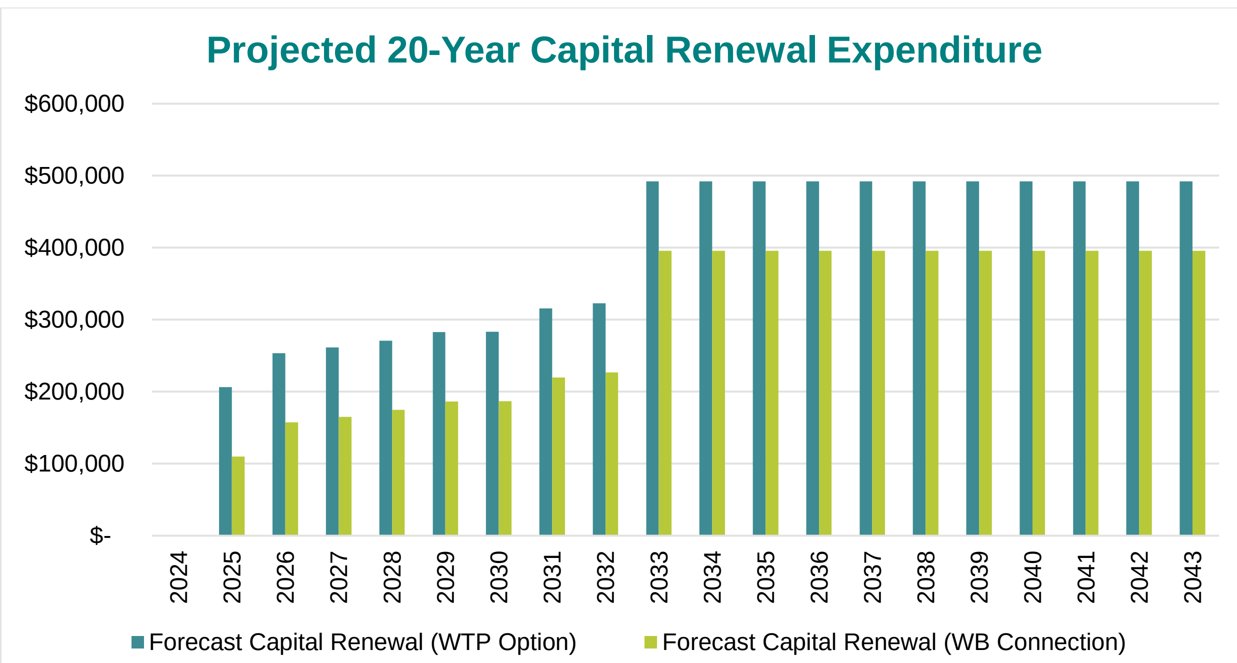
Financial Analysis

A 20-year forecast for operations and maintenance (O&M) budget requirements and annualized renewal costs as contributions to reserves for future replacement based on new capital works was developed for the existing system and two proposed supply options.

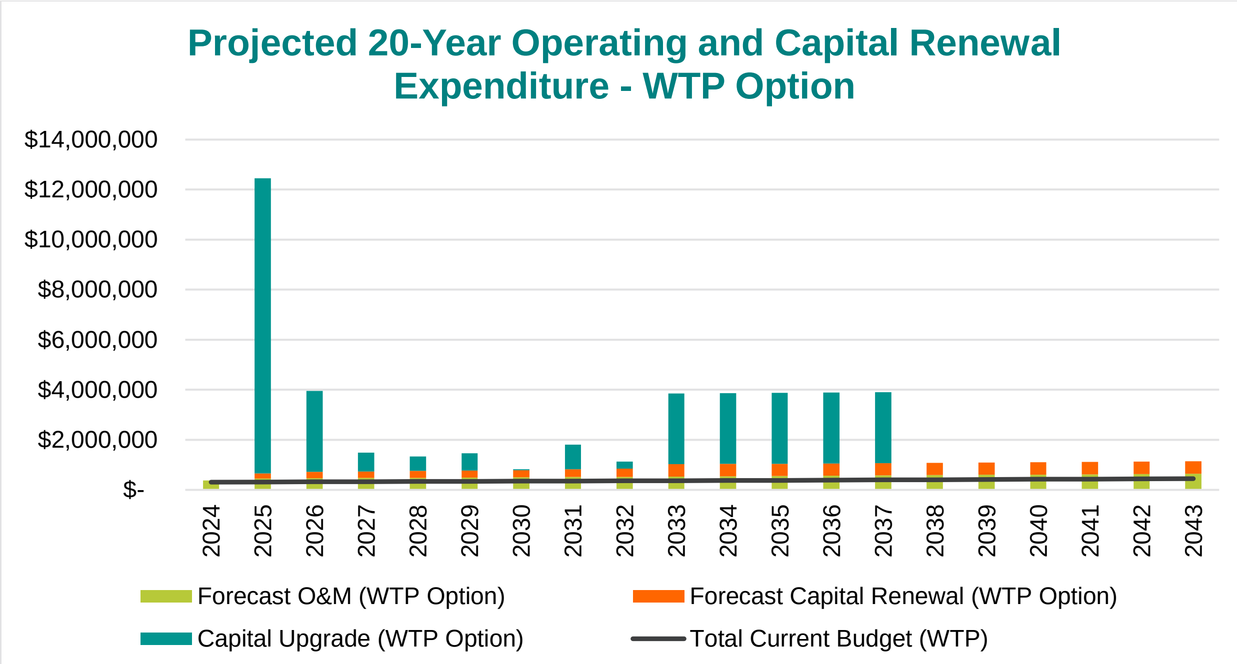
The annual O&M cost for the existing system including additional administrative and financial assistance is estimated at $369,989 in 2024. The forecasted short-term (5-year) O&M expenditures for the existing Sage Mesa system and both water source options against the projected O&M budget (based on the 2023 O&M budget) are shown in the figure below. All costs are in 2023 dollars and include 2% annual inflation.

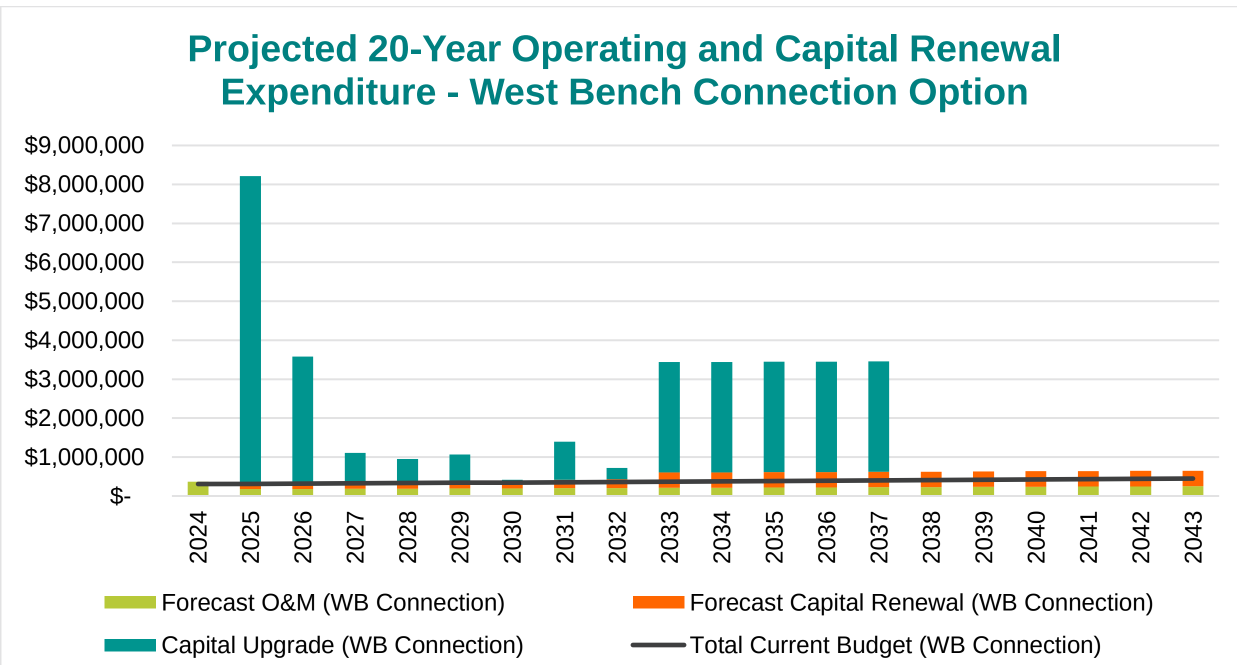


Annualized renewal costs for the new WTP option in its fully built-out state including the total distribution system are estimated at $492,191 at the end of the 20-year planning period. Annualized renewal costs for the West Bench Connection option in its fully built-out state including the total distribution system are estimated at $395,948 at the end of the 20-year planning period.



Combined O&M and annualized renewal costs for the WTP option is estimated at $1,141,377 at the end of the 20-year planning period. Combined O&M and annualized renewal costs for the West Bench Connection option is estimated at $648,709 at the end of the 20-year planning period.





Additional Considerations

Other considerations and options that should be reviewed in the future but were not included as part of this assessment are as follows:

1. Expanding the new WTP to supply water to Westbench and Penticton Indian Band (PIB) as well as Sage Mesa as part of the WTP option analysis should be considered. Currently Westbench is supplied water by the City of Penticton and PIB is serviced via a combination of their own wells

and the City of Penticton. Expanding the rate payer base (demand) will reduce the per household rate payer costs. In addition, as the City, Westbench, and PIB are all expanding, transferring the water Westbench and PIB demand to a new WTP will allow the City of Penticton to defer expansions to the City's WTP.

Note that at the time of writing the report, discussions with the PIB had been initiated to understand their future needs.

2. The location of the WTP should also be reviewed depending on the areas ultimately serviced. The existing location was suggested based on access to existing infrastructure and to minimize changes to the supply network. However, if Westbench and PIB are also supplied by a new WTP, there are likely other sites closer that would be more appropriate to avoid major reconfiguration of the Westbench system.

1. Introduction

1.1. PROJECT BACKGROUND

The Regional District of Okanagan-Similkameen (RDOS) received a request from the private owners of the Sage Mesa Water & Public Service Co. Ltd. to consider acquisition of the water system. Prior to acquiring the Sage Mesa Water System, the RDOS needs to assess and understand the state of the existing system including source water characteristics, upgrades required for the treatment plant to meet current regulations, and the current state of the waterworks system including distribution deficiencies, and capital and operating costs to upgrade the system.

The RDOS has engaged McElhanney to provide engineering and financial assessments as a key step in the acquisition process according to the RDOS Utility Acquisition Policy. The assessments will give the RDOS a clear picture of how the system is currently operating, as well as what and when future maintenance and upgrades will be needed based on the water source. Well-formulated assessments with the right level of detail will be key to helping the RDOS make well-informed decisions in the acquisition process.

1.2. PROJECT GOALS

Key project goals are to assess and understand the state of the existing water system from an engineering and financial perspective. In addition, goals identified by the RDOS during the project kick-off meeting are to provide a potable water system for Sage Mesa and to ensure users are aware of the related costs.

1.3. REFERENCE INFORMATION

Background documents provided in the RFP are listed in Appendix B. Appendix B also includes a list of additional documents and references provided during the course of the project work.

1.4. KEY CONSIDERATIONS

The engineering and financial assessment of the Sage Mesa Water System has three major aspects to consider. These items are water quality, water supply and storage, and the water distribution network.

Item #1 – Water Quality Considerations

The Sage Mesa Water System currently draws water from an inlet in Okanagan Lake and there is no water filtration or treatment other than chlorination. During freshet the entire system is often placed on a boil water advisory. In addition, the lower areas of the Sage Mesa system are on a year-round boil water advisory.

Water quality, and by extension human health, is the top priority of any water supplier and as such improving the water quality of the system is priority number one. Two options investigated to accomplish this were:

1. Upgrading the existing water intake and treatment system. The location of the water treatment system would need to be confirmed if it cannot be accommodated on the same property as the existing pump house.

2. Reconfiguring the water system to connect to the nearby West Bench water system and entering into a bulk water purchase agreement with the City of Penticton to provide water to Sage Mesa. This option requires analysis of the modifications needed to both the West Bench and Sage Mesa systems to accommodate for this.

In either case, these options would have to be reviewed in the context of the outcomes from the other considerations, as the best option for improving the water quality may not be the best option for the overall system.

Item #2 – Water Supply and Storage

The Sage Mesa System has two reservoirs: the Upper and Lower Reservoir. The Lower Reservoir, feeds the Lower Zone and water from the Lower Reservoir is pumped to the Upper Reservoir. The Upper Reservoir feeds into the Uppers Zone. As noted in the 2020 Structural Assessment of the Upper and Lower Reservoirs, both are near end of life and in need of either replacement or substantial repairs.

Two reservoir scenarios were evaluated as part of this assessment: Consolidating an adequately sized reservoir in one location or maintaining an Upper and Lower Reservoir system. These options assume that regardless of the water source (Okanagan Lake or City of Penticton via the West Bench water system) the reservoir(s) can remain in the same or similar locations.

Item #3 – Water Distribution Network

The final major engineering issue for this system is the water distribution network. The Upper and Lower zones were built at different times and both reservoirs are now undersized. The result is that some piping may be undersized to deliver flows while maintaining velocities and pressures within design guidelines and fire flows and hydrant coverage may be inadequate.

A water model was developed, based on GIS information provided by the RDOS, for the Sage Mesa Water System, to determine the following:

- Areas where existing mains are undersized due to high velocities or low flows;
- Fire flow demands and where the demands are not met;
- Sections in need of replacement due to condition and / or age, or at an increased risk of future breaks using available record drawings and water main break repair information;
- Adequacy of fire hydrant coverage; and
- Adjustments or required reconfiguration to change the water source from Okanagan Lake to the City of Penticton via the West Bench water system.

The outcome of the model and analysis will be used to produce a priority ranking identifying where improvements are required. The priority ranks are expected to be:

1. Immediate improvements to accommodate the water quality improvements (water treatment system or connection to the West Bench water system)

2. Short-term replacement of severely undersized water mains to allow for appropriate domestic and fire flows/velocities.

3. Medium to long-term replacement of water mains that are reaching end of service life and/or at a higher risk of future breakage or maintenance issues.

The costs of replacing these items will be broken down in a similar format to assist in determining when the funding will be required.

2. Infrastructure Assessment

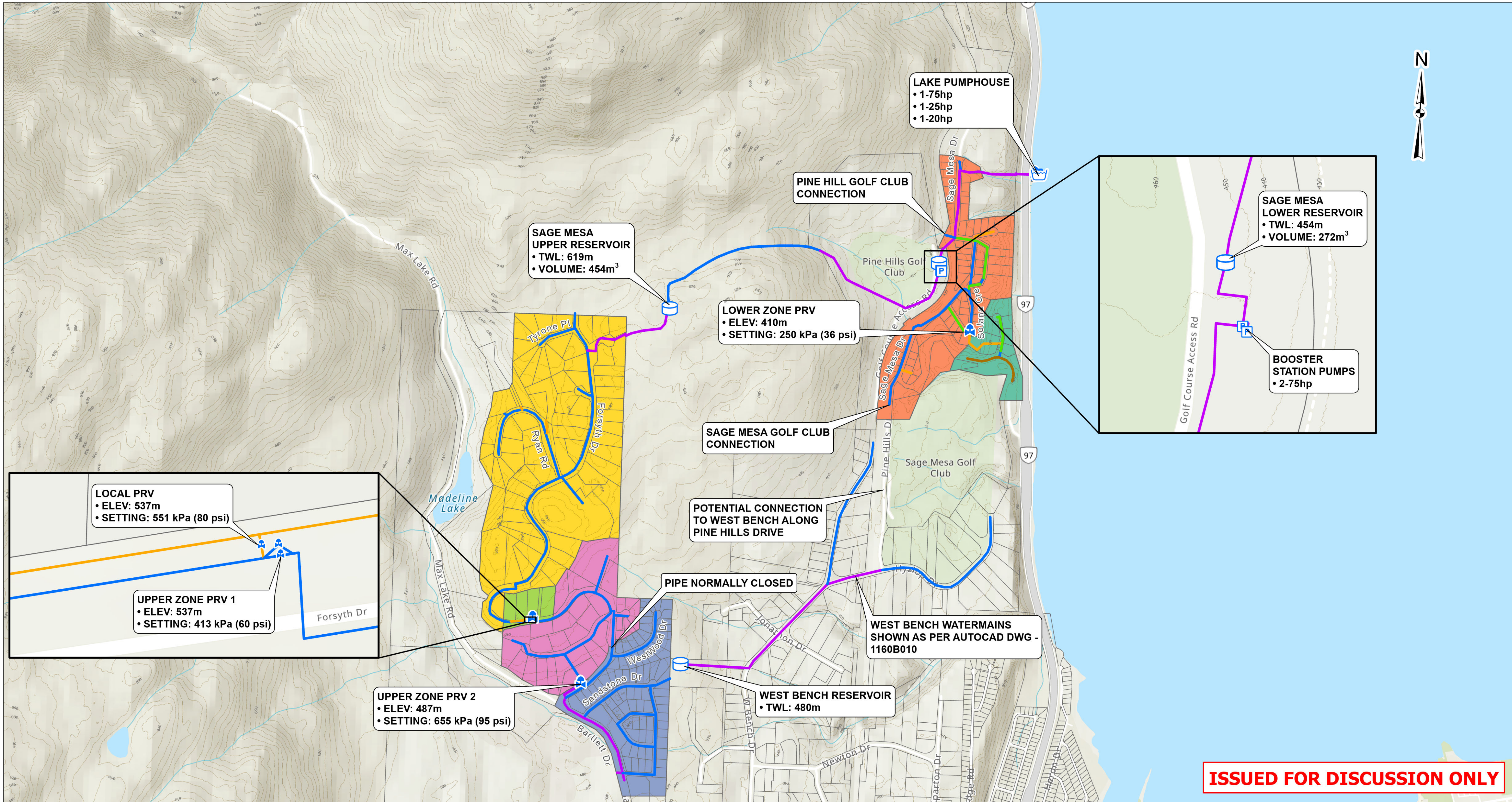
2.1. EXISTING SYSTEM OVERVIEW

The condition assessment is based on a tabletop review of existing reports. The following section provides an overview of the existing Sage Mesa water system based on the background information provided in the reports and drawings referenced in Appendix B.

An overview of the system showing the water intake, pumphouses, reservoirs, pressure zones, watermains, and PRV's are presented in Figure 1.

The Sage Mesa water system consists of a raw water intake and pumphouse along Highway 97 at Okanagan Lake. Sodium hypochlorite is pumped directly into the pumphouse wet well and water is pumped directly into zones PZ436 and PZ456, and up to the Lower Reservoir, located within the property boundaries of the Pine Hills Golf Club. The Lower Reservoir acts as a balancing reservoir and provides fire flow storage for the lower zone properties, WOW Golf course and Pine Hills Golf Club.

A booster station situated adjacent to the lower reservoir, pumps water from the Lower Reservoir to the Upper Reservoir. The Upper Reservoir supplies water to properties located in the upper reservoir pressure zones which include, in descending order, PZ619, PZ593, PZ579, and PZ554. The pressure zones are in series except for PZ579 which services four properties and dead-ends. Each pressure zone is split by a PRV which drops the water pressure to an acceptable pressure for the properties in that zone.



McElhanney

Projection:
NAD 1983 UTM Zone 11N

TITLE

Figure 1. Sage Mesa Water Distribution System - Existing Configuration

Project: Sage Mesa Water System Assessment

Location: Sage Mesa, BC

Scale 1:13,000

0 — 1,000 Meters

INSET

LEGEND

	Watermain (mm)	Pressure Zone
Raw Water Lake Intake	50	Lower,PZ436
Reservoirs	100	Lower,PZ456
Pump	150	Upper,PZ554
PRV	200	Upper,PZ579
	250	Upper,PZ593
		Upper,PZ619

Original Paper Size: 11" x 17"

Author: ACHAPUT

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2.2. WATER LICENSES

The active water licenses associated with the system which are owned by the Sage Mesa Water & Public Service Co. Ltd are summarized in Table 2 below.

Table 2. Active water licences associated with the Sage Mesa water system

License Number	Year Issued	Limit	Purpose
C030606	1966	31,000 Igal/day	Waterwork for Lower Zone
C052739	1979	18,000 Igal/day	Waterworks for Upper Zone
C058922	1983	10,500 Igal/day	Waterworks for Upper Zone
C059060	1983	1,500 Igal/day	Waterworks for Upper Zone
C061571	1984	4,000 Igal/day	Waterworks for Upper Zone
C064196	1986	1,500 Igal/day 182,500 Igal/year	Waterworks for Upper Zone
C104081	1992	30 acre ft/year	Pine Hills Golf Course Irrigation
C104082	1992	44.67 acre ft / year (Irrigation) 500 Igal/day (Commercial)	WOW Golf Irrigation & Clubhouse
C107735	1996	61,500 Igal/day 7,482,500 Igal/year	Waterworks for Upper Zone

2.3. ASSESSMENT CRITERIA

Below is a list of key references used to assess the existing system and determine required upgrades. Application of these references is discussed in more detail throughout the report in the relevant section.

- RDOS Subdivision Servicing Bylaw No. 2000, 2002
- Any other RDOS Bylaw related to consumption – per MDD comments/
- Penticton Subdivision & Development Bylaw 2004-81
- MMCD Design Guidelines (2022)
- Fire Underwriters Survey (2020)
- Guidelines for Canadian Drinking Water Quality (GCDWQ)
- BC Source Drinking Water Quality Guidelines (BC SDWQG) (2023)
- Interior Health Authority's (IHA) 4-3-2-1-0 drinking water objectives
- Canadian Electrical Code
- WorkSafe BC
- Infrastructure was also evaluated based on typical service life

2.4. WATER INTAKE

Mesh Screen

The Okanagan Lake intake is fitted with a stainless-steel mesh screen that was installed in 2005 and is 18 years old. The 2015 Diving Dynamics report noted there was some rusting where the mesh meets the screen frame and recommended that the support cables for the screen are replaced (including adding tensioners) to address the leaning observed (Johnston & Gartner, 2015). In 2018, another diving inspection took place, with the Diving Dynamics report noting similar findings and indicating that the support cables were continuing to fail (Johnston, 2018). The April 2022 Diving Dynamics report noted that the south support cable was no longer there. In June 2022, Diving Dynamics installed one new chain support at the south side of the lake intake screen; according to the RDOS, the north side chain was reportedly in acceptable condition and left as is (Johnston & Gartner, 2022).

According to the 2007 Associated Engineering report, the screen size met Ministry of Environment standards at that time (Harvey, 2007). The screen size is noted to be 1.5mm in the 2022 Diving Report. It is unconfirmed if this was with or without the marine growth noted at that time. Regardless, this 1.5mm noted falls below the maximum screen size of 2.54mm as per the current “Interim Code of Practice: End-of-pipe fish protection screens for small water intakes in freshwater” (*Design Guidelines for Drinking Water Systems in British Columbia*, 2023).

The screen capacity could not be confirmed as only the screen mesh size was found in the background information provided and not the overall size of the screen itself.

Intake Location - Length and Depth

The intake is located 135-177m from shore and 7m-13.7m below the average surface level of Okanagan Lake and was installed in 2005 (*Sage Mesa Water Supply Study*, 2012). The BC Small Water System Guidebook - Section 6.2 recommends intakes should be strategically located at an appropriate depth to maximize quality (*Design Guidelines for Drinking Water Systems in British Columbia*, 2023).

A 2019 RDOS Inspection Report noted that intake water temperatures rise to approx. 25 degrees C in the summer due to the shallow intake. These high temperatures are also noted in historical water quality sampling data provided by the RDOS, with readings above 20 degrees C recorded at sampling points throughout the distribution network during the summer months. The guidelines for Canadian Drinking Water Quality note temperature should be ≤ 15°C.

Intake Main – Screen to Pumphouse

Approximately 120m of 300mm diameter PVC pipe extends from the screen towards the Lake Pumphouse before it switches to approx. 32m of 600mm corrugated metal pipe (CMP).

The 300mm PVC portion was installed in 1980 and was noted to be intact in the 2022 Diving Dynamics report .

The 600mm CMP portion was installed in 1987. The 2022 Diving Dynamics report noted that the expected service life of CMP pipe in this application is 40 years, putting its anticipated end of service date at 2027. The report also noted that the CMP pipe is buried along the lake bottom, making an external inspection impossible.

Observations in the 2000 TRUE report and 2022 Diving Dynamics report noted that ballast anchors with a consistent spacing were not observed and that there was "the occasional sandbag, concrete bag, and several ½" concrete collars laying over the pipe".

2.5. WATER QUALITY

The Sage Mesa Water system currently draws water from Okanagan Lake and there is no water filtration or treatment other than chlorination.

During freshet the entire system is often placed on a boil water advisory. In addition, the lower areas of the Sage Mesa system are on a year-round boil water advisory. Based on these boil water advisories, it is clear that the treatment system is not meeting current Guidelines for Canadian Drinking Water Quality (GCDWQ) and BC Source Drinking Water Quality Guidelines (BC SDWQG) (2023).

The existing water treatment infrastructure is discussed in Section 2.6 below. Water quality and treatment system upgrade options are discussed in detail in Section 3.

2.6. WATER TREATMENT

2.6.1. Lake Pumphouse

The lake pumphouse is located on the east side of Highway 97 approximately 950m north of the intersection of Sage Mesa Dr and Highway 97. The pumphouse sits on a small piece of land that juts out from the shoreline of Okanagan Lake and Operations staff have indicated that since 2010, they have had had to rely on BC forestry crews twice to sandbag the area around the lake pump station shoreline to protect it from high lake levels eroding and almost breaching the rocks around the station. Operations staff have expressed concerns that these instances may occur more frequently in the future as a result of global warming.

Wet Well

The 2000 TRUE Report notes there is a 6m deep x 1.8m dia. precast concrete wet well, the base of which is approximately 1.4m lower than the 600mm CMP pipe inlet coming from the intake screen. It is assumed that this is still the current wet well as this is the most recent recorded information (Underwood, 2000).

It is unclear if there are one or two cells, however we have assumed there is only one cell.

As additional wet well information is limited, determination of the adequacy of the wet well size was not undertaken. It is assumed that if the basin was undersized there would have been documented operational concerns provided.

Pumps and Internal Piping

The Lake Pumphouse houses three pumps. No record drawings for the pump station were provided. Information presented in this section was determined from past reports. Available information on the three pumps are as follows:

- 75HP Byron Jackson MG-L 150mm 4 stage vertical turbine pump with a General Electric motor. The pump was installed in 1970, and reconditioned in 1994 as mentioned in the water assessment report by TRUE Consulting Ltd., before the vertical turbine was replaced in 2022, giving the wet end a refreshed age of 2 years.

- 25HP Unknown Model Johnson 100mm 8 stage vertical turbine pump with a Newman Electric motor. The pump was installed in 1970 and according to Operations staff is used all year long The 2019 RDOS Inspection report notes that it will probably be due for replacement soon (RDOS, 2019; Underwood, 2000)

- 20HP Berkeley submersible pump. Operations staff indicate that the pump was installed in 2008, but a previous inspection report noted pump and motor were replaced in 2012, putting its age at 11 years old.

Discharge piping was mentioned to be 150mm diameter in the water assessment report by TRUE Consulting Ltd. No record drawings for the pump station were provided. Information presented in this section was determined from past reports. Due to the minimal record information provided, a comprehensive review of the other appurtenances in the Lake Pumphouse (valves and piping) was not completed. The 2019 Inspection Report did note that the check valve on the discharge side of the 20HP pump was noted to make noise during pump shutdown. It was recommended at that time to replace the check valve with one of a different style, but it is unconfirmed if this replacement occurred (RDOS, 2019; Underwood, 2000).

A 2022 technical memo prepared by McElhanney investigated noted corrosion on the inside the pump pedestals. The memo concluded that while the pedestal was still structurally sound at the time, monitoring should be completed annually to confirm the rate of corrosion.

Pumping Capacity

Based on information provided by the RDOS Operations staff, the 75HP Byron Jackson runs at 37.88 l/s, the 25HP Johnson runs at 10.60 l/s, and the 20HP submersible pump is estimated at 10.22 l/s

As pump curves were not available (only flow and discharge pressure were provided), adequacy of the pump efficiency could not be confirmed. The most recent report Focus Corporation report compared overall pump capacity to demand values but did not consider the pump head (*Sage Mesa Water Supply*

Study, 2012). Regardless, the previous reports using the simple capacity comparison have indicated the existing pumphouse capacity is inadequate.

Pump operation was also not confirmed by Operations staff. but single day operational record data provided showed one pump running off and on throughout the day with a second pump kicking on with the first pump during a single period of what is assumed to be high demand. A third pump remained off for the entire day. This record does not appear to illustrate a conventional lead/lag/standby or lead/lag/lag operational setup.

Best practice is to have at least two pumps capable of providing peak flows. This does not appear to be the case with the current pumping setup in the Lake Pumphouse.

2.6.2. Water Treatment System

The current treatment system located inside the Lake Pumphouse consists of chlorination using aqueous sodium hypochlorite which is dosed into the raw water wet well. Dosing was originally manually controlled, and a residual analyzer recorded dosages, but no control was provided.

Substantial upgrades in 2020 included the addition of a duplex ProMinent Gamma/x ProSIP-S dosing skid complete with a Severn Trent MicroChem2 Series 4000 Controller. Operations staff confirmed that chlorine is still added to the wet well with the sodium hypochlorite discharged at the top of the well and mixed in when the pumps are running.

Analysis of the performance of the existing treatment system is provided in Section 3.0.

2.7. WATER STORAGE & DISTRIBUTION

The storage system includes a Lower Reservoir and an Upper Reservoir. Each reservoir generally supplies water to its respective distribution zones that are made up of multiple pressure zones separated by pressure reducing valves (PRVs). Pressure zone names are based on the zones hydraulic grade line (HGL), which is the theoretical elevation of the static water pressure. For example, PZ619 is the pressure zone serviced by the Upper Reservoir where 619m is the top water level of the reservoir.

The Lower Zone consists of two pressure zones (PZ456 & PZ436), with the Lower Reservoir directly servicing most of the Lower Zone with PZ456, and the Lower Zone PRV drops the pressure to service the properties along Verano Place in PZ436.

The Upper Zone consists of four pressure zones and begins with the Upper Reservoir that services the properties along Forsyth Drive in PZ619 to the Upper Zone PRV 1 and Local PRV located adjacent to 2619 Forsyth Drive. The Local PRV services 4 properties in that area in PZ593. Upper Zone PRV 1 services the properties down Forsyth Drive to 2505 Pinetree Place in PZ579 where a closed valve separates PZ579 and PZ554. Upper Zone PRV 2 receives water from a watermain that passes by the east of 1911 Estates Place to Forsyth Drive. The Upper Zone PRV 2 then services the properties off Sandstone Drive in PZ554.

There are approximately 68 connections in the Lower Zone and 176 connections in the Upper Zone.

Further details on the existing storage and distribution system are covered in the following subsections. Upgrade needs for the piping, reservoirs, and additional infrastructure are based on modeling results, and are discussed in Section 4.

2.7.1. Reservoir Supply Main

A dedicated discharge main provides water from the Lake Pumphouse up to Sage Mesa Drive, between 4655 and 4675 Sage Mesa Dr. The first 60m of main outside the pumphouse is 200mm ductile iron pipe, with the portion crossing Highway 97 contained in a 600mm CMP casing pipe. From there, the remainder of the dedicated main that runs between the Highway 97 crossing to Sage Mesa Drive is 200mm PVC that was installed in 1980.

Comments on the lifespan of this pipe are provided in Section 2.7.5 and Table 1. An assessment of the hydraulic capacity of the main between the Lake Pumphouse and Lower Reservoir can be found in Section 4.

2.7.2. Lower Reservoir

The reinforced concrete Lower Reservoir, has a design capacity of 272m^3 (60,000gal). It sits adjacent to the parking area of the Pine Hills Golf Club (3610 Pine Hills Dr), west of the Kettle Valley Railway (KVR) trail, and provides water storage for the Lower Zone with a design top water elevation of 454m.

As a structural assessment of the Lower Reservoir was recently completed (McElhanney, 2021), this section will not touch on any structural related aspects on the concrete reservoir.

Capacity

Capacity concerns have been noted as far back as 2000 (TRUE, 2000). Operations staff also claimed they have had trouble keeping water levels up during the summer when demand is high due to irrigation. The partial fix has been to run both the 75HP and 25HP pumps; the 25HP pump was a standby pump at other times of the year (Underwood, 2000).

An analysis of the current reservoir capacity and recommended upgrades is provided in Section 4.

Overflow and drainage piping

Previous reports indicate that the Lower Reservoir does not currently have overflow or drainage piping. Adding these items, particularly the overflow piping, was deemed a “necessary future capital improvement” previously (Underwood, 2000).

2.7.3. Upper Zone Booster Station and Dedicated Main

The booster station that supplies water from the Lower Reservoir to the Upper Reservoir is located just south of the Lower Reservoir at the Pine Hills Golf Club.

Pumps and Internal Piping

The station houses are twin 75HP 6-stage Goulds 7CLC canned vertical pumps powered by 3500rpm USEM vertical electric motors. The discharge piping was plumbed to accommodate a third pump (Underwood, 2000). Based on the record information provided, the two pumps were originally installed in 1995, with one of the pumps having its wet end replaced in 2014; the other pump still has its original wet end.

Operations staff confirmed that there is one chlorine pump located inside the booster station that automatically turns on whenever the booster pump is on and is used all year long.

Record drawings were provided for the Booster Station showing piping and valves, but the pumps in these record drawings did not match the 75HP Gould's pumps, so it is unclear if what is shown in the record drawings is accurate. Servicing information provided by the RDOS has indicated that the pressure reducing valve inside the station, along with a check valve for one of the two pumps have been replaced in the past year.

A second booster system located in a separate room at the Lower Reservoir also draws water from the Lower Reservoir for the Pine Hills Golf Club. This booster system includes a pump, water meter and backflow preventer. This system **was not included in this assessment** as it is privately operated and maintained by Pine Hills Golf Club and not considered to be a part of the overall Sage Mesa system.

Pump Capacity

Based on the record information provided, the two Goulds canned vertical booster pumps were originally installed in 1995, with one of the pumps having its wet end replaced in 2014; the other pump still has its original wet end.

The pump curve provided for the individual booster pumps shows that the design operating point is approximately 20.1 l/s (320gpm). As noted in Section 4.1, MDD for the Upper Zone is 18.8l/s, indicating that these pumps have been sized appropriately for this demand.

In terms of efficiency, the Goulds pumps appear to have been selected appropriately as their design operating point is very close to the best efficiency point (BEP). Typical best practice is to have pumps operate within 70-120% of their BEP flow (in accordance with ANSI/HI 9.6.1-2012).

Booster Station Chlorination System

The booster station includes a chlorine dosing system that runs whenever the booster pumps run according to Operations staff. Background reports have indicated that the chlorine dosing is manually controlled, there is no feedback control system on the chlorine dosing system to increase the dose when the lag pump operates, and there is no monitoring sensors or alarms.

Hoist System for offloading Sodium Hypochlorite barrels. The “home-made” hoist system poses a safety and spill containment risk.

Dedicated Main (Between Booster Station and Upper Reservoir)

The booster station pumps water to the Upper Reservoir through a 200mm diameter ductile iron main and up to a vault/junction box noted in record drawings as being for a future 100mm water service. The vault location is assumed to correspond with the valve in that area that was included in the GIS information provided. It is unclear if this valve/service is currently in use. From the service vault, the ductile iron main reduces down to 150mm diameter before running directly to the Upper Reservoir. All of this ductile iron piping was installed in 1977 as per the record drawings.

This connection is one-way only. There is currently not a way for water stored in the Upper Reservoir to flow down to the Lower Reservoir. Operations staff noted the static pressure in the watermain leaving the booster station is 255psi and increases to approximately 262 psi when a pump is in operation.

Three air release valves and a blow off drain on the lower 200mm section of the ductile iron main are shown in record drawings, but they are not mentioned in any other record information provided, including the GIS data. Operations staff noted that in 2010, all the air release valves along the pumping water main were removed as they were all reported to be leaking.

Comments on the lifespan of this pipe are provided in Section 2.7.4. An assessment of the hydraulic capacity of the main between the Booster Station and Upper Reservoir is discussed in Section 4.

2.7.4. Upper Reservoir

The reinforced concrete Upper Reservoir has a design capacity of 454m^3 (100,000 imperial gallons). It sits approximately 250m off the end of Forsyth Place and provides water storage for the Upper Zone with a design top water elevation of 619m.

GIS information provided for this report indicates that there are two air release valves adjacent to the reservoir, one on the pipe from the Booster Station, the other on the pipe to the Upper Zone, but there is no other record information provided for them. RDOS staff noted the air release valves are in manholes located approximately 3.14 m (10 feet) from the reservoir and as both air release valves leak, their respective isolation valves are closed.

As a structural assessment of the Upper Reservoir was recently completed (see the report “2020 Sage Mesa Reservoir Assessments” by McElhanney dated February 8, 2021), this section will not touch on any structural related aspects on the concrete reservoir.

Reservoir Sizing

An analysis of the current reservoir capacity, including recommended upgrades, is provided in Section 4.

2.7.5. Distribution Watermains – Lower and Upper Zones

Lower Zone

The lower distribution zone consists of mains, valves, and hydrants in the area north of the WOW Golf course between the KVR trail and Highway 97. The extent of the lower and upper distribution zones are depicted in Figure 1.

50mm, 100mm, 150mm, 200mm, and 250mm mains make up the distribution network in the Lower Zone with a mix of AC, PVC, and ductile iron pipe. Comments on the service life of the existing distribution network are provided in Table 1. Hydraulic analysis of the distribution network is provided in Section 4.

The Lower Zone PRV station is located near 3877 Solana Crescent and consists of a small concrete chamber (~1.2 m deep) with a cast iron manhole lid. Operations staff have not been able to confirm the current PRV pressure setting and prefer not to touch the valve due to the condition of the existing pipe in that area. Operations staff have also noted that the existing 50mm main on the discharge side of this PRV potentially runs under the garage at 3877 Solana Crescent.

Upper Zone

The Upper Distribution Zone consists of mains, valves, and hydrants in the area directly north of the Westhills Aggregate gravel pit. This includes the Husula Highlands neighbourhood, and areas surrounding Westwood Drive and Sandstone Drive. The extents of the zone are depicted in Figure 1.

150mm, and 200mm mains make up the distribution network in the Upper Zone that consists entirely of PVC pipe. Comments on the service life of the existing distribution network are provided in Table 1. Hydraulic analysis of the distribution network is provided in Section 4.

Two PRV stations are used in the Upper Zone:

- The Upper Zone PRV 1 and Local PRV station located near 2619 Forsyth Dr consisting of 50mm, 100mm, and 200mm ClaVal PRVs in a ~1.2m deep concrete vault covered with a checker plate aluminum lid. The 50mm PRV only services four properties in the area. Operations staff have noted that the 50mm PRV is set to 80psi, the 100mm PRV is set to 60psi, and the 200mm PRV is set to 45psi. (*Note – 2022 inspection form notes indicated the pressures were 68psi and 58 psi respectively for the latter two PRVs; operating pressures should be confirmed*). Recent maintenance records show that the valves are disassembled and cleaned on an annual basis and a replacement diaphragm was installed in the 200mm valve in 2021.

- The Upper Zone PRV 2 station located near 2204 Forsyth Dr consisting of 50mm and 100mm PRVs in a ~3.66m (12ft) deep vault covered with a cast iron manhole lid. The station does not have any power for lights, no heat, and no means of forced air movement and as such, it is considered a confined space. Operations staff have noted that the 50mm PRV is set to 95psi and the 100mm PRV is set to 80psi. Recent maintenance records show that the valves are disassembled and cleaned on an annual basis and a replacement diaphragm and pilot repair kit were installed in the 100mm valve in 2022.

Mearls Machine Works Ltd. completed some service work in June 2023 on the Upper Zone PRV 2 station and noted that the pipe is deteriorating, specifically where it enters/exits the vault and around some of the threadolets on the piping inside the vault.

The PRV stations split the Upper Zone into 4 pressure zones as shown in Figure 1. A normally closed gate valve sits in Forsyth Dr adjacent to 2402 Westwood Dr.

Distribution Piping Age

A summary of the type of pipe, year of installation, approximate total length, and typical service life for the watermains in both the Lower and Upper distribution zones is presented in Table 1. Additional details on distribution pipe are included in Appendix C.

Table 3 – Lower Zone Pipe Material, Typical Lifespan and Year of Installation

Material	Typical Life Span (Years)	Location and Time of Installation	Approx. Total Length (m)	Comment
		Lower Zone		
Asbestos concrete (AC) (1)	50-100	1960's	935	Potentially at the end of life
Ductile Iron (2)	100	1960's Lake Pumphouse Discharge	1,232	No concerns
Galvanized Iron (3)	50	1962 Located between Solano Crescent and Verano Place	177	Potentially at the end of life
PVC (4)	100	Mid-80s to 90's	1,582	No concerns
		Upper Zone		
PVC (4)	100	Mid-70s to 90's	6,162	No concerns as current age is between 29-53 years
	Notes: 1. AC: 50 years according to 2022 US EPA report [1]; 65-105 years AWWA report 2. Ductile Iron: Similar to PVC, it is estimated by suppliers and groups like DIPRA as having a 100 year design life so long as it is installed properly 3. Galvanized Iron: Typically estimated at 40-50 years 4. PVC: Typically estimated at 100 years			

1 https://dec.vermont.gov/sites/dec/files/dwgwp/dwpermitting/Pipe%20Bursting%20Asbestos%20Cement%20Pipe%20%28EPA%20Memo%29.pdf

Note that the design lives listed above for the various pipe types are all approximate and will be based upon proper installation methods and typical install conditions. These design lives may differ in the field.

As seen in Table 1, the AC and Galvanized Iron pipes found in the Lower Zone are potentially at the end of their service life. As discussed in Section 4, some of the piping will have to be upgraded for hydraulic reasons.

Please note that for a couple of pipes in the system, record information and GIS data were different from one another. In these instances, the GIS data diameters were used for the modelling and analysis discussed in Section 4.

Recent Breaks / Leaks

Service leaks were reportedly an issue in the past due to the use of galvanized iron fittings. Acoustic monitoring was performed 2-3 times per year to check for leaks according to the 2000 TRUE report, and no reports past that have discussed it being an issue.

- **Lower Zone**:
  - 4258 Sage Mesa Drive in March 2022 – Leaking service connection.
  - 4675 Sage Mesa Drive in May 2022 – A sink hole was repaired along the existing water main.
  - 4423 Ladera Place in October 2022 – Leaking service connection.
  - 316 & 320 Sage Mesa Dr Service in December 2022 - Leaking service connection.
- **Upper Zone**:
  - 3019 Forsyth Dr in July 2017 – Leaking service connection.
  - 2619 Forsyth Drive in June 2023 – Tee in the 50mm service line was cracked. Tee was replaced.
  - 2615 Forsyth Drive in July 2023 – Leaking service was replaced

Dead ends (non-looped sections of the distribution network)

Dead-ends identified in each zone of the system are outlined below.

- **Lower Zone**: The Center of the Lower Zone has two looped areas, but beyond that, the system has multiple dead ends including the west end of Sage Mesa Dr and all of Verano Place.

- **Upper Zone**: The Sandstone Drive area has some looping but beyond that, the remainder of the upper zone is all dead ends including Ryan Road and Estates Place.

While dead ends are not ideal, they are often unavoidable. The hydraulic modeling did not identify any easy remedies for looping to improve hydraulics without incurring significant costs. The risks of not looping the system to improve resiliency of the system would have to be evaluated in the future. A regular flushing program may be warranted to reduce water stagnation and build-up within the dead-end pipe sections.

2.7.6. Distribution Network Valves

Valve Maintenance

Operations staff confirmed water main gate valve exercising and air release inspections were performed in 2016, 2020 and 2023 and that records are kept in the RDOS EDMS Water System Maintenance web map. The 2023 reports still needed to be uploaded at the time of writing this report.

Although record information provided on valves was limited, the 2019 Inspection Report noted that the mainline valves at the Lower Reservoir were seized and inoperable at the time of their inspection (RDOS, 2019). Operations staff confirmed that these two valves, one on the suction side and one on the discharge pipe outside the booster station, are seized in the open position but did not indicate any other concerns. A comprehensive review of the other appurtenances in the Booster Pump Station (valves and piping) should be completed.

Valve location

Operations staff noted that in 2011, all water main gate valve locations were confirmed using GPS. In 2012, all fire hydrant, blow off pipes and air release valves were located using GPS.

Distribution Network Meters

Both pumpstations in the system have water meters installed in their internal piping. A Neptune Trident Turbine meter was installed in 1970 at the Lake Pumphouse and an ABB Model 10DX4300 meter installed in 1995 at the Booster Station according to record information provided.

Based on GIS record information and comments from previous reports, water meters are installed for some, but not all, properties in the Upper Zone, and no residential properties in the Lower Zone.

GIS information notes that the majority of the meters are Neptune T-10s, with a few Neptune Mach 10s in service. The two golf courses (WOW Golf and Pine Hills Golf Club) each have 50mm water meters on their services, and the park and two properties in the Sandstone Drive area all have 25mm water meters on their services. All other residential meters are noted to be 19mm in size.

The GIS data does not include the date of meter installation and the age in the GIS appears to be the date they were input into GIS system. As such, comments on the condition of the meters cannot be made. Operations staff noted that many of the existing meters are over 20 years old and only replaced if they stop reading or break. Neptune Technology group notes that water meters have a typical lifespan of around 20 years.[2]

Additional information on the existing water meters, including location of install, is included in Appendix C.

2.7.7. Distribution Network Hydrants

Based on the GIS information and maintenance records provided, hydrants are spread out throughout the Lower and Upper Zone, with the Lower Zone hydrants between 25 and 39 years old, and Upper Zone hydrants between 18 and 46 years old. The lifespan of hydrants is typically from 25-50 years. Even assuming the hydrants have a lifespan of 50 years old, the majority of the hydrants are close to the end of their life.

There are also multiple blowoffs in system in both zones with most being around 25 years old. Further details on the hydrants and blowoffs, including specific location, are included in Appendix C. Hydrant coverage is reviewed in Section 4.

Maintenance

Based on maintenance information provided, it appears most if not all the hydrants are tested annually in the fall. The most recent round of testing was completed through September, October, and December of 2022.

2.8. ELECTRICAL AND INSTRUMENTATION ASSESSMENT

2.8.1. Intake Station

The following main electrical and instrumentation infrastructure were identified:

1. Electrical Service. Noted in the 2000 TRUE report, the 230V 3-Phase service was at capacity and any pumping upgrades will require an upgrade to 600V service. The 230V service utilizes an ungrounded Delta electrical service and was fitted with a ground fault indication system during the 2020 upgrade, as required by the Canadian Electrical Code (*Canadian Standards Association*, 2023; Underwood, 2000).

2. Pump motor starters (soft-starters). Some of the pump motor soft-starters are of the same vintage as the 1970 pumps.

3. Lack of backup power. No standby electrical generator or other form of back-up supply exists.

4. Flow meter: The 1970 vintage flow meter was noted as “difficult” to integrate into the control system upgrade of 2020.

[2] https://www.neptunetg.com/globalassets/products/literature/spec-58-2-meter-03.20.docx

5. Turbidity analyzer. A new turbidity analyzer was installed at the pump station in 2020.

2.8.2. Booster Station

The following main electrical and instrumentation infrastructure deficiencies were identified:

1. Pump soft starters. Although newer than the intake pump motor soft-starters, these 1995 Benshaw soft-starts are reaching end of life.

2. No standby electrical generator or other form of back-up power supply exists.

2.9. SYSTEM MONITORING AND COMMUNICATION

After the 2020 control system upgrade, no major deficiencies were found at any of the sites requiring attention or replacement.

The Lower Sage Mesa Reservoir is used as a repeater station on the RDOS radio network. Currently there is a UPS (GXT5-1500LVRT2UXL) with a 48V external battery cabinet (GXT5-EBC48VRT2U) to increase the UPS runtime and ensure the availability of the RDOS radio network repeater.

2.10. SCADA & RADIO SYSTEM

MPE Engineering are currently analyzing the radio repeater system – the results may influence some of the observations below.

The control system upgrade in 2020 included a stand-alone implementation of VTSCADA, with a SCADA Computer installed at the Booster Station. The stand-alone installation was implemented due to the "curatorship" of the water system, rather than ownership, so full integration into the RDOS SCADA network was not implemented.

2.10.1. Hardware

The stand-alone VTSCADA installation was completed on an RDOS supplied Lenovo Desktop Computer, and not a "Central SCADA Computer" compliant to the RDOS Standard Control System Specifications Rev 1.2 (June 2021) ("Control Specs"), yet adequate for its intended purpose at the time.

The SCADA computer is currently backed-up with a simple backup client to the RDOS IT central backup server, but the VTSCADA is not synchronised to redundant servers and so restoration following any hardware failure would not be seamless or synchronised.

Initially a SOPHOS Firewall was installed at the Booster Station, but following a router failure, a standard RDOS SD WAN Node was implemented at the Booster station. This node is not tied-into the RDOS VTSCADA network but can become a SCADA node with the re-purposing of the of the stand-alone VTSCADA computer as a SCADA client, and would be the recommendation for full integration.

Currently RDOS has two active VTSCADA servers and one backup server. The addition of the small SCADA node at the booster station would not require any additional hardware or software on the RDOS' side.

During the stand-alone VTSCADA implementation, automated reporting was not implemented due to budgetary constraints. If the Sage Mesa Water systems was fully integrated into the RDOS SCADA network, automated reporting would be a required upgrade (SCADA software development) to bring the Sage Mesa system in line with existing RDOS sites.

2.10.2. Connectivity

The booster station currently connects through a Rogers Cellphone modem to the internet. The RDOS has been actively engaging Telus Fibre as there appears to be Fibre infrastructure near the booster station and connection through Telus Fibre seems to be viable. If this Fibre connection is established, backup challenges (large data transfers) would be mitigated, and site connectivity (access) redundancy would be greatly improved.

2.11. INFRASTRUCTURE UPGRADE RECOMMENDATIONS

Recommended upgrades and activities based on a simple review of the existing infrastructure are summarized below for ease of reference. The recommendations below do not consider upgrades related to improving water quality, covered in Section 3.0, or hydraulic performance and reservoir storage, identified in Section 4.0. A collated list of all recommended upgrades is presented in Section 5.0 where water supply scenarios are evaluated.

Intake / Lake Pumphouse (if it is kept operational):

- The intake should be extended to below the thermocline layer. Proper determination of the depth of the thermocline layer of the lake should be completed prior to this. The 2007 AE Report proposed a 700m long intake pipe, extending the current intake 550m further out into the lake and down to the 25m depth required (Harvey, 2007).

- Proper pipeline ballast or earth anchors should be engineered and installed on the intake pipe between the screen and pumphouse.

- The intake mesh screen, currently 1.5mm, should be changed to a maximum screen size of 2.54mm as per the current "Interim Code of Practice: End-of-pipe fish protection screens for small water intakes in freshwater" referenced in the 2023 BC Water Design Guidelines.

- Intake diving inspections should be conducted yearly in the spring in accordance with the federal "Guidance for providing safe drinking water in areas of federal jurisdiction".

- Ideally, per the 2023 BC Water Design Guidelines, two wet well cells are recommended to allow for maintenance and repair.

- NSF61 compliance of the Lake pumphouse system and components should be verified.
- The pumphouse electrical service should be upgraded from 230V to 600V
- The pump motor soft-starters likely have to be replaced.
- A standby electrical generator or other form of back-up supply should be installed.
- The hoist system for offloading sodium hypochlorite barrels should be upgraded or replaced.
- The existing 1970 flow meter should be replaced.

Lower Reservoir

Should the lower reservoir be re-used, aspects to consider based on previous assessments include as a minimum sediment depth, hatch seal replacement, lack of lock alarm on lid, etc. However, in general, the reservoir is at the end of its life and should be replaced.

Booster Station and Dedicated Reservoir Supply Main

- The two seized water main gate valves on the suction and discharge pipes of the booster station should be serviced or replaced.
- The existing water meter in the station should be replaced. The other components and piping within the Booster Station should also be inspected.
- Service vault, and blow-off drain on the main between the Upper and Lower Reservoirs should be inspected.
- As all the air release valves on the dedicated supply main were removed in 2010, the need for re-installing new air release valves, should be reviewed and confirmed, particularly if upgrades to the system are being made,
- Pump soft starters should be replaced.
- A standby electrical generator or other form of back-up power supply should be installed

Piping Upgrades

Recommended piping upgrades will be confirmed based on modeling results, discussed in Section 4.0. Thereafter, piping should be upgraded based on areas requiring increased maintenance and if other road works are required. A replacement plan would have to be prepared based on funding.

Valve Locations

Valve locations throughout the system should be reviewed to ensure they are located to allow for isolation of portions of the system as appropriate and according to the guidelines in RDOS Bylaw 2000 (*Subdivision Servicing Bylaw No. 2000*, 2002).

Distribution Network meters

The flow meter installed at the Lake Pumphouse and the flow meter installed at the Booster station are considered to be at the end of their life and should be replaced.

In addition, previous reports recommended that meters be installed in the Lower Zone properties (RDOS, 2019; *Sage Mesa Bulk Water Supply*, 2015) and that Upper Zone meters be potentially replaced as their condition is unknown (*Sage Mesa Bulk Water Supply*, 2015).

These recommendations for replacement of all meters are carried on to this report and cost estimates included in Section 6 have an allotment for new meters installed for every property, including the two golf courses in the Lower Zone.

PRV Stations

As there were no other comments regarding the PRV stations in previous reports or provided by the Operations staff, it is recommended that the condition of the other PRV stations be assessed in the future. In addition, operating pressure of the PRVs should be confirmed given the discrepancies between 2022 inspection form notes and more recent Operations staff comments.

Pumphouse Hardware

Currently the RDOS has two active VTSCADA servers and one backup server. Due to the prior implementation of the RDOS SD WAN Node at the Booster station, as discussed in Section 2.10.1, no SCADA hardware upgrades would be required at the Booster Station to incorporate the site as a SCADA node. The existing VTSCADA computer can be repurposed as the SCADA client, and would be compliant with the RDOS Control Specs in this repurposed use.

If the Sage Mesa Water systems was fully integrated into the RDOS SCADA network, as suggested above, automated reporting would be a required upgrade (SCADA software development) to bring the Sage Mesa system in line with other existing RDOS sites.

3. Water Treatment Supply Options Evaluation

3.1. WATER QUALITY

3.1.1. Document Review

A list of documents used for the water treatment supply evaluation are provided in Appendix B.

3.1.2. Water Quality

The Sage Mesa Water System currently draws water from an inlet in Okanagan Lake and there is no water filtration or treatment other than chlorination. The inlet is considered shallow and during freshet the high sediment concentration in the water results in a boil water advisory for the entire system. In addition, the lower areas of the Sage Mesa system are on a year-round boil water advisory as there is insufficient chlorine contact time before the water reaches the first users in the lower area.

Water quality, and by extension human health, is the top priority of any water supplier and as such improving the water quality of the system is priority number one.

3.1.3. Overview of Water Quality Guidelines and Treatment Objectives

Drinking water quality guidance in BC is established through two main guidance documents, the Guidelines for Canadian Drinking Water Quality (GCDWQ) and the BC Source Drinking Water Quality Guidelines (SDWQG):

- The **GCDWQ** are assessed by parameter and adopted in the SDWQGs if they make sense as a source water guideline in BC. The GCDWQ are also used as a reference for other parameters (chemical, physical, microbiological) to further evaluate health risks of potable drinking water beyond requirements under the Drinking Water Protection Regulation, but implementation is at the discretion of the Drinking Water Officer.

- The **SDWQG** can be either used as a benchmark in a drinking water source-to-tap screening tool or a comprehensive drinking water source-to-tap assessment guideline.

Both establish maximum allowable concentrations (MAC) and aesthetic objectives (AO) requirements. The SDWQG guidelines apply to the water before it is treated and distributed for domestic use. The SDWQG do not supersede any requirement related to drinking water quality established under the *Drinking Water Protection Act*.

In addition to these guidance documents, there are the BC Drinking Water Treatment Objectives (often referred to 4-3-2-1-0) for surface water adopted by the regional health authorities. The drinking water treatment objectives are expectations for disinfection to reduce microbiological risks in potable water as required by the Drinking Water Protection Regulation. The objectives are as follows:

- 4-log (99.99 percent) reduction of enteric viruses.
- 3-log (99.9 percent) reduction of *Giardia* and *Cryptosporidium* (both protozoa).
- 2 forms of treatment for pathogen log reduction - see next paragraph.
- 1-Less than or equal to 1 nephelometric turbidity unit (NTU) of turbidity.
- 0 detectable E. coli, total coliform, and fecal coliform (bacteria indicative of fecal presence – this objective is prescribed in the Regulation).

The provincial treatment objectives for surface water call for two forms of treatment. Filtration, as described in Section 6 of this document, followed by disinfection are the two forms of treatment recommended by Health Canada.

3.1.4. Water Quality Data

A review of the three engineering studies (TRUE, Focus, and AE) revealed that no previous review of water quality was carried out with the exception of the 2007 AE report which analyzed data from Penticton and Kelowna water systems as a proxy for water quality on Okanagan Lake (*Sage Mesa Bulk Water Supply*, 2015; *Sage Mesa Water Supply Study*, 2012; Underwood, 2000).

The RDOS supplied reporting of raw water quality was limited but the select data is summarized in Table 4 below following the format of the 2021 *Annual Water Quality Monitoring Report.* More detailed breakdown of the water quality is provided in Appendix D.

A review of the complete selection of water data indicates that the water quality of the source water is very high, with only total organic carbon (TOC) and turbidity exceeding the BCSDW and GCDWQ MACs and AO.

Table 4 – Summary Key Water Quality Sampling

Analyte	Unit	SDWQG MAC	GCDWQ MAC	2017	2018	2019	2020	2021		
		(AO)	(AO)	avg May	avg May	(4)	Max (1)	Avg	Min	Max
Conductivity	uS/cm					277	299	301	256	391
pH			7-10.5			8.22	8.4	8.31	7.68	8.64
Total Dissolved Solids	mg/L		(500)			163	218	214	182	271
Temperature						-	5.8 (2)	11.8	4.6	24.9
Turbidity	NTU	See Turbidity Section		2.5	7		1.25	0.53	0.2	1.76
Alkalinity (total as CaCO3)	mg/L					118	122	119.3	89.3	178
Total Organic Carbon	mg/L	4				4.24	8.46	4.21	3.67	5.11
Colour (True)	CU	15	15			<5.0	8.5	4.1	<5.0	15
Hardness (as CaCO3)	mg/L					121	128	122	113	139
UV transmittance - unfiltered	%					-	80.5 (2)	84.9	77.2	88.4
Calcium	mg/L					31.7	34 (3)	32.4	30	36.6
Magnesium	mg/L					10.2	9.56 (3)	10.06	9.2	11.5
Manganese	mg/L	0.12 (0.02)	0.12 (0.02)			0.001	0.0019 (3)			
Iron	mg/L	(0.3)	(0.3)			0.013	0.036(3)			
(1) Single samples in January, April, June, September										
(2) Lowest value										
(3) Single sample September										
(4) Single sample August										

3.1.4.1. Turbidity

Turbidity is caused by biotic and abiotic suspended or dissolved substances in the water body and often represent a microbiological risk to drinking water. BC SDWQG states that Health Canada's turbidity guideline is not appropriate for source waters as it is an operational water treatment guideline specific to water treatment filter type.

For source waters of exceptional clarity, which normally do not require treatment to reduce natural turbidity, total turbidity should not exceed 1 NTU. This level is adopted from the drinking water treatment objectives for surface water in B.C. Sampling to date indicates that the source water has exceeded 1 NTU and as such filtration for the reduction of turbidity will be required.

For raw waters that normally require treatment for particulates to reduce natural turbidity to a level which meets the drinking water treatment objective for turbidity of ≤ 1 NTU, BC has adopted guidance that minimizes change from "background turbidity" in source water, that in turn decreases the level of water treatment and thus cost required for safe consumption. This change in background turbidity should not exceed 5 NTU when background turbidity is ≤ 50 NTU. When background levels are > 50 NTU, the change from background should not be more than 10% of background turbidity.

3.1.4.2. Total Organic Carbon and Disinfection By Products

TOC is in a wide variety of organic compounds found in runoff containing decaying vegetation. As summarized in Table 4, TOC has exceeded the MAC guidelines in all but one sample. The dissolved component of TOC (DOC) has not been tested for to date.

TOC is often utilized as an indicator to measure the capacity of drinking water to form disinfection by-products (DBP) rather than testing specifically for the numerous types of THMs or HAAs.

Trihalomethanes (THMs) and haloacetic acids (HAAs) are groups of compounds that can form when water is treated with chlorine and the chlorine reacts with naturally occurring organic matter present in the raw water. The four most common THMs found in drinking water treated with chlorine are bromodichloromethane, dibromochloromethane, bromoform, and chloroform, with chloroform being the most common.

DBPs formation potential is generally higher in surface water sources due to the higher natural organic matter (NOM) content normally found in surface water. The formation rate of THMs is a function of temperature, with higher water temperatures increasing the formation rate. As a result, higher THM concentrations may occur during the summer months when surface water temperatures are higher.

To reduce the precursors associated with disinfection by-product formation, drinking water engineers generally try to reduce TOC concentrations to < 2 mg/L prior to chlorination.

3.1.4.3. Colour

Colour in water may result from natural minerals (such as iron and manganese), algae, and vegetation origins (such as humus material and tannins), or from industries such as logging and mining. Elevated colour can be an indication of high organic content which can react with chlorine and result in the creation of DBPs.

Colour was noted to only meet the guidelines threshold in 2021, but sampling in other years is marginal and it should be a consideration for treatment.

3.1.4.4. Ultraviolet Transmittance

Ultraviolet transmittance (UVT) is a critical parameter if using UV disinfection. It is a measurement of the UV energy, at precisely 254 nanometers wavelength, that passes through the water column and is usually expressed as a percentage, with a higher number corresponding to more penetration of UV radiation for the inactivation of pathogens.

Some UV products require a minimum UVT of 80% to meet NSF certification, while other products require much lower although perhaps at a higher dosing rate or reduced flow for EPA certification.

Although the single UVT sample for the source water is below <80%, it is important to note that the UVT analyzed was for the raw water and does account for any filtration or colour removal by the treatment system.

3.2. WATER SYSTEM DEMAND

3.2.1. Total Demand

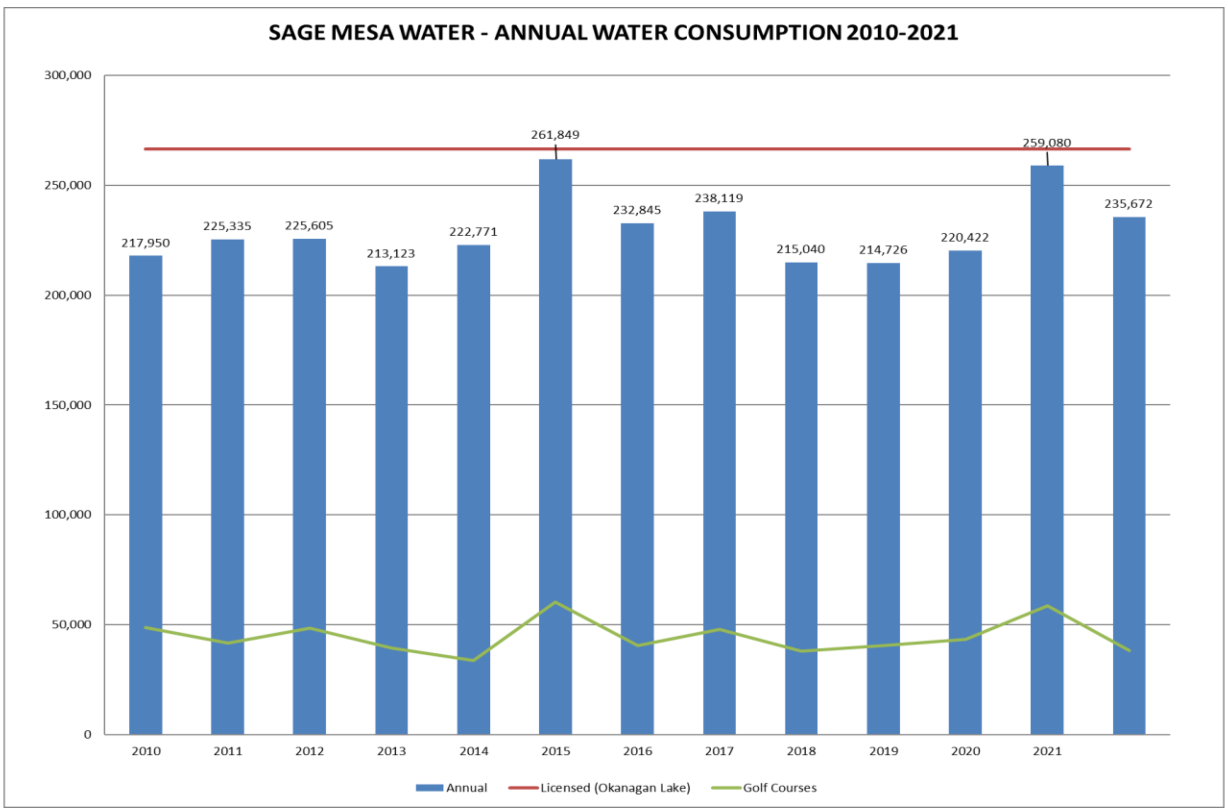
The RDOS provided flow data from the intake pumps from 2010 to 2023 (Jan – May). The monthly consumption rates from 2010-2022 are summarized in Table 5, and include the amount of pumped metered water the golf courses.

Table 5 – Summary- Recorded Monthly Consumption Rates

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019 Total	2019 Golf	Irrigation	2020 Total	2020 Golf	Irrigation	2021 Total	2021 Golf	Irrigation	2022 Total	2022 Golf	Irrigation
Month	**m^3**	**m^3**	**m^3**	**m^3**	**m^3**	**m^3**	**m^3**	**m^3**	**m^3**	**m^3**	**m^3**	**%**	**m^3**	**m^3**	**%**	**m^3**	**m^3**	**%**	**m^3**	**m^3**	**%**
January	4,178	3,960	3,855	3,610	3,691	3,732	3,523	3,673	3,510	3,405	0	0	3,832	0	0	3,650	0	0	5,169		0
February	3,760	3,732	3,573	3,382	3,278	3,191	3,269	3,387	3,055	3,169	0	0	3,510	0	0	3,400	0	0	4,832		0
March	4,987	3,819	3,673	3,941	3,714	7,187	6,792	3,728	4,746	3,987	429	11	6,274	1,719	27	7,337	2,944	40	6,846	1,353	20
April	16,516	10,047	8,419	10,183	12,329	22,835	25,358	6,278	8,919	12,161	3,399	28	16,289	4,525	28	18,616	5,004	27	15,252	5,488	36
May	20,644	19,735	28,968	28,195	26,244	36,182	32,427	17,025	32,163	34,227	7,866	23	25,226	4,368	17	33,827	8,374	25	21,453	4,589	21
June	24,658	30,240	23,094	28,631	33,532	40,146	31,354	39,305	33,805	40,528	8,389	21	23,590	3,798	16	44,638	10,623	24	23,412	3,851	16
July	51,693	43,520	41,247	52,675	48,298	50,543	38,537	57,067	47,175	40,506	9,271	23	42,888	9,534	22	56,835	14,964	26	45,161	12,520	28
August	48,007	52,407	52,262	46,015	45,197	45,906	48,216	53,739	45,643	43,847	8,704	20	47,443	11,507	24	42,047	8,620	21	51,684	6,980	14
September	24,431	41,988	38,533	21,644	28,508	31,504	25,144	35,028	22,449	18,671	1,928	10	33,700	7,025	21	29,090	5,734	20	38,814	2,315	6
October	11,261	7,901	14,266	7,287	10,270	13,552	10,761	11,806	6,674	6,851	565	8	10,210	964	9	11,270	2,396	21	15,602	1,132	7
November	3,964	3,951	3,855	3,737	3,946	3,478	3,691	3,464	3,323	3,505	0	0	3,464	0	0	3,678	0	0	3,228		0
December	3,851	4,037	3,860	3,823	3,764	3,591	3,773	3,619	3,578	3,869	0	0	3,996	0	0	4,692	0	0	4,219		0
Annual	217,950	225,335	225,605	213,123	222,771	261,849	232,845	238,119	215,040	214,726	40,551		220,422	43,440		259,080	58,659		235,672	38,227	

2015 saw the highest annual consumption of 261,849 m^3, with 60,413m^3 being used for the golf courses. Table 6 depicts this annual consumption vs the utility's water licences on Okanagan Lake (266,663m^3). The utility has come close to exceeding the licences in 2015 and 2021.

Table 6 – Annual Consumption vs Existing Water Licences



Per the Province's *Design Guidelines for Rural Residential Community Water Systems* (2012), for existing systems the water demand should be preferably established from reliable water consumption records such as metering data and pumping records. This methodology was used to determine the water demands for the Sage Mesa utility.

Total demand is highest in all reviewed years during July and August, except for 2019 and 2021 when demand was highest in June and August and June and July, respectively. Looking at the average for the highest months between 2019 and 2022, the average irrigation use is 23%.

3.2.2. Domestic Demand

The actual annual domestic demand from Table 5 is summarized in Table 7, with the highest annual demands in 2015 and 2021, respectively.

Table 7- Summary - Annual Domestic Demand

Year	m^3	Year	m^3
2010	173,706	2017	Unknown
2011	186,277	2018	Unknown
2012	177,059	2019	174,175
2013	177,899	2020	176,982
2014	188,994	2021	200,421
2015	201,436	2022	197,445
2016	192,369		

Reviewing the RDOS 2018-2022 daily flow logs for June through August, the total maximum day demand (MDD) was determined. The domestic MDD was estimated using the percentage water usage in Table 6.

As the golf course irrigation volume was not provided in 2018, the average Domestic MDD / Total MDD ratio from 2019-2022 (77%) was used to estimate the 2018 domestic MDD.

Average day demand (ADD) was also determined each year for total and domestic consumption. Results are presented in Table 8.

Table 8 – Average Day Demands

Year	Total ADD (m^3/day)	Total MDD (m^3/day)	Calculated MDD Peaking Factor	Domestic ADD (m^3/day)	Domestic MDD (m^3/day)
2018	589	1881	3.2	Unknown	1448
2019	588	2106	3.6	477	1624
2020	604	2049	3.4	485	1557
2021	710	2092	2.9	549	1590
2022	646	2585	4	541	2223

RDOS Subdivision Servicing Bylaw No 2000,2002, Schedule A states the MDD design criteria for a single family unit to be 8000 L/day. With 265 serviced lots, this equates to 2,120 m3/day, which is median between the 2012 and 2015 Focus recommended values in Table 10.

Table 9 summarizes the MDDs presented in the Report by Focus Engineering, *Sage Mesa Water Supply Study (2015)*. Focus recommended a domestic MDD of 2,000m^3/day and a total MDD of 2,450m^3/day, reduced from their 2012 report which suggested a more conservative 2,250m^3/day for domestic MDD and of 2,700m^3/day for total MDD for design values.

RDOS Subdivision Servicing Bylaw No 2000,2002, Schedule A states the MDD design criteria for a single family unit to be 8000 L/day. With 265 serviced lots, this equates to 2,120 m^3/day, which is median between the 2012 and 2015 Focus recommended values in Table 10.

Table 9 – Summary of Maximum Day Demand in Focus Engineering's Reports

Year	MDD Total (m^3/day)	MDD Domestic (m^3/day)
2009-2011	2100-2300	1650-1850
2013	2276	1826
2014	2100	1650
2012 –Recommended Design Value by Focus	*2,700*	*2,250*
2015 – Recommended Design Value by Focus	*2,450*	*2,000*

Although the data in Table 8 and Table 9 would indicate that the MDD is typically lower than the recommended values in Focus's 2015 report, in 2022 the values were more in line with the 2012 report's values.

Given that the system will need to react to potentially drier climatic conditions (see Section 3.2.4), it is recommended that the more conservative values be used for design. A review of the golf course consumption also indicates that the golf course consumption (irrigation) is typically 450m3/day but is recommended to be increased to 500m3/day per climate impact considerations in Section 3.2.4.

RDOS indicated in the June 12th kickoff meeting that the system should be designed to provide drinking water to the entire system, including the two golf courses. As the system has reservoirs which can buffer the peak hour demand (PHD), the treatment system will be designed for MDD.

Since there is no recorded data from which to calculate PHD, the Design Guidelines for Rural Residential Community Water Systems suggests a peaking factor of 5xADD for arid areas such as the Sage Mesa system. However, as the MDD peaking factor is 40% more than the 2.5xADD peaking factor suggested in the same guideline, it would be appropriate to consider a higher value for a PHD peaking factor. RDOS

Subdivision Servicing Bylaw No 2000,2002, Schedule A states the PHD design criteria as 13,600 l/single family unit/day. With 265 lots this equates to 41.7 l/s domestic. For Sage Mesa, it is suggested that a peaking factor of 7 be applied to the ADD, resulting in a PHD of 51 l/s which includes for the golf course demand.

As such, the design criteria for treatment shall be as follows:

Table 10 – Summary of Recommended Design Values

Parameter	Design Value
ADD	627 m3/day
MDD, Domestic	2,250 m^3/day
MDD, Irrigation	500 m^3/day
MDD, TOTAL	**2,750 m^3/day (31.8 l/s)**
PHD, TOTAL	**51 l/s**

3.2.3. Projected Water Demands

Projected water demands are considered when there is possibility of an increase in usage. The RDOS has confirmed there are minimal development possibilities due to geotechnical restrictions in the area. For the purposes of this report, no development has been assumed.

Additionally, there is no sanitary sewer present in the area, further restricting development. Three lots are visible from orthophoto without any structure present so there is possibility of development in these locations. However, it was assumed that there would be limited impact on system demands.

3.2.4. Climate Change Considerations

The 2020 Climate Projections for the Okanagan Region report indicated several factors that may impact water quality and quantity demand/availability. These findings are generalized and not necessarily specific to Sage Mesa, but still need to be considered in determining demand and potential water quality changes.

Weather

Warmer winters will on average result in less snow accumulation in the uplands, reducing water availability and increasing the need for water storage. Flooding and water shortages may decrease source water quality especially if wastewater and stormwater infrastructure failure rates increase, leading to reduced water quality in Lake Okanagan. This could trigger higher water restrictions and water use conflicts, particularly in years where water demand increases to manage wildfire activity.

Fires

The increased number of fires due to drier weather also has an impact on the water quality. Many of the products used to fight fires along with the ashes and firefighting water entraining other pollutants into the lake all have a direct impact on lake water quality.

Geohazards

The Electoral Area ‘F’ Official Community Plan, Schedule ‘D’ identifies the majority of the lower pressure zone of the Sage Mesa water system as a High Geotechnical Hazard. This hazard encompasses slope stability concerns and sink holes. There is a history of sink holes in this area from both natural ground water/geohazards, and damaged infrastructure (water main breaks, storm water infiltration). RDOS staff have noted that there have been sink holes either resulting from or the result of water main breaks. In addition, the storm water management system in the Sage Mesa area is under developed and may not be able to efficiently deal with storm water runoff which could result in additional hazards related to uncontrolled surface run-off. Any upgrades to the existing system must consider these concerns.

Demand

While water supply is decreasing, additional annual demand increases and competition for water use from users would be expected. It is noted in the report that the growing season length is projected to increase from about 5.5 months to almost seven months by the 2050s, and to almost eight months by the 2080s. For Sage Mesa this could mean longer periods of irrigation for people’s lawns and/or duration of golfing seasons. The recommended design criteria were established bearing the above in mind, with the demand erring on the highest MDD in the last ten years, and golf course irrigation being increased by10-15% to account for a longer season.

Allocation decisions will be required to meet domestic, agricultural, industrial, and ecosystem water needs for larger systems and additional resources to monitor and manage water supply may result in increasing water-related costs. This could become more apparent if Sage Mesa is connected to the larger City of Penticton’s water system.

Siting of the water treatment plant is covered in section 3.6. This location would be outside of any 200-year flood hazard lands indicated in Schedule G (Hazard Lands-Flooding) OCP Bylaw 2790.

3.3. WATER TREATMENT EVALUATION AND OPTIONS

It is important to conceptualize and understand the various water treatment processes that can effectively address the water quality issues in the MSWS, and how to best meet the IHA’s 4-3-2-1-0 drinking water objectives, the BC Source Drinking Water Quality Guidelines (BC SDWQG) and the Guidelines for Canadian Drinking Water Quality (GCDWQ).

After evaluating the existing system, treatment options to are discussed below section for viability for the Sage Mesa system.

3.3.1. Evaluation of Existing Treatment Process

As currently only chlorination is being used for treatment, the system must provide the full 3-log reduction/inactivation of both Cryptosporidium Oocyst and Giardia Cysts, and 4-log reduction/inactivation of viruses. As Giardia is the most resilient of the three pathogens, the necessary contact time (CT) is governed by Giardia inactivation. The effectiveness of chlorination is negatively impacted by increased pH and lower water temperature.

For Sage Mesa, assuming a water temperature of 5°C and pH of 8.5, with a minimum free chlorine residual of 0.4mg/L, a CT value of 236 min-mg/L is required to ensure 3-log reduction/inactivation of Giardia.

As previously noted, with both pumps running, the flow rate is approximately 31.8l/s or equivalent to the MDD. The length of 200mm pipe from the wet well to the first users is approximately 250-300m; at MDD flows, this would result in a CT of 1.6 min-mg/L. This is insufficient to achieve a 3-log reduction of parasitic cysts or even to achieve 4-log reduction of viruses which requires a CT 8 min-mg/L.

Consequently, additional retention is required to achieve the minimum CT before the first users.

3.3.2. Assumption of New Two-Way Flow

As indicated in Section 3.3.1, for the first customers to be protected from pathogens, significant log reductions/inactivation must be achieved prior to chlorination. The ability to meet the requirements of 4-log reduction of viruses and 3-log reduction of *Giardia and Cryptosporidium* by chlorination alone to the first customer using the existing one-way flow distribution system, i.e. no dedicated reservoir fill line, is summarized in Table 11 below.

Table 11: Levels of Pathogen Reduction by Chlorination – Existing One-way Flow

Reduction level at 5°C and pH 8.5 and 0.4 mg/l residual	300mm Pipe Length (m)	Pipe Contact Volume (m3)	CT req (min-mg/L)	CT avail (min-mg/L)	Sufficient CT?
To first customer - 3 log Giardia	300	21.20	236	3.7	NO
To first customer - 4 log virus	300	21.20	8	3.7	NO

As demonstrated, for the first customer to be protected <u>without changing the distribution system to a two-way flow,</u> i.e., dedicated reservoir fill line and a dedicate distribution main, additional treatment (likely both filtration and UV) would be required to meet IHA's 4-3-2-1-0 drinking water objectives as chlorination provides ineffective treatment to the first customers.

To limit the number of options to be analysed, it is assumed that a two-way flow will be implemented in this project, and a new fill line to the lower reservoir will be installed, as also recommended in Focus's 2012 report. 4 log inactivation of virus could be met via chlorination alone (see Table 12) and consequently, UV would not be required. Filtration would still be required for adequate reduction of Giardia and Crypto (only 0.5 log reduction achieved) and to meet the Drinking Water Objectives of two treatment methods of treatment.

Table 12: Levels of Pathogen Reduction by Chlorination – Two-way Flow – Low Water Scenario at Lower Reservoir

Reduction level at 5°C and pH 8.5 and 0.4 mg/l residual	Tank Volume (m3)	Liquid Low Level Volume (m3)	300mm Pipe Volume (m3)	CT req'd (min-mg/L)	CT available (min-mg/L)	Sufficient CT?
Existing lower reservoir - 3 Log Giardia	272	44	66	236	60.6	NO
Existing lower reservoir - 4 Log viruses	272	44	66	8	60.6	YES
Note: the reservoir low liquid level is based on 25% MDD (lower zone) emergency volume remaining (i.e., emergency storage). The lower zone includes approximately 75 of 260 total dwellings (29%). Domestic MDD = 2250m3/day *0.29 = 652 m3/day.						

The routing of the proposed dedicated supply line is presented in Figure 14 in Section 4. Figure 2 provides a high-level process flow for the options, depending on whether there is a lower and upper reservoir or only a single upper reservoir. All the treatment options would require a wet well if there was only an upper reservoir, and the existing booster pump station would need to be reconfigured to pump from the wet well instead of the lower reservoir.

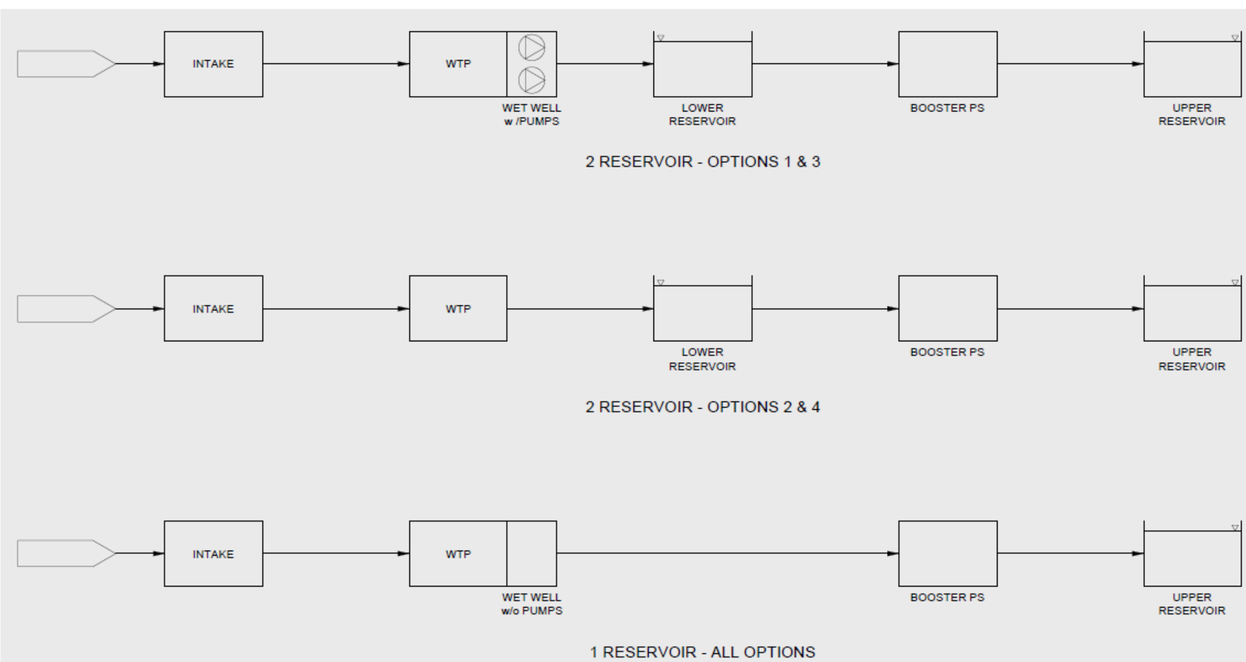


Figure 2. Process Flow for Treatment Options based on Reservoir Option

3.3.3. Filtration Overview

Provincial treatment objectives allow a surface water supply system to operate without filtration if conditions for filtration exemption are met or a timetable to implement filtration has been agreed to by a Drinking Water Officer.

To assist in the filtration exemption process, the Drinking Water Officer has the discretion to rely on sampling of additional parameters to account for local water quality influences and contaminants that could affect treatment.

If a water supply system is permitted to operate without filtration, it does not mean that filtration will not be required in the future. Changes in raw water source quality and increased threats to the watershed or aquifer might necessitate the installation of a future filtration system. Below are the recommended filtration exemption criteria, excerpted from the "*Guidelines for Pathogen Log Reduction Credit Assignment"* (Province of BC, 2022) (Refer to Figure 3).

1. Overall pathogen inactivation is met using a minimum of two types of disinfection providing at a minimum 3-log reduction of *Cryptosporidium* and *Giardia*, and 4-log reduction of viruses.
2. The number of *E. coli* in raw water does not exceed 20/100 mL (or if *E. coli* data are not available, less than 100/100 mL of total coliform) in at least 90% of the weekly samples from the previous six months[52].
3. For all water systems, treated water is to contain no detectable *E. coli* or fecal coliform per 100 mL. Total coliform objectives are also zero based on one sample in a 30-day period. For more than one sample in a 30-day period, at least 90% of samples have no detectable total coliform bacteria per 100 mL and no sample has more than 10 total coliform bacteria per 100 mL.

   For Surface Water Supplies:
4. Average daily turbidity levels measured at equal intervals (at least every four hours) immediately before the disinfectant is applied are around 1 nephelometric turbidity unit (NTU)[53] and do not exceed 5 NTU for more than two days in a 12-month period.
5. A watershed control program[54] is maintained that minimizes the potential for fecal contamination in the source water.

Figure 3. Recommended Filtration Exemption Criteria taken from Guidelines of Pathogen Log Reduction Credit Assignment (BC, 2022)

Previous reports by AECOM (2007) and Focus (2012) both indicate a possible filtration exemption similar to that granted to the City of Kelowna's water utility. However, it is McElhanney's opinion, which is supported by the RDOS, that it is unlikely this exemption is achievable at Sage Mesa due to the higher turbidity periods exceeding requirement #4 above, i.e., raw water turbidity exceeds 5 NTU for more than 2 days in a twelve-month period (Harvey, 2007; *Sage Mesa Water Supply Study*, 2012).

A review of several filtration treatment technologies for the Sage Mesa system was undertaken including:

1. Dissolved Air Floatation (DAF) and Rapid Sand Filtration
2. Hollow Fibre Nanofiltration (HFNF)

3. Ballasted flocculation (BF) and sand filters
4. Pressure Filters

The intent of each of the above technologies is to remove the turbidity and dissolved organic matter in the water to reduce the formation of THMs and HAAs in the final drinking water.

- All processes except the HFNF require chemical addition of coagulants to ensure that the dissolved and suspended solids are flocculated into larger sized particles, big enough to be floated and then retained on the filter media.

- The HFNF membrane system requires chemicals for cleaning cycles which occur automatically and at regular intervals.

- All plants require the addition of Chlorine disinfection to ensure conformance to the BC 4-3-2-1-0 rule for surface water treatment. Pressure filters require additional UV disinfection as they are considered by the Province to be pre-treatment only.

Treatment processes and additional systems are summarized in Table 13 below.

Table 13: Summary of Treatment Process and additional systems to meet Regulations.

Treatment Process	Chlorine Disinfection Req'd	Coagulants Req'd	Chemical for Cleaning Req'd	UV Disinfection Req'd
Dissolved Air Floatation (DAF) and Rapid Sand Filtration	X	X		
Hollow Fibre Nanofiltration (HFNF)	X		X	
Ballasted flocculation (BAF) and sand filters	X	X		
Pressure Filters (GAC)	X	X		X

For a small community such as Sage Mesa, it is important that the WTP be less complex, easy to operate, have less chemical handling, be automated and less expensive. The largest challenge will be dealing with the waste streams generated by all the treatment technologies due to there being no available connection to a sanitary sewer.

As none of the systems can provide the required 4-log inactivation requirement to the first customer with one-way flow, it is assumed that two-way flow will be implemented. Note that pressure filters are not a viable option for one way flow even with UV.

The treatment processes listed above are discussed in more detail below.

3.3.4. Dissolved Air Flotation (DAF) with Rapid Sand Filtration

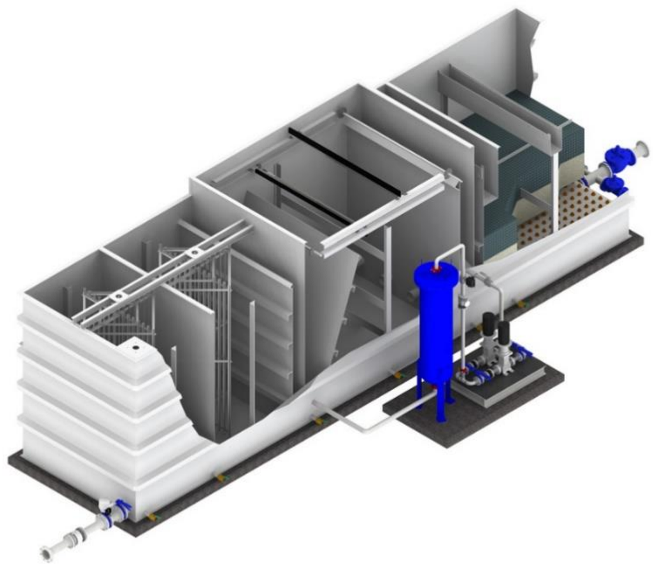


Figure 4. Typical DAF System with Rapid Sand Filtration

For municipal systems, the conventional treatment process for reducing turbidity and naturally occurring organic matter is coagulation, flocculation and sedimentation (or floatation) followed by rapid gravity filtration. Chemical conditioning is used to encourage suspended solids to bind together to form larger particles (flocculation). These larger particles are then removed after they sink (sedimentation).

For low density particles, the process of Dissolved Air Floatation (DAF) can be used in place of sedimentation. After flocculation, water is exposed to fine bubbles that entrain the floc causing them to float to the surface where they are skimmed into a waste stream. The water then passes though a multi-media sand filter followed by disinfection to meet potable water standards. TOC removal should be in the range of 60-75%, colour will be almost completely removed and turbidity will be below 0.3 NTU. (Refer to Figure 4).

It is proposed that this water be stored in a backwash recovery tank with up to 10% of the inflow being recycled to the head of the plant. Sludge would be pumped from this tank either directly or to a holding tank for offsite disposal to Landfill.

DAFs require an open water surface to operate and do not operate under pressure, thus requiring a clear well for treated water and booster pumps to pump water to the treated water reservoir(s). Disinfection via sodium hypochlorite takes place after filtration.

Log reduction credits achieved by conventional filtration is presented in Table 14.

Table 14. Log reduction credits for pathogen reduction using conventional filtration.

Conventional Filtration Pathogen Log Reduction Credits and Assignment Criteria

Maximum Pathogen Log Reduction Credits Assigned [a]	*Cryptosporidium* Oocysts	*Giardia* Cysts	Viruses
Conventional Filtration	3	3	2

[a] Pathogen log reduction credit assignment is based on the conventional filtration treatment process being fully operational and the applicable pathogen log reduction credit assignment criteria being met.

AWC solutions was contacted for treatment equipment pricing. Their proposal includes for 2 separate trains, each capable of treating 2,750m^3 net water. The estimated capital and life cycle costs for a conceptual level DAF WTP are presented in Table 15 and Table 16.

Table 15. Estimated Capital Cost for the Conceptual DAF WTP

Option 1 – DAF	
Item Description	
Packaged System – 2 module – 2750 m3/day each	$3,809,000
Building structural, foundation	$756,000
Building Electrical distribution and Lighting	$100,000
HVAC and plumbing	$150,000
Site Electrical	$150,000
Site Work	$264,000
Wet well	$75,000
Pumps- wet well to lower reservoir – see infrastructure costs(1)	-
Emergency Generator (WTP plant only)	$150,000
Backwash Recovery	$320,000
Sludge Holding tank	$10,000
Commissioning	$60,000
BC Hydro Allowance	$50,000
General requirements (15%)	$884,000
Contingency (30%) Rounded to nearest $1000	$2,711,000
Estimated Capital Cost	**$9,489,000** (2)

Notes

(1) 1 duty /1 standby pump will be required to pump water from wet well to lower reservoir. If only an upper reservoir, existing booster pumps will be reconfigured to pump from wet well to upper reservoir. See Infrastructure costs.

(2) A system with no redundancy (1 module at 2,750m3/day) would have a capital cost of approximately $5.2M

.

Table 16. Estimated Life Cycle Costs for Operations and Maintenance – DAF WTP

Option 1 – DAF Annual Costs	
Consumables	
Coagulant & pH adjustment	$40,000
Sodium Hypochlorite (12% @ 4mg/L) – Disinfection	$16,000
Replace sand media every 10 years	$20,000
Energy Consumption	
Pumping, Mixing, and Backwash Systems	$10,000
Maintenance	
Operating staff time for O&M	$58,400
Sludge Disposal	$90,000
General equipment maintenance allowance	$95,000
Total annual average costs	$329,400
Net Present Value for 20 Years of Operation	$4,476,653
NPV plus Capital Cost	$13,966,000

3.3.5. Hollow Fibre Nanofiltration (HNF)

HFN technology utilizes modules that look identical to ultrafiltration membranes (also hollow fibre) but are made with a different material that includes a molecular charge on the separation layer of the membrane fibers. This gives it the ability to reject ions based on surface charge, typically falling under standard nanofiltration. Refer to Figure 5.

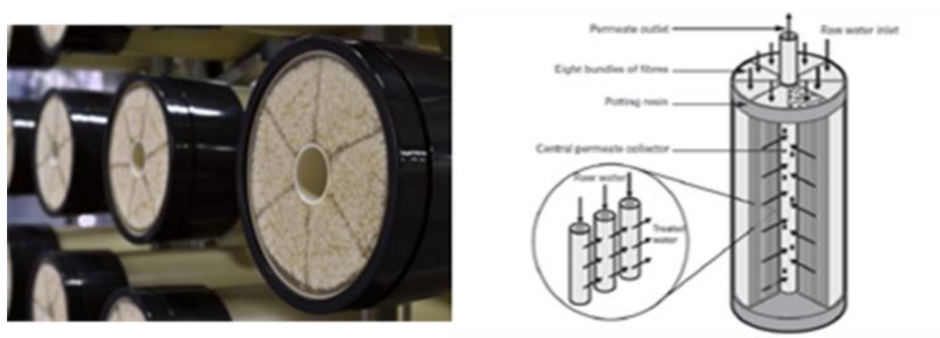


Figure 5. Hollow Fibre Nanofiltration

HFN uses pressure, via pumps or gravity, to drive water through a membrane with pore sizes ranging from 0.001 to 0.01 microns.

This technology is effective in the removal of DOC, turbidity, color, and oxidizing metals along with log removal of pathogens. It does not use process chemicals, and minimal maintenance cleaning chemicals.

The protozoan based pathogens are effectively removed with the membrane, thus UV is not required and the membrane plus primary chlorination would meet the 2 barriers of treatment, provide 4 log reduction/inactivation of viruses and 3 log reduction/inactivation of parasitic cysts, and maintain turbidity levels below 1 NTU.

These membranes also require a backwash system consisting of pumps typically supplied with unit and a backwash tank to provide clean water. As the waste stream would be considered very low in concentrated waste, it is possible that the system could discharge to the lake. **This would require permitting by the Ministry of Environment and Climate Change**, but the reduced ongoing operational and maintenance cost benefits could be significant enough to pursue. The system does require the use of caustic and oxidant cleaning agents for periodic deep cleaning.

The drawbacks with HFN are that the technology is relatively new and has only been around for 10 years, are high in capital cost and they typically operate at 75-95% recovery (i.e., 5-25% of raw water is wasted).

Log reduction credits achieved by conventional filtration presented in Table 16.

Table 17. Log reduction credits for pathogen reduction using nanofiltration.

Nanofiltration Pathogen Log Reduction Credits and Assignment Criteria

Maximum Pathogen Log Reduction Credits Assigned [a]	*Cryptosporidium* Oocysts	*Giardia* Cysts	Viruses
Nanofiltration	4 [b]	4 [b]	0 [c]

[a] Pathogen log reduction credit assignment is based on the nanofiltration treatment process being fully operational and the applicable pathogen log reduction credit assignment criteria being met.

[b] Removal efficiency is demonstrated using challenge testing and verified by direct integrity testing.

[c] Pathogen log reduction credits for viruses are not assigned for membranes as direct integrity tests to verify virus-sized leaks are not commercially available.

Delco Water was contacted for treatment equipment pricing. Their proposal includes for 2 separate trains, each capable of treating 1375m^3 net water. This option only provides 50% redundancy due to membranes needing to be constantly wet. If one train was to go offline, the system will only provide 50% of the MDD. The estimated capital and life cycle costs for a conceptual HNF Plant are presented in Table 18 and Table 19.

Table 18. Estimated Capital Cost for the Conceptual HNFN Plant

Option 2 – HFNF	
Item Description	
Packaged System – 2 module – 2750 m3/day total	$3,900,000
Building structural, foundation	$924,000
Building Electrical distribution and Lighting	$100,000
HVAC and plumbing	$150,000
Site Electrical	$150,000
Site Work	$308,000
Wet well (only required if no lower reservoir)	$75,000
Emergency Generator (WTP plant only)	$175,000
Backwash Holding Tank	$250,000
Sludge Holding tank	$10,000
Commissioning	$60,000
BC Hydro Allowance	$50,000
General requirements (15%)	$923,000
Contingency (40%) Rounded to nearest $1000	$2,830,000
Estimated Capital Cost	**$9,905,000**

Table 19. Estimated Life Cycle Costs for Operations and Maintenance – HNFN Plant

Option 2 – HFNF Annual Costs	
Consumables	
Acid/Caustic/Neutralization	$30,000
Sodium Hypochlorite (12% @ 4mg/L) – Disinfection	$16,000
Membrane replacement – every 10 years	$65,000
Energy Consumption	
Pumping and Backwash Systems	$20,000
Maintenance	
Operating staff time for O&M	$29,200
Sludge Disposal	$21,000
General equipment maintenance allowance	$98,000
Total annual average costs	$279,200
Net Present Value for 20 Years of Operation	$3,794,419
NPV plus Capital Cost	$13,699,000

3.3.6. Ballasted Flocculation and Sand Filtration

Ballasted flocculation provides excellent efficiency in clarifying the water by rapidly mixing coagulant and flocculant chemicals prior to the clarification stage, which features a specially graded sand (microsand) that acts as a ballast, allowing the flocs to stick to the sand and settle very rapidly. The clarifier would be followed by a rapid sand filter. Refer to Figure 6. The sand is recycled through a cyclone separator at the top of the flocculant tank, and sand loss is minimal throughout the process.

Figure 6. Ballasted Flocculation and Sand Filtration Tank.

The clarification process would be based on two units, each designed for 75% of the required capacity to provide redundancy. This would be followed by two sand and anthracite filters, each capable of treating the full treatment flow plus water losses for backwashing. In this configuration both filters are completely independent, and one can be taken offline (or backwashed while the other is in operation). The system uses both a coagulant for clarification and polymer for flocculation. Disinfection via sodium hypochlorite takes place after filtration.

The sand filters require backwashing with an estimated volume of water rejected per backwash per filter of 150m3/day. It is proposed that this water be stored in a backwash recovery tank with up to 10% of the inflow being recycled to the head of the plant. Sludge would be pumped from this tank either directly or to a holding tank and disposed of to Landfill.

BFs require an open water surface to operate and do not operate under pressure, thus requiring a clear well for treated water and booster pumps to pump to the treated water reservoir(s).

Veolia was contacted for treatment equipment pricing. Their proposal includes for 2 separate trains, each capable of treating 2,063m^3 net water. This option provides 75% redundancy. The estimated capital and life cycle costs for a conceptual BF and Sand Filtration Plant are presented in Table 20 and Table 21.

Table 20. Estimated Capital Cost for the Conceptual Ballasted Flocculation and Sand Filtration Plant

Option 3 - Ballasted Flocculation	
Item Description	
Packaged System - 2 module - 2163 m3/day/each	$2,723,000
Building structural, foundation	$661,500
Building Electrical distribution and Lighting	$100,000
HVAC an plumbing	$150,000
Site Electrical	$150,000
Site Work	$256,500
Wet well	$75,000
Pumps- wet well to lower reservoir - see infrastructure costs(1)	-
Emergency Generator (WTP plant only)	$150,000
Backwash Recovery	$350,000
Sludge Holding tank	$10,000
Commissioning	$20,000
BC Hydro Allowance	$50,000
General requirements (15%)	$704,000
Contingency (40%) Rounded to nearest $1000	$2,160,000
Estimated Capital Cost	**$7,560,000**

(1) 1 duty /1 standby pump will be required to pump water from wet well to lower reservoir. If only an upper reservoir, existing booster pumps will be reconfigured to pump from wet well to upper reservoir. See Infrastructure costs.

Table 21. Estimated Life Cycle Costs for Operations and Maintenance – – Ballasted Flocculation, Rapid Sand Filtration

Option 3 - Ballasted Flocculation Annual Costs	
Consumables	
Coagulant & Polymer & microsand	$30,000
Sodium Hypochlorite (12% @ 4mg/L) - Disinfection	$16,000
Replace sand media every 10 years	$40,000
Energy Consumption	
Pumping, Mixing, and Backwash Systems	$23,000
Maintenance	
Operating staff time for O&M	$58,400
Sludge Disposal	$90,000
General equipment maintenance allowance	$68,000
Total annual average costs	$325,400
Net Present Value for 20 Years of Operation	$4,422,292
NPV plus Capital Cost	$11,982,000

3.3.7. Pressure Filtration – Sand Media and Granular Activated Carbon

Pressure filters are similar in bed construction to rapid gravity filters used in the DAF process, except they are housed in carbon steel pressure vessels (Refer to Figure 7). The vessels are cylindrical and typically arranged vertically, with either perforated pipes or a steel plate with nozzles used for collecting the filtered water and for distribution of the backwash water and air scour (if used). Media can be a single media, dual media or mixed media. It should be noted that a complete turnkey, prefabricated treatment system is proposed for this option assessment.

Figure 7. Pressure Filters

For Sage Mesa, granular activated carbon (GAC) is suggested in conjunction with anthracite coal, however piloting would ultimately be recommended in the preliminary design stage to determine the most effective media for a particular water.

The activated carbon particles have a large surface area with high adsorptive qualities that provide a surface on which molecules in either the liquid or gaseous stage can be concentrated. Activated carbon can be used to reduce dissolved organic carbon (TOC/DOC) and natural organic matter (NOM) compounds that are generated by decaying vegetation in the watershed, which is often the main cause of high colour events. For this application two sets of three filters are considered to provide 100% redundancy. Disinfection via sodium hypochlorite takes place after filtration.

GAC requires backwashing but not air scouring like normal sand filtration. Overtime, even with backwashing, the media will become spent and will need to be replaced with new, virgin or fresh reactivated carbon. The spent media would have to be disposed of. The backwash from non-coagulated pressure filters is typically not considered a deleterious substance by the Ministry of Environment and Climate Change, and should be able to be discharge to ditch, however additional permitting may be required with the ultimate receiving environment being fresh water.

Backwashing would be required every 1 to 2 weeks on a set of three filters. Backwash volumes would be approximately 23 m3/filter. It is suggested that each filter would be backwashed at 2.5-day intervals, with the backwash being stored and released at 7 lpm to the ditch. Two 13,000L poly tanks would provide necessary capacity including some space for sludge. It will be assumed that sludge would need to be pumped out once every 2 weeks for this review.

As these are pressurized tanks, no clearwell would be required to store treated water and the treated water could be discharged directly to the lower reservoir. A clearwell and booster pumps would be required if the plant was required to discharge to the upper reservoir directly.

The main disadvantage of pressure filter use in BC is that they are considered by the Province to be pre-treatment only. This means that although they are considered filtration, **they are not eligible for pathogen log credit assignment** and requires that the Public Health Engineer will accept using an alternate additional disinfection method such as UV, in lieu of a log reduction credit filtration method.

3.3.8. UV Disinfection

UV disinfection is recommended to provide the necessary pathogen log reduction credits and minimize chlorine disinfection requirements. UV disinfection is an effective treatment process for the inactivation of pathogens. UV light inactivates pathogens by damaging their DNA and RNA so that they cannot replicate and infect humans. The effectiveness of this inactivation depends on the UV dose.

One of the advantages of using UV disinfection is that the disinfection by-products typically associated with the use of chemical disinfectants such as ozone or chlorine are not formed. Unlike chlorine which can be used for both primary and residual disinfection, UV light can only be used for primary disinfection as it does not have any residual disinfection capability.

UV would be a required addition to any of the filtration systems, unless a two-way flow was implemented. As two-way flow has been assumed, only the pressure filters require UV. 2 duty and 1 standby UV systems have been allotted for, with each providing 1,375m^3/day capacity.

Log reduction credits achieved by UV is presented in Table 22.

Table 22. Log reduction credits for pathogen reduction using UV Disinfection.

Ultraviolet Disinfection Pathogen Log Reduction Credits and Assignment Criteria

Validation Protocol or Certification Standard	Minimum UV Dosage [a]	Maximum Pathogen Log Reduction Credits Assigned [b, c]		
		Cryptosporidium Oocysts	*Giardia* Cysts	Viruses [d]
DVGW W294	RED = 40 mJ/cm^2	3	3	0.5 or 2
NSF Standard 55 (Class A Systems only)	40 mJ/cm^2	3	3	0.5 or 2
ÖNORM M 5873	RED = 40 mJ/cm^2	3	3	0.5 or 2
UVDGM	Validated dose ≥ required dose for target pathogen log inactivation	Determined on a case by case basis	Determined on a case by case basis	Determined on a case by case basis

RED = Reduction Equivalent Dose. May also be called the REF (Reduction Equivalent Fluence).

a Validated reactors establish a RED for a specific organism (e.g. an MS2 RED or a *B. subtilis* RED). Similarly, NSF Standard 55 Class A certified systems are designed to deliver a UV dose that is at least equivalent to the MS2 bacteriophage dose-response at 40 mJ/cm^2 when the systems are tested in accordance with the Standard.

b Pathogen log reduction credit assignment is based on post-filter applications of UV equipment, or application of UV equipment to drinking water systems that use a groundwater source at low risk of containing pathogens; a 'GARP-viruses only' water source; or a water source that has been granted a filtration exemption by a Drinking Water Officer.

c Pathogen log reduction credit assignment is based on UV equipment being fully operational and the applicable pathogen log reduction credit assignment criteria being met.

d For drinking water sources that a Drinking Water Officer considers to be at risk from human fecal contamination, a 0.5-log reduction credit should be assigned because of the high level of resistance of adenovirus to UV treatment. For drinking water sources that a Drinking Water Officer does not consider to be at risk from human fecal contamination[55], a 2-log reduction credit should be assigned based on rotavirus inactivation.

Bi-Pure was contacted for treatment option pricing. They provided costs for a complete turnkey solution with the treatment system being provided completely installed in a prefabricated building with all process, electrical, HVAC and plumbing installed, tested and ready to connect the site service. The estimated capital and life cycle costs for a conceptual Pressure Filtration / UV Plant are presented in Table 23 and Table 24.

Table 23. Estimated Capital Cost for the Conceptual Ballasted Flocculation and Sand Filtration Plant

Option 4 - Pressure Filters (Anthracite/GAC)	
Item Description	
Turnkey System - 2 skids of 3 filters- 2750 m3/day/each skid	$2,150,000
Building structural (included), foundation	$230,000
Building Electrical distribution and Lighting	INCLUDED
HVAC and plumbing	INCLUDED
Site Electrical	$150,000
UV (2 duty/1 stndby)	$150,000
Site Work	$209,000
Wet well (only required if no lower reservoir)	$75,000
Emergency Generator (WTP plant only)	$150,000
Backwash Holding tank	INCLUDED
Dirty Backwash Holding Tanks	$20,000
Commissioning	$16,000
BC Hydro Allowance	$50,000
General requirements (5%) - reduced due to turnkey	$160,000
Contingency (40%) Rounded to nearest $1000	$1,008,000
Estimated Capital Cost	$4,704,000

Table 24. Estimated Life Cycle Costs for Operations and Maintenance for the Conceptual Ballasted Flocculation and Sand Filtration Plant

Option 4 - Pressure Filters (GAC) Annual Costs	
Consumables	
Coagulant & pH adjustment	$0
Sodium Hypochlorite (12% @ 4mg/L) - Disinfection	$16,000
Media Replacement	$75,000
Energy Consumption	
Pumping, UV, and Backwash Systems	$24,000
Maintenance	
Operating staff time for O&M	$43,800
Backwash Waste and Spent Media Disposal	$50,000
General equipment maintenance allowance	$54,000
Total annual average costs	$262,800
Net Present Value for 20 Years of Operation	$3,571,538
NPV plus Capital Cost	$8,276,000

3.3.9. Probable Cost Summary of Treatment Technologies

Table 25 provides a comparison of the estimated total capital and 20-year net present value of O&M and 20-year O&M NPV plus capital costs for the four options above. As indicated, Option 4 has the lowest capital, O&M total NPV cost.

Table 25. Probable Cost Summary

	Option 1- DAF	Option -2 HFNF	Option 3- BAF	Option 4- GAC/UV
Estimated Capital Costs	$9,489,000	$9,905,000	$7,560,000	$4,704,000
NPV for 20 Years of Operation	$4,476,653	$3,794,419	$4,422,292	$3,571,538
Capital Costs + Net Present O&M Costs	$13,966,000	$13,699,000	$11,982,000	$8,276,000

3.3.10. Comparison of Treatment Technologies

The treatment system for Sage Mesa needs to be reliable, relatively easy to operate and maintain and be relatively compact, given the space limitations of the possible sites for construction.

A comparative assessment of the options is presented in Table 26 below, which ranks each treatment technology in 11 categories, each with a factored level of importance. The importance factors (IF) are multiplied by the performance rating (PR) and the cumulative score is presented at the bottom.

Based on the factors for this community, the pressurized filters using GAC media, UV primary disinfection and chlorination for primary and secondary disinfection plant (Option-4) scores the highest and should be the preferred option.

The caveat of this recommendation is that this treatment system should only be considered if a new dedicated line is installed (i.e., two-way flow is implemented) to the lower reservoir or upper reservoir. The current one-way flow does not allow for sufficient chlorine contact time to the first customer to provide the 1-log credit reduction of protozoa necessary to complement the 3-log reduction provided by the UV system. If two-way flow is not installed, then Option 3, ballasted flocculation and sand filtration becomes the preferred option.

Table 26: Comparison of Water Treatment Technologies

Options Analysis Parameter	IF	(1) Dissolved Air Flotation (DAF)	PR	(2) Hollow Fibre NanoFIltration (HFNF)	PR	(3) Ballasted Flocculation (BAF)	PR	(4) Pressure Filters w/ UV (GAC/ UV)	PR	Comments
Robust efficacy of filtration in meeting **1** NTU for the 4-3-2-**1**-0 Rule	**10**	Relies on stable water source, but should be relatively consistent if chemical addition is properly monitored and optimized	9	Fully automated process with reliable, consistent results	10	Better reaction times to varying raw water quality, efficient nutrient, organic and dissolved solids removal	9	Hig turbidity spikes results in high backwash cycles which increases waste water.	7	All plants can meet the 4,3,2,1,0 rule, but some require more attention than others
Pathogen removal for fecal coliform, viruses, bacteria , cryptosporidium and giardia for meeting **4,3,2** and **0** criteria for **4-3-2**-1-**0**	**10**	Generally good in pathogen control. Well proven. Many installations in the region. Only requires CL a seond barrier and disinfection for virus (assuming two-way flow to reservoir installed).	10	Generally good in pathogen control. New technology, very few installations in the region. Only requires CL a seond barrier and disinfection (assuming two-way flow to reservoir installed).	10	Generally good in pathogen control. Well proven. Only a few installations in the region. Only requires CL a seond barrier and disinfection for virus (assuming two-way flow to reservoir installed).	10	No Pathogen control from filtration - requires UV disifection in conjunction with Chlorination for two barriers. In case of UV failure chlorine doasge can compensate but higher DBP potential	8	All systems must be designed and operated to meet the 4-3-2-1-0 rule. All can meet this but option 4 requires higher cl doisng than the others and potentially higher DBP formation.
Operability, complexity of controls (SCADA) and level of operation intervention	**8**	Change to influent water quality will have a much more immediate impact. Thus operation staff will need to be even more attentive and more time in plant is anticipated. The saturation system is more complex thus requiring a higher level of service support. There can be more reliance on outside support	7	Fully automated: commissioning and operation should be relatively straightforward. Operator attendance required during CIP process on a monthly to bi-monthly basis. No addition of clearwell or booster pumps required if feeding lower reservoir.	8	The advantage of this system is it starts and stops very quickly without upset to treated water quality. The experience level in the province for this technology is very limited. This risk is offset by strong support provided by the Process Suppliers.	7	Operationally simple and system can be automated via dual trains and pressure transducers. No addition of clearwell or booster pumps required if feeding lower reservoir. During high turbidity events, more backwashing will be required.	9	The selected process must be aligned to operator's experience and capacity. In addition, can staff understand the process and address issues themselves or is outside support required. Can remote controls and monitoring be used to allow simple adjustments to address warnings and alarms?
Mechanical and Control Complexity and differences in operational cost	**7**	The saturation tank, air compressor, surface skimmer add several moving parts to treatment and control complexity	7	The feed pumps, recir pumps, backwash pumps, air compressor, pneumatic valves all add complexity to the system. The controls can also be proprietory which can result in specialized maintenance call outs.	6	The introduction of the Microsand and the recirculation system adds several wear parts plus the system includes more automation to maintain the treatment.	7	Although manual control can be utilized, the automation of backwash cycles and switch overs from duty to standby filters is reommended to reduce operator involvement. UV is farly straight forward but requires cleaning as well as prefilters. GAC needs to be replenished once depleted.	7	As a rule of thumb, the less moving parts, the lower the operational cost as there are less wear items. Fewer controls and instrument have a similar affect of operational costs as each instrument requires continual calibration and periodic replacement.
Chemical consumption	**6**	Requires chemical addition for coagulation and additional chemicals for pH adjustment. In addtion a disinfectant is required.	7	Although no coagulants are used the system does requre acids and caustics for cleaning and neutralizers. In addtion a disinfectant is required.	8	This process uses the most chemicals, requiring coagulant, and polymer flocculant. In addtion the system uses microsand. The raw water solids attach to the sand that rapidly settle in the specialized clarifier. The Microsand is continually recycled and is not a large impact on operational cost	8	Lowest chemical consumption, disinfectent only. Although not a chemical the GAC needs replenshment when depleted and is a high cost.	6	Chemical costs are an important consideration. Limited time is allocated to this comparison due to the detailing required. During detailed design, this could be the difference between options as chemical costs are incurred every day to potentially make a considerable change in the overall selection.
Energy Consumption	**7**	Moderate - although the treatment system has one of the lower energy consumptions, the addition of required booster pumps to pump to either the lower resesrvoir or the upper reservoir make this moderate.	7	Although second in cost only to Option 4, this is rated moderate as if a lower reservor is maintained the system would not require booster pumps to discharege to the lower reservoir.	7	Moderate, however the addition of required booster pumps to pump to either the lower resesrvoir or the upper reservoir make this moderate.	6	Although highest in cost due to the addtion of UV, this is rated moderate as if a lower reservor is maintained the system would not require booster pumps to discharge to the lower reservoir.	7	Options 1 and 3 all require mixing motors. All require and backwash pumps. HFNF requires a pressure pump to drive the water through the membranes <<<cehck if intak pumps enough>>>.
Redundancy	**9**	Two 100% DAF units will be included with standby pumps and full redundancy in chemical feed. All pumps will include a redundant spare. There will be full redundancy in chemical feed.	10	System comes in modules with each module providing 50% of the capacity.	7	Two 75% ballasted floc units will be included with all the ancillary elements including the floc tank, maturation tank and clarifier. All pumps will include a redundant spare. There will be full redundancy in chemical feed and with the filtration banks.	10	Two complete separate trains provide 100% redundancy. All pumps will include a redundant spare. There will be full redundancy in chemical feed.	10	All process must have redundancy of the process elements. This will be a part of the approval process and technology selected must meet Ministry guidelines
Relative Capital Costs	**8**	Comparable to HNFN.	6	Highest captial cost.	5	Slightly favoured over DAF for slightly lower capital, and O&M costs	7	Lowest capital cost. This comes as a turnkey solution from Bi-Pure, with the entire building and systems prefabricated allowing from easier construction.	10	
Residuals (sludge) Handling	**7**	High levels of residuals that need to be pumped and discharge at the Pentiction seeptage reciveing station.	6	Lowest levels. Backwash shoud be able to discharge to environment.	9	High levels of residuals that need to be pumped and discharge at the Pentiction seeptage reciveing station.	6	Moderate levels due to backwashing but could be significantly higher during freshet. Most backwash water should be able to discharge to environment.	7	No sanitary connection. If no ability to recyle back to front of plant or discharge to lake must be stored and pumped.
Technology fits on current site (lower reservoir)	**7**	Slightly larger than the BAF option. Building size required is in the order of 12m wide by 18m long, but also requires large recovery tank	6	Largest option of the package plant. Building size required is in the order of 12m wide by 22m long, but smaller BW holding tank needed than Option 1 or 3.	7	Second smallest of the package plant. Building size required is in the order of 9m wide by 21m long, but also requires large recovery tank.	7	Smallest option of the package plant. Building size required is in the order of 9m wide by 16m long	9	Existing right-of-way is very limited and would need to be expanded regardless of the chosen technology <<<CHECK THIS>>>
		608		**618**		**622**		**638**		
		DAF		**HFNF**		**BAF**		**GAC/UV**		

3.4. WATER TREATMENT CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are provided based on the conceptual treatment plant evaluation and the review of the previous review reports.

1. A review of the available water quality data indicates that the source water is of acceptable quality, with only total organic carbon (TOC) and turbidity exceeding the BCSDW and GCDWQ MACs and AO at times. However, there is a risk that turbidity may not be accurately captured in this sampling. **Sampling during Freshet is recommended to determine the range of raw water turbidity before proceeding with a design**.
2. The water demand used for the treatment system design was 2,750m^3 / day and included for the estimated 500 m$^{3/}$day treatment of irrigation water used at the two golf courses. This demand is considered slightly conservative; however, it is reflective of the additional demand that could come from a trending warmer drier summer climate.
3. Four water treatment technologies were explored for the application of improving the water delivered to the residents of Sage Mesa. The recommended option, **if two-way flow is implemented, is granular activated carbon pressure filters followed by primary UV disinfection and primary and secondary chlorination**. This method of treatment provides for the lowest capital cost, and the lowest operation and maintenance cost while providing an adequate water treatment system meeting the drinking water objectives and requirements of the GCDWQ. In addition, the system provides 100% redundancy and is available from local suppliers as a complete turnkey packaged system which presents for easier construction and accountability. **This option will have to be reviewed at the preliminary design stage with the Public Health Engineer as they will need to make a determination if two disinfection methods with pressure filters can be used in lieu of log reduction credit filtration.**

   If two-way flow is not implemented or if the Public Health Engineer does not accept the use of two disinfection methods in lieu of log reduction credit filtration, then the preferred option is Option 3 – ballasted flocculation with sand filtration.
4. Cost estimates at the conceptual stage of study carry significant contingency as limited site-specific information and investigation has been completed; these estimated costs will need to be reviewed as design progresses.

3.5. TREATMENT PLANT SITING

The potential area available for a new WTP would be south of the existing booster station.. This right of way is approximately 25m long by 13m wide.

3.5.1. Maintaining the Lower Reservoir In-Service

Using this in-service area means that good access is available and if the lower reservoir is to be maintained or replaced, then the treatment system is simplified by not requiring a wet well or booster pumps.

The recommended treatment, Option 4, would have a building footprint of approximately 15.2m long by 8.5m wide if there is a lower reservoir (ie no wet well is required). In addition to the building, two 2.4m diameter (15m³) dirty backwash tanks would be sited near the road to allow settled sludge to be pumped out. (Refer to Figure 8).

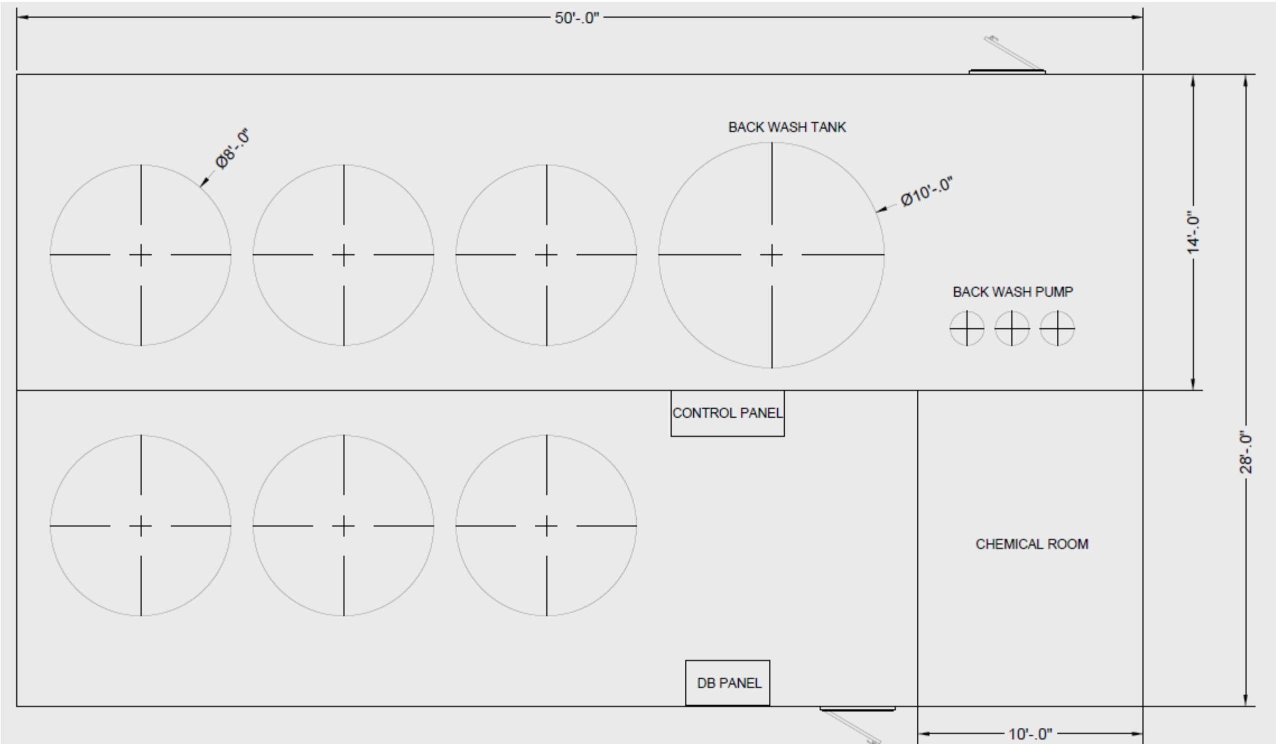


Figure 8. Conceptual Option 4 WTP Layout - Assuming the Lower Reservoir is Maintained (no wet well)

In summary, re-using Okanagan Lake as the raw water supply and installing a new water treatment plant based on Option 4 is anticipated to require the following upgrades:

- Condition assessment and upgrades/replacement of the existing Lake Pumphouse and raw water intake line. Extending the intake and upgrading the power supply and pumps are all anticipated.
- Constructing of the WTP.
- Linear infrastructure additions to accommodate the new WTP which include:
  - A new 200mm main in Sage Mesa Drive so there's a dedicated main between the Lake Pumphouse and WTP with no service connections; and
  - Piping between the WTP and Lower Reservoir or Booster Station, depending on how many reservoirs will be used.

3.5.2. Decommissioning the Lower Reservoir

If there is only an upper reservoir, then the length of the building would be extended to 18.5m to allow for a pump room and wet well.

In addition to the building, two 2.4m diameter (15m³) dirty backwash tanks would be sited near the road to allow settled sludge to be pumped out.

3.6. CONCEPTUAL WEST BENCH CONNECTION OPTION

The second water supply option evaluated is to consider tying into the nearby West Bench water supply system and entering into a bulk water purchase agreement with the CoP to provide water to Sage Mesa.

A water model was not available for the West Bench distribution network and as such, a detailed analysis of their system was not undertaken as a part of this project. However, the Penticton Model was updated with the additional demands for Sage Mesa to confirm adequate water supply is possible, as noted in Section 4.6 of this report. As the City of Penticton water model includes an allowance to supply water to West Bench and Sage Mesa, it was assumed that the 2017 West Bench piping system upgrades also included an allowance to supply water to Sage Mesa. Refer to Section 4.7 for the desktop analysis of the West Bench piping system.

The required piping modifications and flow control upgrades are detailed in Section 4.0 as part of the hydraulic evaluation of this option. The proposed connection to the West Bench system is presented in Figure 16.

In summary, there would be a connection at Hyslop Drive and Sage Mesa Drive from where the water would be conveyed to the existing lower reservoir/booster pump station in the Sage Mesa system. The linear infrastructure additions to connect the Sage Mesa distribution network to the West Bench distribution network will include:

- A new 200mm main between the intersection of Hyslop Drive / Sage Mesa Drive and the Lower Reservoir/Booster Station
- A new water meter in an aboveground kiosk for custody purposes.
- A PRV/FCV station in an aboveground kiosk to control the flow from the West Bench.

This section of the report is focused on likely additional upgrades to ensure that the water quality meets current guidelines.

3.6.1. Re-chlorination of West Bench Connection

It is anticipated that the water from a West Bench connection will have a low residual of free chlorine by the time it makes it to Sage Mesa. Re-chlorination will be required to maintain adequate chlorine residuals. Additional chlorine should be injected into the system prior to entering the reservoir(s) to keep microbial growth to a minimum in the reservoirs. For design, it is assumed that there will be zero chlorine residual by the time water from West Bench reaches the first user in the Sage Mesa system. It is assumed that a chlorine booster station would be required somewhere in the system if the West Bench water supply option is chosen.

The Sage Mesa system has a disinfection booster (re-chlorination) station at the booster pump station to boost residual levels when water leaves the lower reservoir. As Operations staff have indicated there are no concerns regarding the condition of the pumps, these pumps could possibly be re-used, pending ability to integrate them with the new control system.

The drawing of the booster pump station is from 1978 and it was noted that the pumps shown in the record drawings do not match the 2019 inspection report. So although the actual pump station layout was not confirmed, and the record drawings would indicate that there is very little room in this structure, it would appear there is sufficient room to install components to ensure the chlorination system can be upgrade to meet WorkSafeBC requirements.

System components would include: A hot water tank, emergency shower with tempering valve, sodium hypo dosing tank with containment and a set of dosing pumps. This may require some modification to the building, including changing baseboard heater to ceiling mounted unit heater, ventilation, alarms, and additional plumbing.

In summary, connecting to the existing West Bench water distribution network for potable water supply is anticipated to require the following upgrades:

- A new 200mm main between the intersection of Hyslop Drive / Sage Mesa Drive and the Lower Reservoir/Booster Station
- A new water meter in an aboveground kiosk for custody purposes
- A PRV/FCV station in an aboveground kiosk to control the flow from the West Bench reservoir. It is anticipated that this would be located near the Booster Station
- The addition of a sodium hypochlorite chlorine booster system in the Booster Station pumphouse. An allowance has been included for a new system to ensure it meets WorkSafeBC requirements, including safety eye-wash and shower requirements, and potential need to upgrade the existing systems.
- Decommissioning of the Lake Pumphouse and existing raw water intake in Okanagan Lake

4. Water Modelling and Distribution Network Assessment

The hydraulic modelling system InfoWater Pro, which is an attachment to the popular ArcGIS Pro, was used to model the demands, pressures, and velocities in the existing Sage Mesa hydraulic system and size watermain upgrades to meet the RDOS design criteria and engineering best practices.

While the model is validated based on professional experience and best practice, the model is uncalibrated and is only as good as the data available for input.

The model is a steady state simulation model appropriate for determining the operating behaviour under static conditions. This is useful for analysing the effects of fire flow, ADD, MDD and PHD conditions.

4.1. WATER MODEL DEVELOPMENT

The model was developed using ArcGIS Pro V3.1.0, InfoWater Pro V2024.2 August 2023. The model was developed from scratch (to our knowledge, no existing hydraulic model for Sage Mesa has been developed) using the GIS information provided by the RDOS and supplemented by provided record drawings. The GIS information provided included watermains with material, age, and size. Valve, pump reservoirs and hydrant locations with various levels of detail were also provided.

The model was inputted with the demands for ADD, MDD and PHD as determined in Section 3.2. No future development demands were developed as no development in the area is planned. The demands are summarized in Table 27.

The golf courses were assumed to have the same peaking factors as the residential properties and equal demand between the two. This is a conservative assumption as the golf courses are likely to have different peak consumption periods than the residential properties, however the impact of this is low. The demands were spatially distributed in the model to junctions based on the quantity of properties nearby. The Upper and Lower Zones have 176 and 68 properties respectively for a total of 244.

Table 27 - Summary of System Demands

Zone	ADD (l/s)	MDD (l/s)	PHD (l/s)
Upper Residential (176)	4.3	18.8	29.8
Lower Residential (68)	1.7	7.3	11.5
Total Residential (244)	5.9	26.0	41.4
Golf Courses in Lower Zone (2)	1.4	5.8	9.6
Grand Total	**7.3**	**31.8**	**51.0**

4.2. MODEL DESIGN CRITERIA

The hydraulic model is governed and developed based on data provided by the RDOS such as the water intake pumps and local design criteria. The following criteria was used to develop the model and size the recommended upgrades:

- In general, the RDOS development servicing bylaw took priority (*Subdivision Servicing Bylaw No. 2000*, 2002).
- Where criteria were not available, the City of Penticton criteria, was followed (*Subdivision & Development Bylaw*, 2004).
- While minimal pipe diameters are provided in the RDOS bylaw, sizing of the recommended upgrades are based on the hydraulic results of the model and the Penticton velocity criteria.

McElhanney reviewed and agrees with the criteria specified by RDOS and the City of Penticton with the exception of the RDOS hydrant spacing criteria, where the Fire Underwriters Survey 2020 Criteria was used (*Water Supply for Public Fire Protection*, 2020). The criteria used is included in Table 28.

Table 28 - Water Distribution Design Criteria

Criteria	Value	Source
Demands	Refer to Section 3.2	RDOS daily flow logs and Sage Mesa Water Supply Study (Focus, 2015)
System Pressures (kPa / psi)	• Min Pressure PHD = 265 (40) • Max Pressure = 620 (90) • Max Pressure with PRV = 865 (125) • MDD+FF Residual = 140 (20)	RDOS Subdivision Servicing Bylaw NO. 2000, 2002
Pipe Velocities (m/s)	• Pump Supply & Reservoir Trunk Mains = 2 m/s • Distribution Mains @ PHD = 2 m/s • MDD + FF = 4 m/s	Penticton Subdivision & Development Bylaw 2004-81
Fire Flows and Durations	• Residential Development = 60 l/s for 1.5 hours	RDOS Subdivision Servicing Bylaw NO. 2000,
Pipe Roughness Coefficients (Hazen-Williams)	• Asbestos Cement = 130 • Ductile Iron = 140 • PVC = 140 • New Pipe = 140	MMCD Design Guidelines 2022 Table 2.8
Reservoir Criteria	• **A + B + C = Required Storage** • Fire Storage (A) = Maximum fire flow serviced by the reservoir - 60 l/s @ 1.5 hours • Equalization Storage (B) = 25% of MDD • Emergency Storage (C) = 25% of A + B	MMCD Design Guidelines 2022 Fire Underwriters Survey 2020
Hydrant Spacing	• Maximum hydrant spacing of 180m • Hydrants to be connected to watermain with a minimal diameter of 150mm • Hydrant cannot provide coverage through a property to another property or across impassable terrain	Fire Underwriters Survey 2020

4.3. MODELLING SCENARIOS

The scenarios shown in Table 29 were run to complete the analysis. A total of five scenarios were required to analyse the existing system and size the recommended upgrades.

Table 29 - InfoWater Pro Modelling Scenarios

Scenario Name	InfoWater Pro Scenario Name	Scenario Purpose
Existing System - ADD	EX_ADD	To determine pressure, velocity and flows throughout the system during ADD
Existing System – MDD	EX_MDD	To determine pressure, velocity and flows throughout the system during MDD
Existing System – PHD	EX_PHD	To determine pressure, velocity and flows throughout the system during PHD
Existing System – MDD + FF	EX_MDD + FF	To determine fire flow results and identify any undersized watermain(s) in the system
Proposed Upgrades – MDD+FF	MDD+FF-UPGR	To size proposed watermain throughout the system to meet the design criteria

4.1. PRESSURE ZONES AND PRV'S

Sage Mesa consists of two main areas:

- The Upper Zone serviced by the Upper Reservoir, which is composed of 4 pressure zones; and
- The Lower Zone, serviced by the Lower Reservoir, which is composed of 2 pressure zones.

The pressure zones are shown in Figure 1 and the details are summarized in Table 30. The pressure zone names are based on the zones hydraulic grade line (HGL), which is the theoretical elevation of the static water pressure. For example, PZ619 is the pressure zone serviced by the Upper Reservoir where 619m is the top water level of the reservoir. The setting is the pressure that the PRV splitting the zones is set at. The upper (min pressure bound) and lower (max pressure bound) elevation are the theoretical bounds that the zone can service within the design criteria pressures of 865 to 265 kPa.

Table 30 - Pressure Zone Summary

Pressure Zone Name	PRV / Reservoir Name	PRV / Reservoir Elevation (m)	Setting (kPa / psi)	Max Pressure Bound / Lowest Elevation (m)	Min Pressure Bound / Upper Elevation (m)
PZ619	Upper Reservoir	619	N/A	531	592
PZ579	Upper Zone PRV 1	537	413 / 60	491	552
PZ554	Upper Zone PRV 2	487	655 / 95	466	527
PZ593	Local PRV	537	551 / 80	505	566
PZ456	Lower Reservoir	454	N/A	368	429
PZ436	Lower Zone PRV	410	250 / 36	347	409

As outlined in Section 2, the Upper Zone begins with the Upper Reservoir that services the properties along Forsyth Drive to the Upper Zone PRV 1 and Local PRV located adjacent to 2619 Forsyth Drive. The Local PRV services 4 properties in that area. Upper Zone PRV 1 services the properties down Forsyth Drive to 2505 Pinetree Place where a closed valve separated PZ579 and PZ554. Upper Zone PRV 2 receives water from a watermain that passes by the east of 1911 Estates Place to Forsyth Drive. The Upper Zone PRV 2 then services the properties off Sandstone Drive.

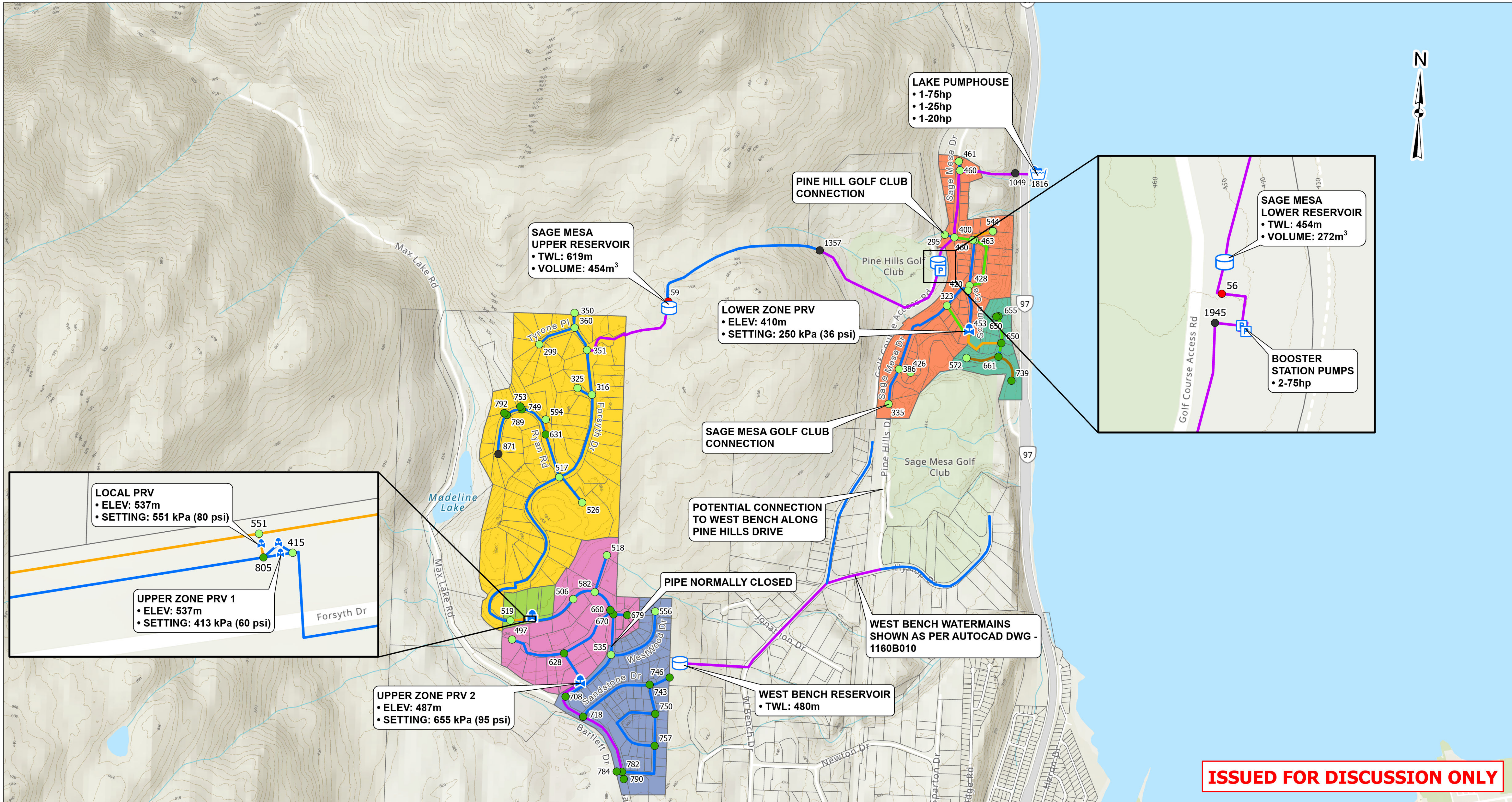
The Lower Zone begins with the Lower Reservoir, servicing most of the Lower Zone, until the Lower Zone PRV drops the pressure to service the properties along Verano Place.

4.2. SYSTEM PRESSURES

The existing system pressures for the ADD, MDD and PHD are shown in Figure 9, Figure 10, and Figure 11. The pressures on the figures are shown in kPa at junctions and dead ends in the system. The junction pressures are colour coded based on the design criteria minimum and maximum pressures as well as 620 - 865 kPa which is the maximum pressure permitted without a PRV servicing the property. Pressures are indicated at ground elevation at the junction point which is typically along the roadway.

As is expected, pressures drop from ADD to MDD and MDD to PHD; however, due to the relatively small size of this system, the variability of pressures as a result of these three scenarios is minimal. The results show that pressures meet RDOS pressure criteria.

The RDOS has mentioned that complaints have been received from the Husula Highlands area regarding low pressures. Presumably this is along Tyrone Place where the pressures are around 300 kPa at ground elevation in PZ619. Reviewing google maps street view, some of the properties are at a noticeable elevation above the road and will presumably have pressures that may be lower than desired for homeowners. Precise values for pressure at these homes requires calibration of the model.



TITLE

Figure 9. Sage Mesa Distribution System - Existing System ADD

Project: Sage Mesa Water System Assessment

Location: Sage Mesa, BC

Scale 1:13,000

0 — 1,000 Meters

INSET

LEGEND

Raw Water Lake Intake

Reservoirs

Pump

PRV

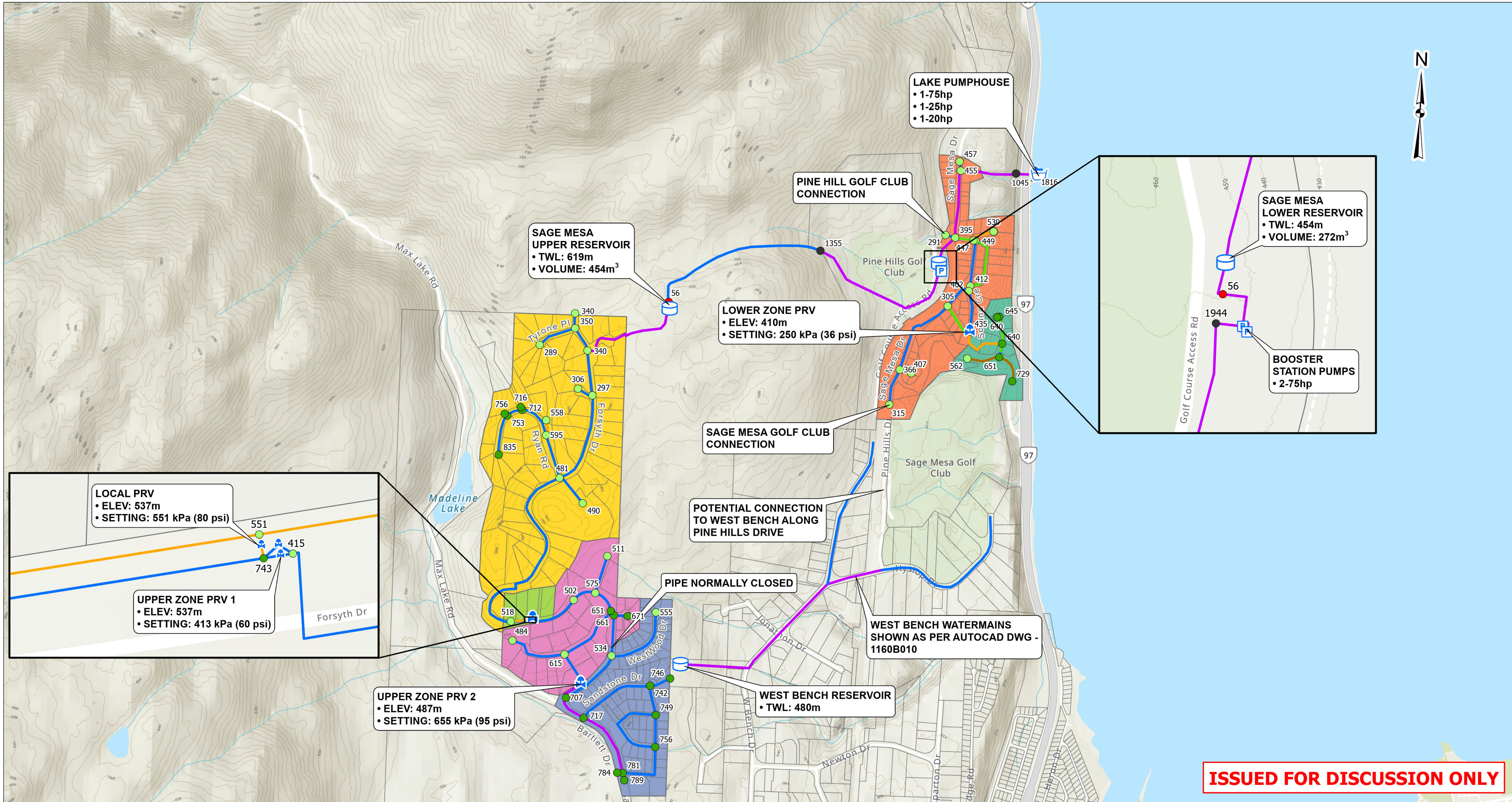
Pressure (kPa)	Watermain (mm)	Pressure Zone
< 265	50	Lower,PZ436
265 - 620	100	Lower,PZ456
620 - 865	150	Upper,PZ554
> 865	200	Upper,PZ579
	250	Upper,PZ593
		Upper,PZ619

McElhanney

Projection: NAD 1983 UTM Zone 11N

Original Paper Size: 11" x 17"

Author: ACHAPUT



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Projection: NAD 1983 UTM Zone 11N

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Figure 10. Sage Mesa Distribution System - Existing System MDD

Project: Sage Mesa Water System Assessment

Location: Sage Mesa, BC

Scale 1:13,000

0 — 1,000 Meters

INSET

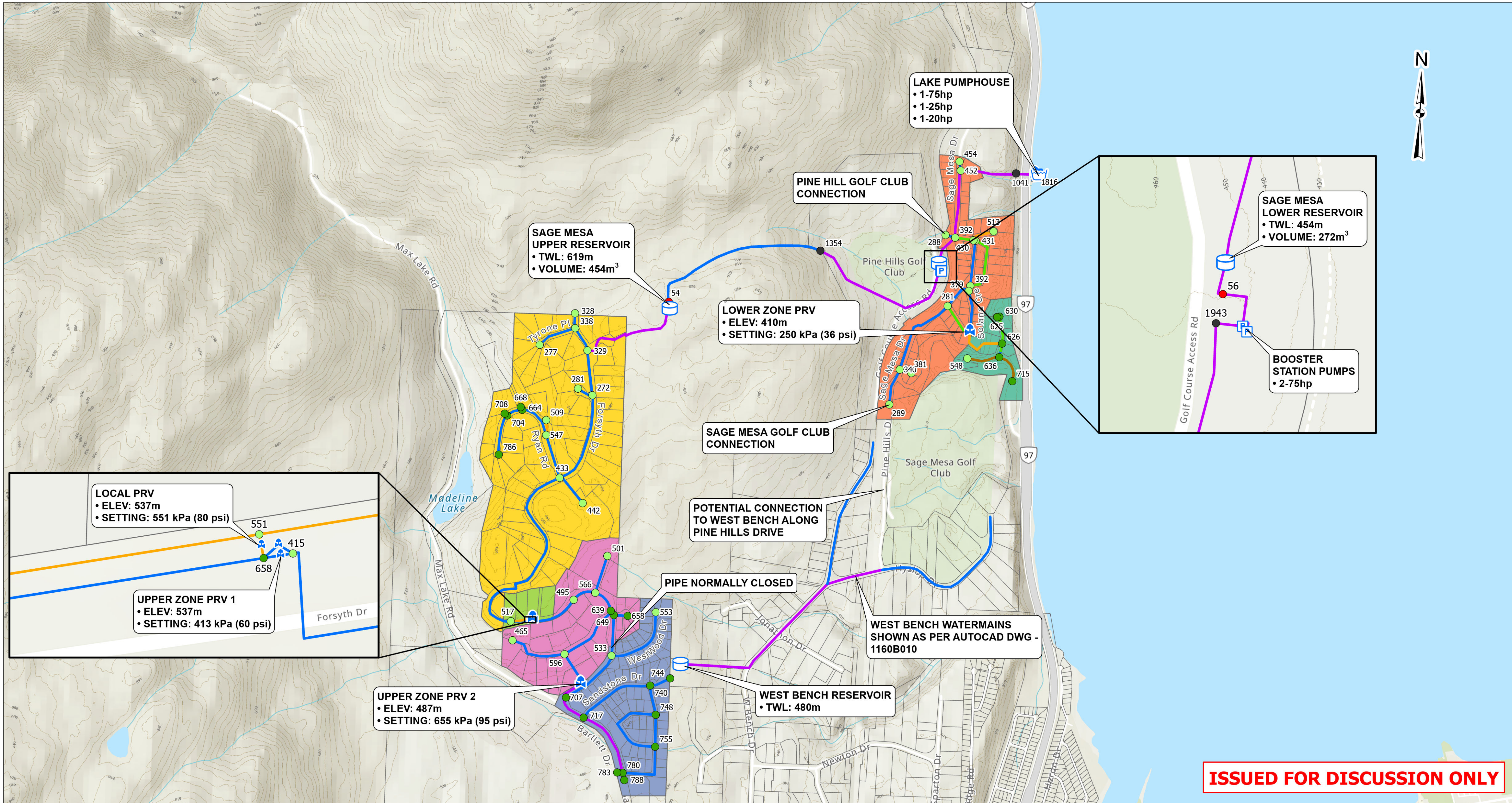
LEGEND

- Raw Water Lake Intake
- Reservoirs
- Pump
- PRV

Pressure (kPa)
- < 265
- 265 - 620
- 620 - 865
- > 865

Watermain (mm)
- 50
- 100
- 150
- 200
- 250

Pressure Zone
- Lower,PZ436
- Lower,PZ456
- Upper,PZ554
- Upper,PZ579
- Upper,PZ593
- Upper,PZ619



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TITLE

Figure 11. Sage Mesa Distribution System - Existing System PHD

Project: Sage Mesa Water System Assessment

Location: Sage Mesa, BC

Scale 1:13,000

0 — 1,000 Meters

INSET

LEGEND

- Raw Water Lake Intake
- Reservoirs
- Pump
- PRV

Pressure (kPa)
- > 265
- 265 - 620
- 620 - 865
- > 865

Watermain (mm)
- 50
- 100
- 150
- 200
- 250

Pressure Zone
- Lower,PZ436
- Lower,PZ456
- Upper,PZ554
- Upper,PZ579
- Upper,PZ593
- Upper,PZ619

Projection: NAD 1983 UTM Zone 11N

One option to increase pressures would be to relocate the Upper Reservoir to a higher elevation. Currently the reservoir has a TWL of 619m and is in ground. However, increasing the TWL will increase pressures along Ryan Road which is already at the maximum design criteria pressure criteria of 865 kPa. If the pressures in PZ619 are increased, more homes will be above 620 kPa and this will likely required PRV's at their service connections. A single node at the end of Ryan Road is currently indicated to have a pressure above 865 kPa, however, the pressure is only 6 kPa above the maximum pressure and within the acceptable manufacturer specifications for pressure of standard pipes and fittings.

4.2.1. MDD + Fire Flow Results

The existing system fire flow analysis is shown in Figure 12. The figure shows the available fire flow at each hydrant in Sage Mesa. The available fire flow is the flow that can be realized at the hydrant while maintaining a minimum pressure of 140 kPa at that node and a maximum velocity of 4 l/s in the watermains.

The model executes the analysis by running a theoretical fire at each node and listing the results at that node for that scenario. Note that for every node, the limiting factor for determining the available fire flow is the 140 kPa pressure requirement which means that headloss in the system is controlling the model result, i.e., if the maximum velocity restraint was removed, the results would be the same.

Only three hydrants are able to meet the minimum fire flow of 60 l/s and these hydrants are nearest to the reservoirs which is to be expected as the watermains closest to the reservoirs are typically the largest, resulting in less total headloss than a junction further away from the reservoir.

The results of the fire flow analysis are provided in Table 31 showing the range of fire flow deficiencies. In general, the Upper Zone falls within the 0-40% deficient range with three hydrants in the 40-60% range. The Lower Zone falls within the 60-100% deficient for most hydrants. The next section discusses the sizing of upgrades to eliminate these deficiencies.

Table 31 - Existing System Fire Flow Analysis

% of Available Fire Flow	Fire Flow (l/s)	Number of Hydrants
0% Deficient	60+	3
1-20% Deficient	48-59	4
20-40% Deficient	36-47	17
40-60% Deficient	24-35	6
60-80% Deficient	12-23	2
80-100% Deficient	0-11	2

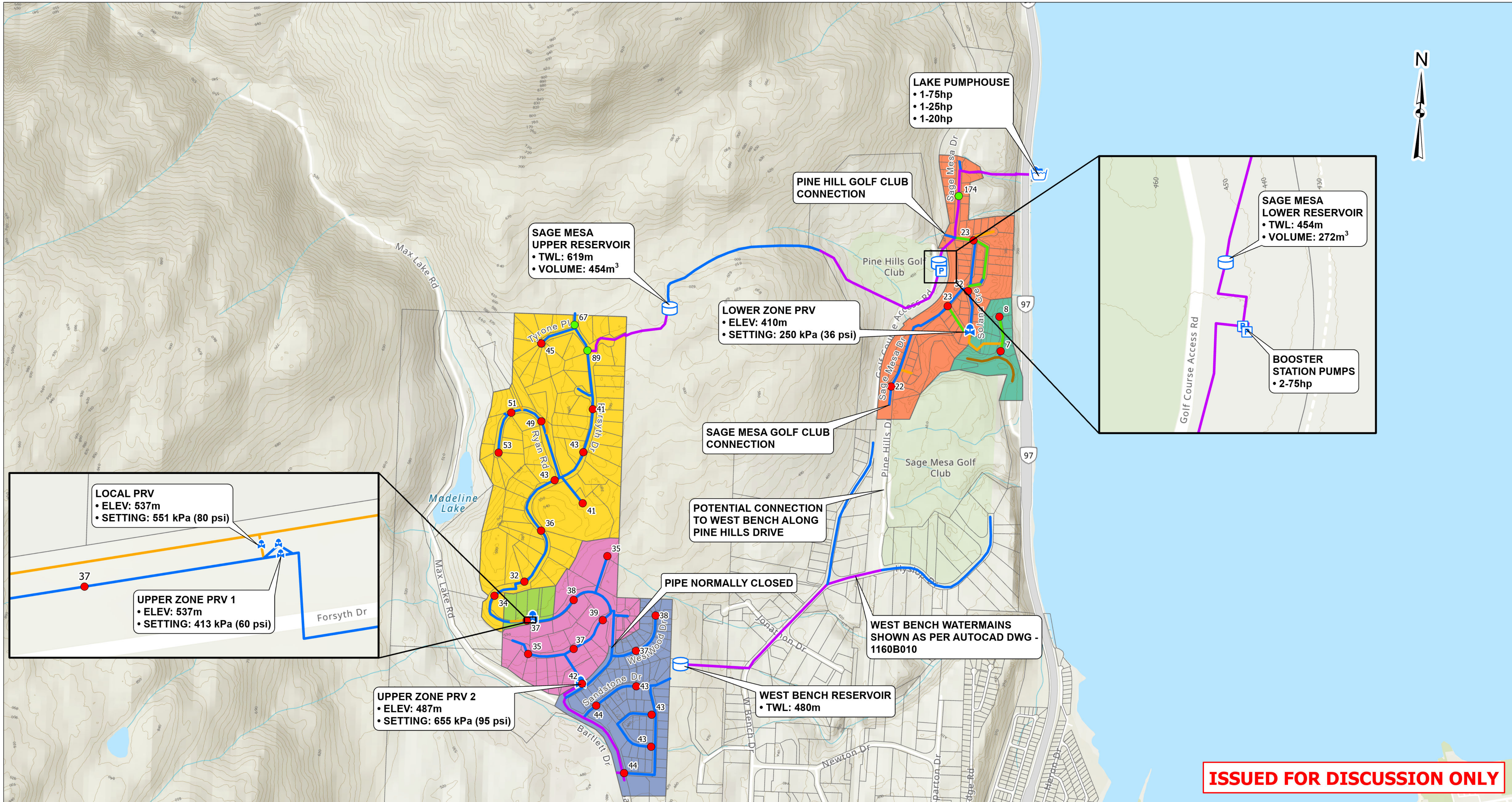

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Figure 12. Sage Mesa Distribution System - Existing System MDD+FF

Project: Sage Mesa Water System Assessment

Location: Sage Mesa, BC

Scale 1:13,000

0 — 1,000 Meters

Projection: NAD 1983 UTM Zone 11N

INSET

LEGEND

- Raw Water Lake Intake
- Reservoirs
- Pump
- PRV

Available Fire Flow (L/s)
- < 60
- ≥ 60

Watermain (mm)
- 50
- 100
- 150
- 200
- 250

Pressure Zone
- Lower,PZ436
- Lower,PZ456
- Upper,PZ554
- Upper,PZ579
- Upper,PZ593
- Upper,PZ619

Original Paper Size: 11" x 17"

Author: ACHAPUT

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4.3. WATERMAIN SIZING AND RECOMMENDED UPGRADES

Following the modelling of the existing system fire flow results, the necessary watermain upgrades to meet 60 l/s at all hydrants in the system was determined using standard practice for upsizing watermains, as follows:

1. Increase the diameter of watermain closest to the reservoir that has a deficient hydrant.

2. Work your way downstream until all hydrants meet fire flow demand.

3. Review looped watermain to ensure the optimal route of watermain length is upsized while still meeting fire flow demand.

4. Review upsized watermain nearest the reservoir going downstream to identify any upgrades that may no longer be required.

Figure 13 and Figure 14 show the recommended watermain upgrades and difference between the West Bench Connection and New Water Treatment Plant Option, assuming two reservoirs. The piping and control station differences between Figure 13 and Figure 14 are detailed in Section 5. Figure 13 and Figure 14 highlight the differences between water supply sources but are not the recommended option.

Per conversation with the RDOS on November 23, 2023, it was decided that a single Upper Reservoir option was preferred over upgrading both the Upper and Lower Reservoir options. The Single Reservoir option and connection to West Bench is presented Figure 16 and is further discussed in Section 4.4.1 Preferred Reservoir Option Evaluation.

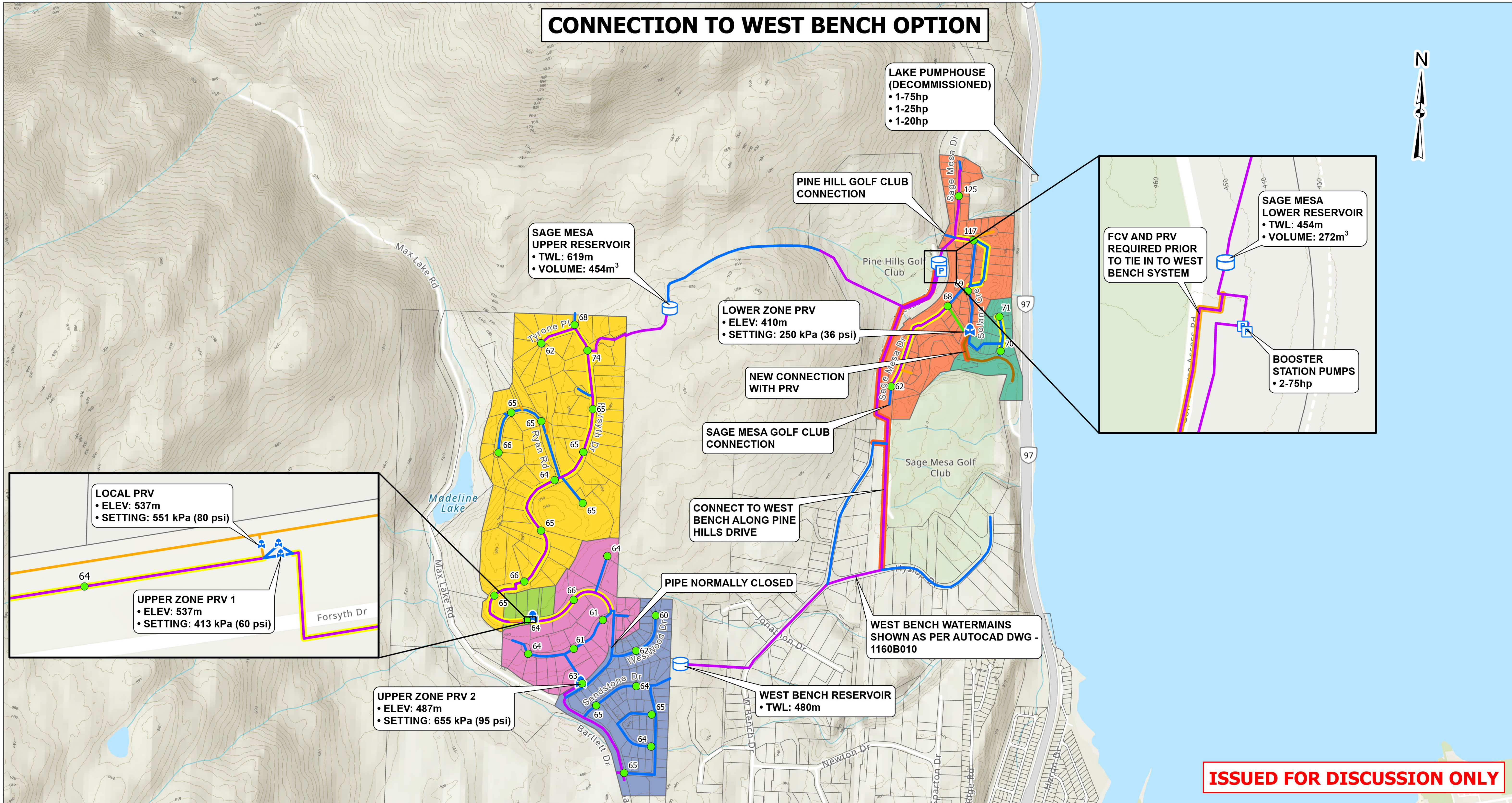
As a model was not obtained for West Bench, modelling was not completed with the West Bench System, however a review of the existing storm mains and background documents was sufficient to confirm West Bench can sufficiently service Sage Mesa.

The fire flow results shown in the figures are the Hydrant Design Flow. This is the fire flow available at the node while not exceeding 4 m/s in the watermains and maintaining 140 kPa (20psi) in the distribution system. Note that the recommended watermain upgrades are specific to ensuring sufficient hydraulic capacity in the system. Refer to Section 7, Financial Assessment, for additional information regarding prioritization of upgrades.

All options result in the same distribution system upgrades within the zones as neither water supply source option impacts the Sage Mesa distribution system’s ability to meet required fire flows. Note that in the single reservoir option, the existing 150mm supply main must be upgraded as the Upper Reservoir will now need to provided fire flow to the Lower Zone through the supply main. The total watermain upgrade recommendations for the Upper and Lower Zone are listed in Table 32.

Table 32 - Watermain Upgrade Summary

Zone	Watermain Upgrade Size (mm)	Length (m)
Upper Reservoir Supply Main	200	640
Upper Zone	200	1890
Lower Zone Upgrade	200	470
Lower Zone Upgrade	150	330
Lower Zone New Pipe	250	115



McElhanney

TITLE

Figure 13. Sage Mesa Distribution System - Watermain Upgrades & MDD+FF (Connection To West Bench)

Project: Sage Mesa Water System Assessment

Location: Sage Mesa, BC

Scale 1:13,000

0 — 1,000 Meters

INSET

LEGEND

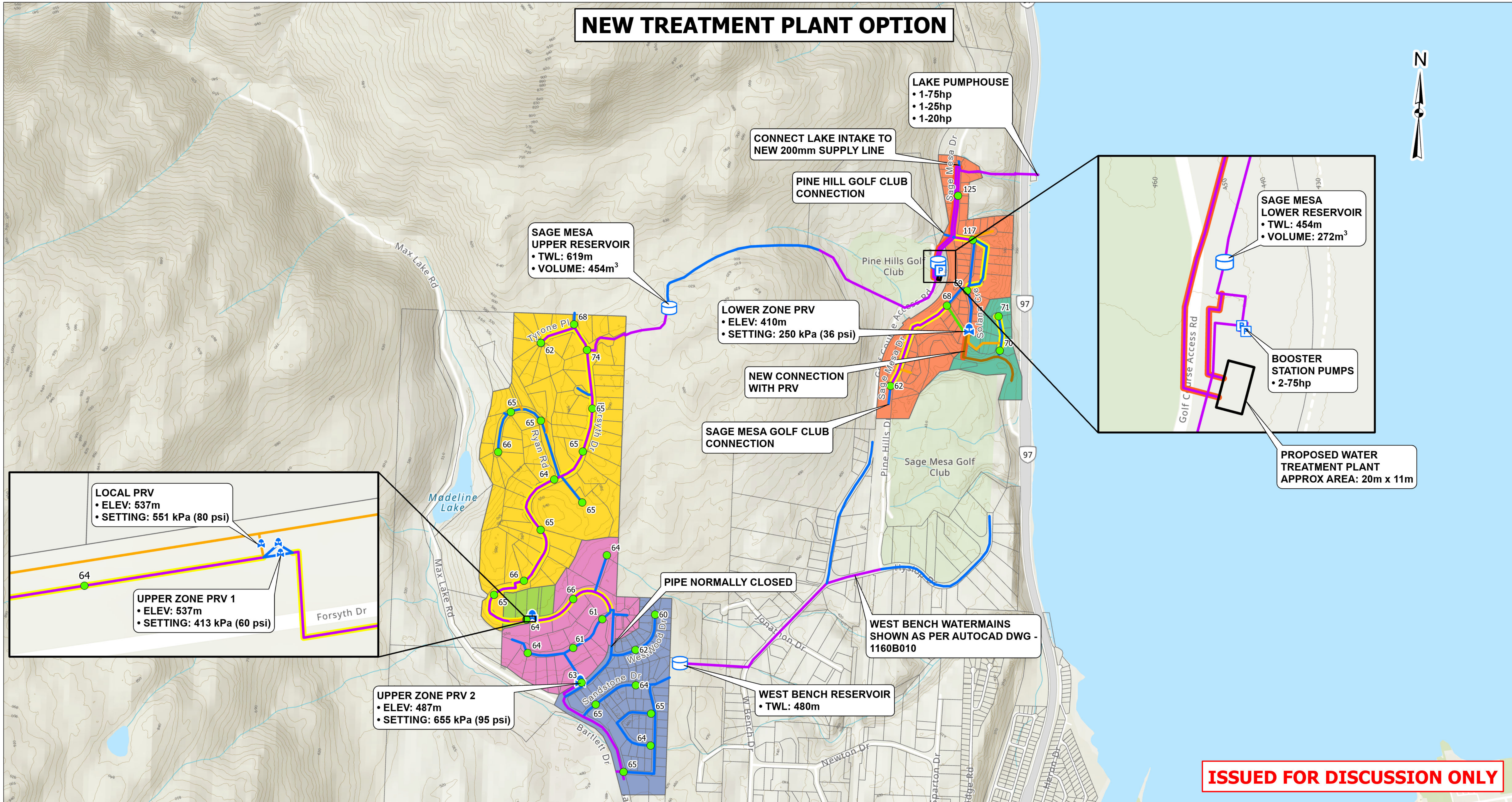
- Raw Water Lake Intake
- Reservoirs
- Pump
- PRV

Design Fire Flow (L/s)
- < 60
- ≥ 60
- Proposed Upgrade
- New Pipe

Watermain (mm)
- 50
- 100
- 150
- 200
- 250

Pressure Zone
- Lower,PZ436
- Lower,PZ456
- Upper,PZ554
- Upper,PZ579
- Upper,PZ593
- Upper,PZ619

Projection: NAD 1983 UTM Zone 11N



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Projection:
NAD 1983 UTM Zone 11N

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Figure 14. Sage Mesa Distribution System - Watermain Upgrades & MDD+FF (New Water Treatment Plant)

Project: Sage Mesa Water System Assessment

Location: Sage Mesa, BC

Scale 1:13,000

0 — 1,000 Meters

INSET

LEGEND

Raw Water Lake Intake

Reservoirs

Pump

PRV

Design Fire Flow (L/s)
- < 60
- ≥ 60

Proposed Upgrade

New Pipe

Watermain (mm)
- 50
- 100
- 150
- 200
- 250

Pressure Zone
- Lower,PZ436
- Lower,PZ456
- Upper,PZ554
- Upper,PZ579
- Upper,PZ593
- Upper,PZ619

4.3.1. Upper Zone Watermain Upgrades

The Upper Zone requires the upsizing of the 150mm watermain from the end of Tyrone Place to the intersection of Pinetree Place and Estates Place. Note that hydraulically, a 150mm watermain with a maximum velocity of 4 m/s can provide a peak flow of 71 l/s (exceeding minimal fire flow), however, the headloss is significant at approximately 100 m/km (meters of headloss per kilometer of pipe) a common unit of measurement for identifying undersized piping.

With a MDD of 18.8 l/s for the upper zone, the flow of water through the watermain closest to the Upper Reservoir would be 18.8 + 60 = 78.8 l/s. Its not until Pinetree Place and Estates Place intersection that the combined MDD+FF flow is low enough that the system is balanced so that the hydraulic loss does not exceed the required fire flow for the system.

When upgrading watermains, the piping closest to the reservoir should be upgraded first, as this pipe handles the most flow and will results in the greatest benefit to the water distribution system.

4.3.2. Lower Zone Watermain Upgrades

The same approach should be taken for the Lower Zone which has more significant deficiencies than the Upper Zone. Upgrade the watermain closest to the Lower Reservoir first and then work towards the end of the system.

There are a few exceptions due to wide variety of pipe sizes and looping and non-looping sections of the zone. These watermains should be upgraded as an immediate priority due to the value that they provide for fire flow improvements:

1. The PRV and watermain that services PZ436 is a 50mm watermain, the watermain also passes through two private properties in steep terrain. A new watermain and PRV with a size of 250mm is recommended through 3873 Solana Crescent between Solana Crescent and Sage Mesa Drive. The lot appears to be unused. A 250mm pipe is recommended as the connection on Sage Mesa Drive is 250mm, however, hydraulically a 200mm watermain is also acceptable. If this option is not possible a new watermain connection along Sage Mesa Drive is also feasible.

2. A 75m length of 100mm AC watermain along Sage Mesa Drive from the Pine Hills Golf Club connection to Crescent Drive is undersized and recommended to be upgrades to 250mm.

4.3.3. Upper Reservoir Supply Main Upgrade

With the recommended option resulting in the Sage Mesa system having a single reservoir where the Upper Reservoir is located, the Upper Reservoir must provide fire flow to the Lower Reservoir Zone that is currently being supplied by the Lower Reservoir. The existing 150 supply main must be upsized to 200mm to meet Fire Flow requirements. A bypass PRV downstream of the booster pumps is also required so water from the Upper Reservoir can provide water to the Lower Zone. The layout of the recommended option is shown on Figure 16.

4.4. RESERVOIR SIZING

Reservoir sizing was performed using the method identified in the MMCD Design Guidelines 2022 which is **A + B + C = Reservoir Volume**.

- Fire Storage (A) = Maximum fire flow serviced by the reservoir - 60 l/s @ 1.5 hours as per RDOS Bylaw 2000 and the 2020 Fire Underwriters Survey (FUS) “Water Supply for Public Fire Protection – A Guide to Recommended Practice in Canda”

- Equalization Storage (B) = 25% of MDD

- Emergency Storage (C) = 25% of A + B

Two reservoir sizing scenarios are provided:

- **Two Reservoirs**: The first option is to have the two **Upper and Lower Reservoir** without any alterations to the function of the system such as new pipe connections or valves.

- **One Reservoir**: The second option is to **upsize the Upper Reservoir** to service both the Upper and Lower Zone. The second option has the benefit of less total volume compared to the combined volume of the first option and only one reservoir is required, however, it requires additional upgrades such as a new connection after the booster station pumps with a PRV to permit water from the Upper Reservoir to flow to the Lower Zone and the upgrade of the 150mm section of the supply main from the lower to upper Reservoir.

The sizing of the two reservoirs for both options is provided in Table 33.

Table 33 - Reservoir Sizing Summary

Option	Existing Size m^3	Req’d Fire Flow Storage m^3	Req’d Equalization Storage m^3	Req’d Emergency Storage m^3	Total Req’d Storage m^3
Upper Reservoir	454	324	406	183	913
Lower Reservoir	272	324	283	152	759
				Total Storage:	**1672**
Single Upper Reservoir	N/A	324	689	253	1266

4.4.1. Preferred Reservoir Option Evaluation

As the existing Upper Reservoir should be replaced and the Lower Reservoir is of the same vintage, the system was modeled considering the replacement of both reservoirs with either a single reservoir or two replacement reservoirs.

To determine which of the two reservoir options was preferred, a preliminary cost estimate including any ancillary upgrades was prepared. These estimates assumed the new reservoirs would be reinforced concrete to match the existing reservoirs and included typical design details such as overflow and drainage piping and water meters. For a more detailed breakdown of what was included, see the cost estimates in Appendix F.

The cost for the replacement of each reservoir is presented in the following Table 34. If only considering the costs, one reservoir is the obvious choice. However, there are numerous advantages and disadvantages related to each scenario which should be considered, as presented in Table 34.

Table 34:Comparison of Single Reservoir vs. Two Reservoirs – Cost Estimate and Other Considerations

Description	**Single Reservoir Option** Upper Reservoir: 1264 m3	**Two Reservoir Option** Upper Reservoir: 1025 m3 Lower Reservoir: 644m3
1. Total Volume (m3)	1264	1665
2. Additional New Infrastructure	• Upgrading the existing 150mm main between the reservoirs to a 200mm main • Adding bypass piping around the Booster Station along with a FCV/PRV station to allow flow from the Upper Reservoir into the Lower Reservoir • Electrical - Single upgrade (with backup power)	• Electrical Upgrades at both reservoirs (each requiring back-up power), communications, controls.
3. O&M Time / Cost	Lower O&M Cost	Higher O&M Costs
COSTS		
4. New Upper Reservoir	$2,230,000	$2,050,000
5. Pipe and flow control valve (FCV)/PRV to bypass Booster Station & Lower Reservoir. Upgrading the existing 150mm pipe between the reservoirs to a 200mm, and adding a wet well for the existing booster station.	$720,000	-

6. New Lower Reservoir	-	$1,580,000
7. Demo of Both Reservoirs	$200,000	
Total incl. 40% Contingency	**$3,255,000**	**$3,630,000**
Note 1. Costs Excl. Engineering Fees		

The costs and pros and cons of the two scenarios were discussed with the RDOS on November 23, 2023. Based on these discussions, it was agreed that the single reservoir was more advantageous and should be used when evaluating the water supply source (Sage Mesa WTP vs. West Bench).

4.5. FIRE HYDRANT SPACING ANALYSIS

A hydrant spacing analysis was performed based on the hydrant locations provided by the RDOS. The criteria used is summarized in Section 4.2, Table 28 and is based on the 2020 Water Supply for Public Fire Protection by the Fire Underwriters Survey (FUS). The full document provides a more detailed explanation of hydrant distribution and water system best practices.

The existing hydrants were added to ArcGIS Pro and given a diameter of 180m to represent the maximum spacing between the hydrants. Additional hydrants were added and are shown in Figure 15. A total of 9 hydrants are recommended to meet the FUS distribution spacing. One of these hydrants will replace the existing standpipe at the end of Verano Place.

The local fire authority should be consulted prior to any new hydrant install as the planning of hydrant locations is a cooperative effort between the water utility and fire department.

4.6. PENTICTON MODEL REVIEW

The City of Penticton provided their InfoWater Pro model which was developed for their 2021 Water Master Plan. The model was used to identify any negative impacts from the estimated additional MDD supply of 31 l/s to Sage Mesa. The Penticton model was run with and without the additional supply to see if any distribution mains or fire flow results would be impacted.

Water Demand

The existing West Bench demand has been identified as 34 l/s in various reports and confirmed by McElhanney. The Penticton Master plan however uses 40 l/s.

An MDD of 31.8 l/s was estimated for Sage Mesa. The combined MDD for West Bench and Sage Mesa is 31.8 + 40 = 71.8 l/s. The West Bench pump station has three parallel pumps with a flow rate of 46 l/s each. Two pumps running in parallel during peak MDD, would provide a total flow rate of 74 l/s based on the 2014 Focus Report (refer to analysis in Section 4.7), which is sufficient to cover the Sage Mesa demand.

Based on most recent reports provided by the RDOS, the Pump Station should be upgraded with a 4th pump to ensure that there is always a standby pump. Based on current predicted flows, likely only two pumps will operate 99% of the time. As expansion possibilities are minimal in Sage Mesa, an expansion in West Bench might trigger a more urgent need for the addition of a 4th pump.

4.6.1. MDD and PHD Scenarios

The Existing MDD and Existing PHD scenarios were first run to confirm pressures in the Penticton system and ensure peak velocities did not exceed the Penticton design criteria of 2 m/s for pump supply and PHD distribution mains and minimum 36 psi during PHD was maintained. No pipes exceeded 2.0 m/s during this analysis and pressure exceeded minimum design requirements of 36 psi during the PHD scenario.

The existing MDD with fire flow scenario was then run. The fire flow was only run on the nearest 25 fire flow junctions to the West Bench connection point. This was deemed an acceptable radius especially considering the considerable looping in the Penticton system.

Three hydrants did not meet fire flow, however, all three were dead end mains that were limited by the 4 m/s critical pipe velocity constraint. **Therefore, the additional demands from Sage Mesa do not impact the existing Penticton fire flows in the area.**

The information above was provided to the City of Penticton on October 20, 2023, for validation on January 15, 2024, the City confirmed the assessment.

4.7. WEST BENCH SYSTEM REVIEW

While the West Bench model was not provided, there was an allowance in the City of Penticton model for supply of water to West Bench and potentially Sage Mesa in the sizing of the booster station, it was assumed that the West Bench system upgrades also considered the potential addition of the Sage Mesa demand, and the system was upgraded accordingly.

West Bench Distribution Piping

When considering the supply of Sage Mesa through West Bench, the water from Penticton is pumped through the West Bench Pump Station to the West Bench Reservoir. From there, it cascades through the West Bench system.

With the connection to Sage Mesa, the water will travel through the distribution network to the connection points along Pine Hills Drive. The additional MDD Sage Mesa flow of 31.8 l/s will now be conveyed through the piping.

While the system was not modelled, an AutoCAD drawing was provided of the West Bench water distribution system which shows the supply main from the West Bench Pump Station to be a 300mm PVC pipe. With a combined MDD for Sage Mesa and West Bench of 71.8 l/s and a design criterion of 2.0 m/s for supply mains, the velocity through the pipe would be approximately 1 m/s.

From the West Bench Reservoir to Sage Mesa, the watermain diameter is 250mm, reducing to 200mm at West Bench Drive and Jonathan Drive. Assuming a fire event were to occur in the West Bench system, a

200mm water distribution main would be able to provide a peak flow of 126 l/s at 4.0 m/s. With an MDD for Sage Mesa of 31.8 l/s and a residential fire flow of 60 l/s, a flow of 34 l/s (126 – 31.8 – 60 = 34 l/s) can still be conveyed in the 200mm distribution pipe, before it would be considered undersized.

In conclusion, the West Bench watermains are sufficiently sized to service Sage Mesa.

West Bench Pump Station

The West Bench Pump Station was designed with spare pump slots for increasing the pump station supply to Sage Mesa. The Focus March 28, 2014, memorandum addressed to the RDOS details the existing pump capacity. There are currently three installed pumps in the West Bench Pump Station, with two fixed speed pumps and one pump on a VFD. Based on operating conditions at the time, the West Bench pumps supply was:

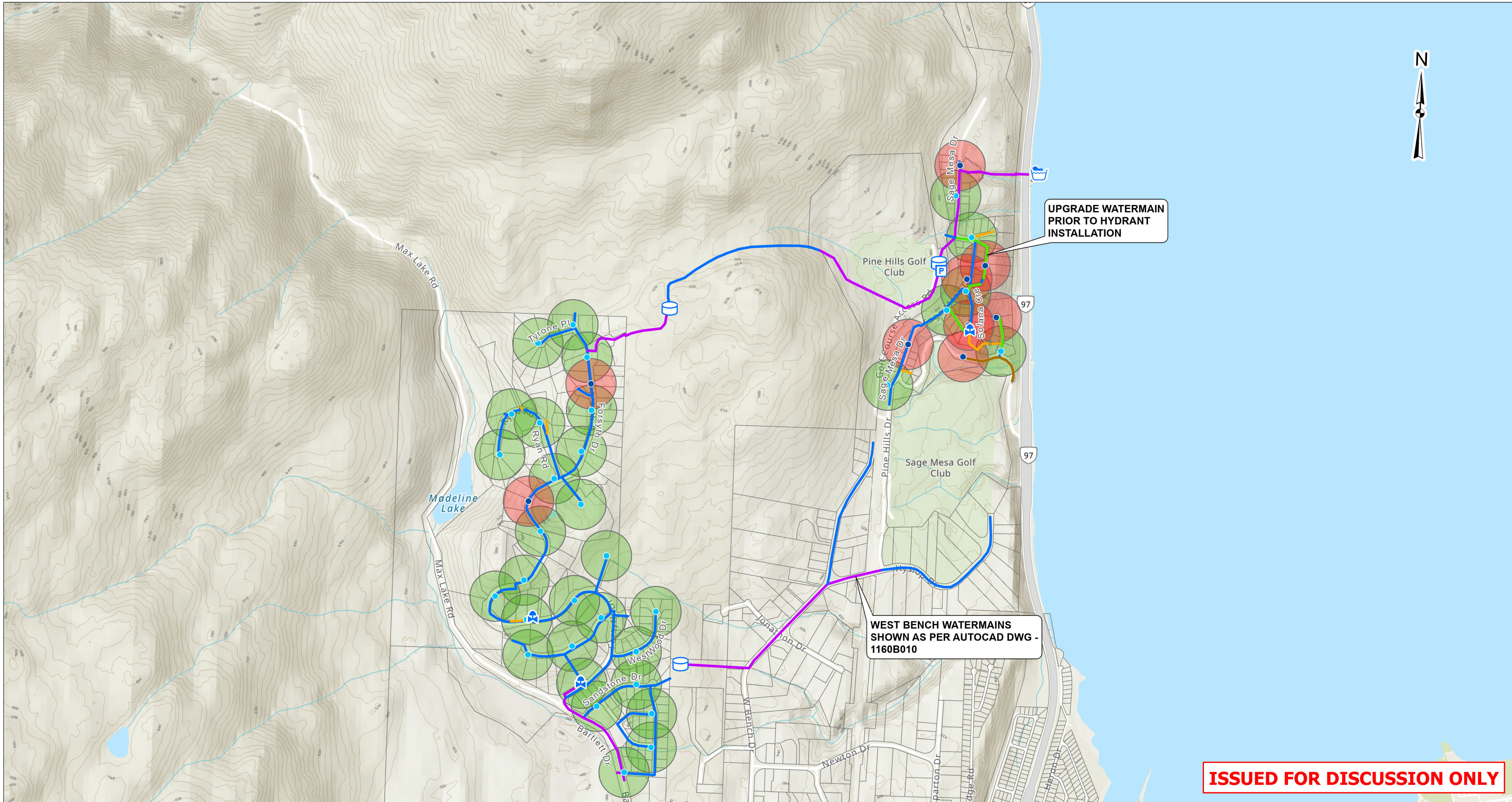
- One pump running – 46 l/s
- Two pumps running – 74 l/s

The flow rates were determined from flow testing during low demands within the City of Penticton. The capacity of the pumps will vary depending upon the suction conditions.

It is unclear what the flow rate would be with all three pumps running continuously. With a Sage Mesa and West Bench combined MDD of 71.8 l/s the existing two pumps would meet the MDD capacity with one pump remaining on standby.

Considering limited opportunity for new development in Sage Mesa and the expectation that MDD may be reduce as old piping is replaced, the existing pump configuration is acceptable, and the installation of a fourth pump is not a required upgrade as part of the tie-in to Sage Mesa.

Should projected MDD demand increase beyond 74 l/s due to an additional connection or new development, particularly in West Bench, a new pump is recommended to be installed to meet pump operational standards of having one pump on standby during MDD.



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McElhanney

Projection: NAD 1983 UTM Zone 11N

TITLE

Figure 15. Sage Mesa Distribution System - Hydrant Spacing Analysis

Project: Sage Mesa Water System Assessment

Location: Sage Mesa, BC

Scale 1:13,000

0 — 1,000 Meters

INSET

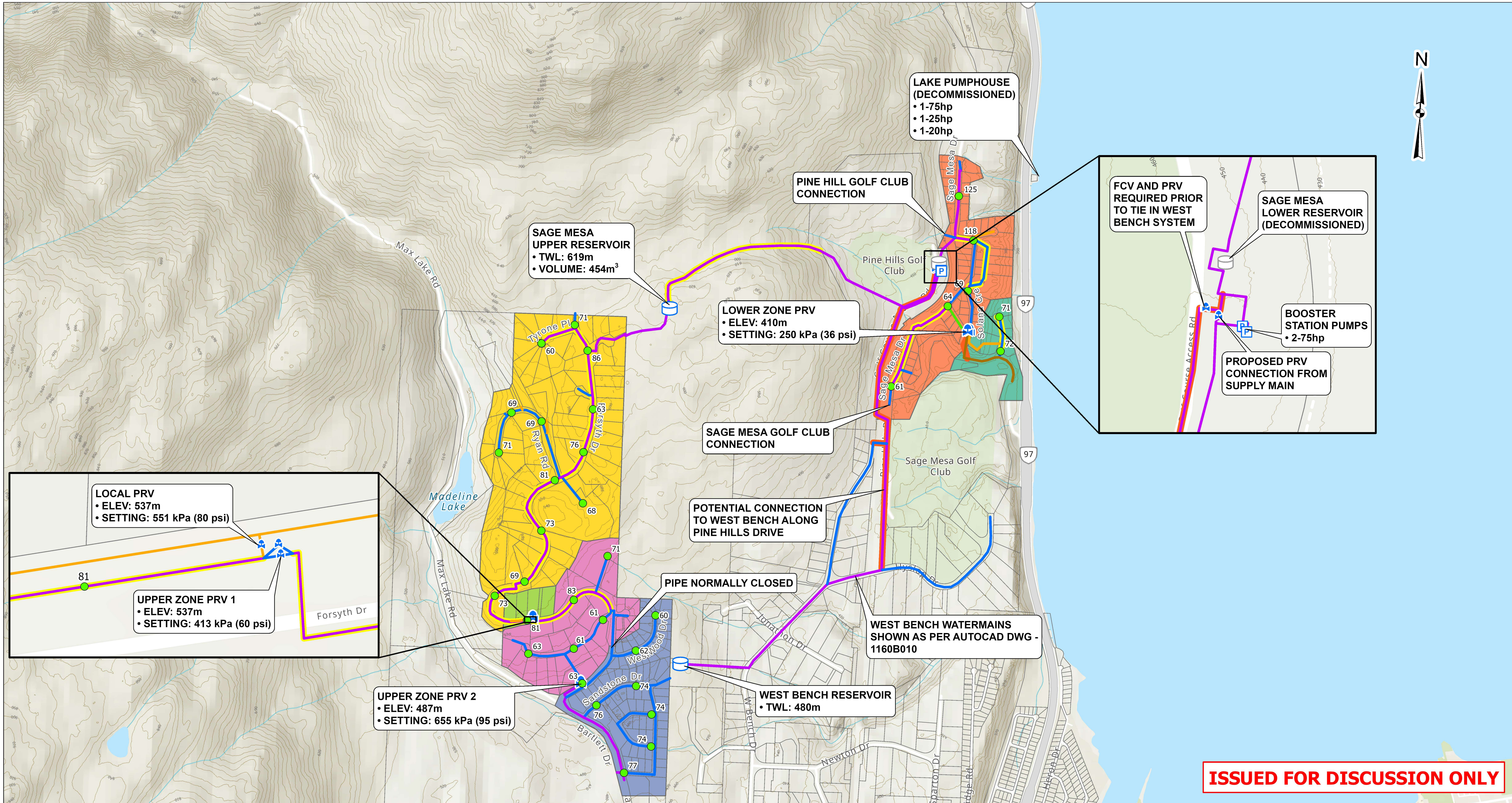
LEGEND

- Raw Water Lake Intake
- Reservoirs
- Pump
- PRV

Hydrant
- Existing
- Proposed

Watermain (mm)
- 50
- 100
- 150
- 200
- 250

90m Hydrant Radius
- Existing
- Proposed



McElhanney

Projection: NAD 1983 UTM Zone 11N

TITLE

Figure 16. Recommended Option - One Reservoir and Connection to West Bench

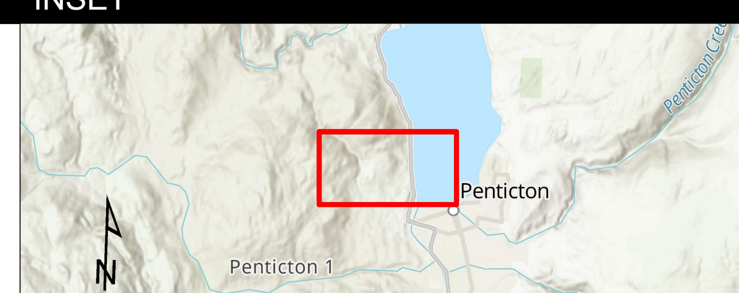
Project: Sage Mesa Water System Assessment

Location: Sage Mesa, BC

Scale 1:13,000

0 — 1,000 Meters

INSET



LEGEND

- Reservoirs
- Pump
- PRV

Design Fire Flow (L/s)
- < 60
- ≥ 60
- Proposed Upgrade
- New Pipe

Watermain (mm)
- 50
- 100
- 150
- 200
- 250

Pressure Zone
- Lower,PZ436
- Lower,PZ456
- Upper,PZ554
- Upper,PZ579
- Upper,PZ593
- Upper,PZ619

5. Summary of Recommendations / Upgrades

The following sections summarize the various recommendations & upgrades discussed in previous sections. Cost estimates for these upgrades can be found in Section 6.

5.1. SYSTEM RECOMMENDATIONS / UPGRADES REGARDLESS OF CONNECTION OPTION

There are a number of recommendations/upgrades that are suggested for the system but are not required to connect to the West Bench system or install a new water treatment plant. The recommendations/upgrades listed below are to address other deficiencies in the system such as infrastructure age, lack of sufficient fire flow, and lack of proper monitoring equipment:

- Upsizing of piping to meet fire flow requirements as shown in Figure 16.
- Installing new hydrants to ensure adequate fire protection coverage as shown in Figure 15.
- Installation of residential meters at all properties and the two golf courses.
- Confirmation that valve locations provide appropriate isolation of the system
- Assessing the condition of the valves and piping in the existing PRV stations including confirming operating pressures
- Addressing existing components associated with the Booster Station, including seized gate valves, and aging soft starters and water meter
- Adding a standby power source to the Booster Station
- Assessing the need for air release valves on the dedicated fill line between the Upper and Lower Reservoir, and confirming the condition of the presence and condition of the service vault and blow-off drain shown in record drawings
- Repurposing the existing VTSCADA computer at the Booster Station to become a SCADA client computer, and implementing an RDOS SCADA node
- Implementing automated reporting through SCADA software development

Regardless of how the water source and distribution system is improved, most of the Sage Mesa upgrades are needed now, to replace ageing infrastructure which is at the end of its life, and which does not provide sufficient fire storage, and in some instances sufficient hydrant coverage. The upgrades discussed below are needed to bring the system up to the minimum requirements based on guidelines and regulations.

5.2. RESERVOIR UPGRADES

To address the age and disrepair of the current reservoirs onsite, along with the current capacity deficiency, the two existing reservoirs should be demolished and replaced **with a single reservoir at or near the location of the current Upper Reservoir.** This upgrade will include upsizing a portion of the existing line between the two reservoirs, installing a flow control / pressure reducing valve station (assumed to be an above ground kiosk), and adjusting the layout and connection of the existing piping surrounding the Booster Station and Lower Reservoir.

5.3. NEW WATER TREATMENT PLANT SPECIFIC UPGRADES

Re-using Okanagan Lake as the raw water supply and installing a new water treatment plant is anticipated to require the following upgrades:

- Lake Pumphouse and raw water intake line upgrades, including:
  - Extending the intake line, installing ballast/anchors, and installing a new mesh screen
  - Conducting yearling intake diving inspections
  - Ideally, upgrading the system to have two wet well cells at the Lake Pumphouse
  - Ensuring NSF61 compliance of the Lake pumphouse system and components.
  - Upgrading the power service to a 600V service and providing a standby power source
  - Replacing the again pump motor soft starters and water meter
  - Replacing the hoist system for offloading sodium hypochlorite barrels.
- Constructing a WTP based on Granular Activated Carbon pressure filters followed by primary UV disinfection and primary and secondary chlorination (Option 4).
- Linear infrastructure additions to accommodate the new WTP as shown in Figure 14. These will include:
  - A new 200mm main in Sage Mesa Drive so there's a dedicated main between the Lake Pumphouse and WTP with no service connections; and
  - Piping between the WTP and Booster Station to adjust the operation of the system, including provisions to accommodate the system switching to using a single reservoir

A new WTP for Sage Mesa alone is likely not viable based on the cost estimate provided herein. The rate payer base is relatively small and fixed due to limited expansion opportunities based on topography, boundaries, and geology.

5.4. WEST BENCH WATER SUPPLY SPECIFIC UPGRADES

Connecting to the existing West Bench water distribution network for potable water supply is anticipated to require the following upgrades:

- Linear infrastructure additions to connect the Sage Mesa distribution network to the West Bench distribution network as shown in Figure 16. This will include:
  - A new 200mm main between the intersection of Hyslop Drive / Sage Mesa Drive and the Lower Reservoir/Booster Station
  - A new water meter in an aboveground kiosk for custody purposes
  - A PRV/FCV station in an aboveground kiosk to control the flow from the West Bench reservoir. It is anticipated that this would be located near the Booster Station
- The addition of a sodium hypochlorite chlorine booster system in the Booster Station pumphouse. An allowance has been included for a new system pending confirmation of whether any existing systems could be re-used.
- Decommissioning of the Lake Pumphouse and existing raw water intake in Okanagan Lake, as confirmed with the RDOS

No upgrades to the existing West Bench Pump Station or the City of Penticton's distribution network are anticipated with the Sage Mesa system connection.

Please note that the costs listed for the West Bench connection above exclude any costs associated with upgrades that may be required in the West Bench distribution network. A water model was not available for the West Bench distribution network and as such, a detailed analysis of their system was not undertaken as a part of this project. However, the Penticton Model was updated with the additional demands for Sage Mesa to confirm adequate water supply is possible, as noted in Section 4.6 of this report. A desktop review of the West Bench piping indicated that there should sufficient capacity in the existing piping system (refer to Section 4.7). As the City of Penticton water model includes an allowance to supply water to West Bench and Sage Mesa, it was assumed that the 2017 West Bench piping system upgrades also included an allowance to supply water to Sage Mesa.

6. Cost Estimates

The following section covers the cost estimates prepared for the various upgrades to the existing system that have been identified by this report. All cost estimates are opinions of probable capital cost and have been included in **Appendix F**. The estimates provided are based on the information available at the time of preparation. While every effort is made to ensure the accuracy and reliability of an estimate, it is important to note that it is an approximation and subject to change.

6.1. COST ESTIMATE CLASS, CONTINGENCIES, & ALLOWANCES

The definition of each class of estimate is described as:

- Class "A" estimate: this is a detailed estimate based on the quantity take-off from final drawings and specifications. It is used to evaluate tenders or as a basis of cost control during day-labour construction. Typically, this carries a +/- 10% contingency.
- Class "B" estimate: this is prepared after site investigations and studies have been completed and the major systems are defined. It is based on the project brief and preliminary design. It is used for obtaining effective project approval and for budgetary control (+/- 20% contingency).
- Class "C" estimate: this is prepared with limited site information and is based on probable conditions affecting the project. It represents the summation of all identifiable project elemental costs and is used for program planning, to establish a more specified definition of client needs and to obtain preliminary project approval (+/- 30% contingency).
- Class "D" estimate: this is a preliminary estimate which, due to limited site information in respect to the project focus, indicates the approximate magnitude of cost of the proposed project, derived from lump sum or unit costs for a similar project. It may be used in developing long term capital plans and for preliminary discussion of proposed capital projects (+/- 40% contingency).

For this report, **Class "D"** estimates were prepared based on a master planning level of design.

Cost estimates for this project have been prepared based on the information available at the time of this report and similar projects that we have received pricing for. The estimates are subject to variations and should be treated as preliminary assessments of the project's potential costs. Final costs may differ based on factors such as inflation, material availability, labor market conditions, unforeseen site conditions, design modifications, regulatory requirements, and other factors. To attempt to capture the potential cost fluctuation based on these factors, a 40% contingency as been applied in alignment with the Class “D” estimate definition above.

A 15% engineering allowance has also been included with these cost estimates for planning purposes. The percentage is based on the capital cost of the project and may change during the progress of the project depending on the scope of the project. Typical engineering fee allowance as a percentage of project capital cost can vary from 20% for smaller projects to 13.3% for large scale water and sewer projects.

6.2. COST ESTIMATE ASSUMPTIONS

The following section covers the assumptions that were made for the purposes of completing the cost estimates for the upgrades identified in this report.

Distribution Network Upgrades

The various distribution network upgrades identified as being required earlier in this report in Figures 13 and 14 have been split into smaller sized projects for costing purposes. The size of each project was based on assumed extents for feasible or realistic construction projects. For distribution network upgrades, the projects have been split as follows:

- **Forsyth:** Includes watermain upgrades from the end of Tyrone Place to the intersection of Forsyth Drive and Estates Place. Also includes the two new hydrants along Forsyth Drive identified in Figure 15 and the replacement of the existing PRV station near 2619 Forsyth Road. Please note that a stretch of the existing main at the top end of Forsyth Drive between Forsyth Place and Ponderosa Place is shown as 200mm diameter in record drawings, but listed as 150mm diameter in the GIS information provided. For the purposes of costing, it’s been assumed that this length of pipe is 150mm diameter and needs to be replaced.

- **Golf Course to Solana:** Includes watermain upgrades from the entrance to the Pine Hills Golf Course to the intersection of Sage Mesa Drive and Solana Crescent. Also includes the new hydrant along Sage Mesa Drive identified in Figure 15.

- **Solana & Sage Mesa:** Includes the watermain upgrades shown in Figures 13 and 14 for Solana Crescent and the small stretch of upgrades on Sage Mesa Drive east of the north intersection of Sage Mesa Drive and Solana Crescent. Also includes the two new hydrants identified in Figure 15 in this area. Based on record information, a small stretch of 150mm pipe exists in Solana Crescent; however, for the purposes of costing, this small stretch has been ignored and it is assumed the entire length of Solana Crescent will be upgraded.

- **Verano:** Includes watermain upgrades from the corner of Solana Crescent down to Sage Mesa Drive in order to bypass the existing 50mm galvanized iron main and provide service to Verano Drive via the existing 250mm main in Sage Mesa Drive. It is assumed for costing purposes that the existing 50mm galvanized iron main will be abandoned in place. Costs for this also include the three new hydrants shown in this area in Figure 15 and a new PRV housed in an aboveground kiosk.

- **Sage Mesa Hydrant:** The proposed hydrant in Figure 15 at the north end of Sage Mesa Drive was the only new hydrant not within the extents of a watermain upgrade project and as such, it was given its own dedicated project.

For all of the upgrade projects listed above, the following assumptions were made:

- Any service connections along the upgrade route assume that a new saddle, corporation stop, and curb stop will be included. The addition of a new meter pit and related hardware is included in the overall water meter addition cost.

- Any existing hydrants along the route will be fully replaced as connecting to an existing hydrant lead with proper restraining is anticipated to be infeasible.

General costs including items like mobilization and traffic control have also been included for each project listed above. Totals for each project are shown in Table 35 below.

PRV Stations

Very little is known about the existing PRVs so no analysis specific to these PRVs was undertaken for this project. However, given the state of the reservoirs and age of the remainder of the system, costs to replace the existing PRV stations in the Upper Zone were included.

Lake Pumphouse & Intake Replacement Costs

For the replacement of the lake pumphouse and Okanagan Lake intake, the following assumptions were made:

- Pumps, pump control system, and pump pedestal will all be replaced.

- As condition of the piping and components inside the pumphouse was not reviewed as a part of this exercise, it is assumed that all piping and components will be replaced.

- The existing building will be suitable for reuse. This will need to be confirmed and could result in additional costs if upgrades to the building or a complete replacement is deemed to be required.

- The lake intake upgrade will be a full replacement and will be roughly 750m long based on comments made in the previous Focus Corporation report (*Sage Mesa Water Supply Study*, 2012).

Wet Well for Suction Side of Booster Station

With the decision to adjust the system to function with a single reservoir, an allotment for a small concrete wet well on the suction side of the booster station has been included in the cost estimates.

Booster Station Upgrades

Booster station upgrade costs listed in Table 35 include the installation of a backup generator, replacement of the existing seized valves outside the booster station, and replacement of the existing water meter and pump soft starters inside the station.

Water Meter Upgrade

For the water meter upgrade mentioned in Section 2.7, it has been assumed for costing purposes that the upgrade will include the addition of an exterior meter at each residential property in an underground meter pit. Costs include the pit, meter setter, and meter (19mm Neptune T10 pricing used). For the two golf courses, it has been assumed that larger meters will be required, each in their own aboveground kiosks. Total costs for this upgrade are shown in Table 35 below.

Hypochlorite Top Up System

It is difficult to gauge the cost of the building modifications or upgrades that would be required to add a hypochlorite system to the existing Booster Station that would meet current structural codes without viewing the internal structure; however, the cost of pumps (1 duty/ 1 standby), chlorine sensor at reservoir discharge and control, calibration panel, tempering valve, hot water tank and E-shower, required to meet WorkSafe BC requirements, would be approximately $60,000 if installed in the existing building. While re-use of either of the existing chlorine boosting systems in the Booster Station or the Lake Pumphouse may be possible, for the purposes of this costing exercise, $60,000 for a new system has been included.

City of Penticton & West Bench Distribution Network Upgrades

A previous analysis by the City of Penticton identified approximately $375K worth of upgrades to their system if the Sage Mesa system was connected to it via West Bench. As noted in Section 4.6, the water modelling exercise undertaken for this project using the City of Penticton's water model has concluded that no upgrades will be required to their system, and as such, the previously estimated $375K has not been included. In addition, based on the information available, no piping upgrades are expected to be required in West Bench to accommodate connecting the Sage Mesa system (refer to Section 4.7).

City of Penticton DCCs

Based on information provided by the RDOS, connecting to the West Bench distribution network will require payment of City of Penticton development cost charges (DCCs) and other charges related to the current bulk water agreement totalling approximately $3,353,000.

6.3. COST ESTIMATE EXCLUSIONS

The cost estimates do not include the following:

- Cost related to acquiring land, rights-of-way, and easements.
- Costs for permits, legal fees, or taxes.

6.4. CAPITAL COST ESTIMATE SUMMARY – TWO WATER SUPPLY OPTIONS

A comparison of the costs of the two water supply options (WTP vs. West Bench) is provided in Table 35. The common upgrades recommended for the system regardless of the water supply source are identified at the top of the table, and the split comparison of the two water source options is included in the bottom half. Costs shown in the table have assumed that WTP option #4 has been selected.

The prioritization of the common upgrades is discussed in more detail in Section 7. Cost estimate details are presented in Appendix F.

Table 35: Comparison of Cost Estimate for the Treatment Option vs. the Connection to Penticton Option

<table>
<tr><th>Description</th><th>New WTP Option</th><th>West Bench Supply - Option</th></tr>
<tr><td>Recommended for Both Options</td><td colspan="2"></td></tr>
<tr><td>1. Distribution Upgrade - Forsyth Main, Hydrants, & Existing PRV Station</td><td colspan="2">$2,720,000</td></tr>
<tr><td>2. Distribution Upgrade - WOW Golf to Solana Main & Hydrants</td><td colspan="2">$560,000</td></tr>
<tr><td>3. Distribution Upgrade - Solana & Sage Mesa Main & Hydrants</td><td colspan="2">$510,000</td></tr>
<tr><td>4. Distribution Upgrade - Verano Main, Hydrant, and PRV</td><td colspan="2">$600,000</td></tr>
<tr><td>5. Distribution Upgrade - Sage Mesa North Hydrant</td><td colspan="2">$30,000</td></tr>
<tr><td>6. New Upper Reservoir. Includes connection and PRV/FCV kiosk to bypass Booster Station & Lower Reservoir</td><td colspan="2">$2,950,000</td></tr>
<tr><td>7. Demolition of Existing Upper and Lower Reservoirs</td><td colspan="2">$200,000</td></tr>
<tr><td>8. Addition/Replacement of Water Meters to all properties (incl. new meter and meter vault)</td><td colspan="2">$850,000</td></tr>
<tr><td>9. Replacement of remaining existing PRV station in Upper Zone</td><td colspan="2">$250,000</td></tr>
<tr><td>10. Booster Station Upgrades Incl. Backup Power</td><td colspan="2">$200,000</td></tr>
<tr><td>Sub-Total including 40% Contingency</td><td colspan="2">$8,870,000</td></tr>
<tr><td>Engineering Allowance (15%)</td><td colspan="2">$1,300,000</td></tr>
<tr><td>TOTAL</td><td colspan="2">$10,170,000</td></tr>
</table>

Water Source / Treatment Options	New WTP Option	West Bench Supply Option
11. Raw Water Pumphouse Upgrades, incl. intake	$1,860,000	-
12. Treatment Plant	$4,704,000	-
13. WTP Connection to Existing Distribution	$540,000	-
14. Connection to West Bench system incl. PRV/FCV kiosk and water meter kiosk	-	$1,970,000
15. Wet Well / Sump for Suction Side of Booster Station Pumps	-	$105,000
16. Hypochlorite Top-Up System	-	$60,000
17. Pumphouse Decommissioning Incl. Intake Capping	-	$100,000
18. Approximate City of Penticton DCCs (based on bulk water purchase agreement with the City)	-	$3,353,000
Sub-Total including 40% Contingency	**$7,104,000**	**$5,588,000**
Engineering Allowance (15%)	$1,100,000	$800,000
TOTAL	**$8,204,000**	**$6,388,000**
TOTAL INCLUDING DISTRIBUTION UPGRADES	**$18,374,000**	**$16,558,000**
ADDITIONAL COST TO REPLACE THE REST OF THE SAGE MESA SYSTEM (INCL. ENGINEERING ALLOWANCE)	**$14,600,000**	

Note that more than 50% of the cost is related to recommended upgrades required for either option to address current system fire storage, hydrant and water supply deficiencies and to improve system pressures and supply.

6.4.1. Capital Cost Estimate – Entire System Replacement

The cost associated with replacing the rest of the ageing Sage Mesa water distribution network beyond the upgrades summarized in Section 5 of this report is estimated at approx. $14,600,000 and is included at the bottom of Table 35. Completing the works in Section 5, along with the upgrades covered by the $14,600,000 estimated here would result in a completely new water system for Sage Mesa. A breakdown of the costs is included in Appendix F.

7. Financial Assessment

In addition to comparing the two water supply options from a simple capital cost perspective in Section 6.0, critical costs to consider with regards to management of the asset base includes ongoing operations and maintenance (O&M) costs as well as the costs of remedial investments required to return asset conditions back to a “good” rating. In summary, the two water supply options were also compared based on the following:

- Annual O&M costs
- Annual capital renewal costs – contributions to reserves for future replacement

Costs provided have been estimated from available tender information, discussions with RDOS staff, and general guidelines for the two water supply options. The value of the utility is summarized to include the total cost of asset ownership over different lifecycle stages.

7.1. OPERATIONS AND MAINTENANCE COSTS

Operations include regular activities to provide services such as public health, safety, and amenity, e.g. cleaning, utility costs, and operating supplies. For the Sage Mesa system, operational activities include general support services to maintain the Sage Mesa water system and direct costs associated with operating facilities such as the treatment plant (if required), chlorine booster systems, and booster and PRV stations.

Maintenance includes all actions necessary for keeping an asset at a condition level that supports its ability to deliver services. This includes any regular ongoing day-to-day work necessary to keep assets operating. Examples of typical maintenance activities include inspection activities, routine flushing programs, and asset repairs.

To determine an appropriate O&M budget for the Sage Mesa system, estimated annual O&M plans were developed for the existing system and both water source options with recommended work tasks and cost estimates based on professional judgement and industry knowledge, as detailed in **Appendix G**.

7.1.1. O&M Costing Assumptions

Since the RDOS already operates and maintains the Sage Mesa system, future basic operating expenditures for the existing system, before upgrades, are assumed to be similar to the current budget. There are administrative and financial requirements that would increase the budget once ownership was transferred to the RDOS as much of these duties are not completed by the RDOS.

For the purposes of cost comparison, future O&M expenditures for both water source options are forecasted based on a fully replaced water system assuming that the water source project (WTP or West Bench Connection) is completed first in 2025 (see Figure 17).

The operator hourly wage used in the O&M plans was based on the 2023 O&M budget.

7.1.2. Short-Term O&M Funding Requirements

Figure 17 summarizes the forecasted short-term (5-year) O&M expenditures for the existing Sage Mesa system and both water source options against the projected O&M budget which is based on the 2023 O&M budget plus additional tasks and 2% each year for inflation. Note that all costs are shown in 2023 dollars.

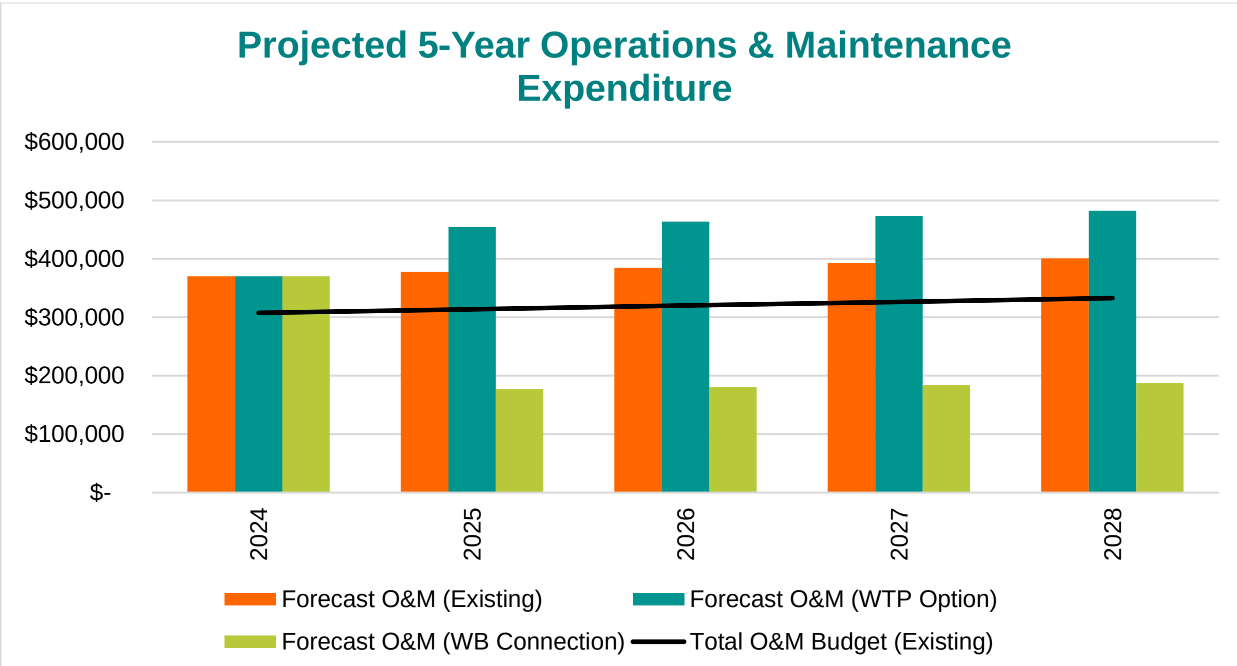


Figure 17. Projected O&M expenditures for the existing Sage Mesa system and both source options versus the current O&M budget for the existing system

Once the RDOS takes over the Sage Mesa system, the required O&M expenditures for the existing system are projected to be higher than the current expenditures as the RDOS will be responsible for ensuring the system is properly maintained to extend infrastructure life. An estimated O&M plan and budget for the existing system is detailed in Appendix G.

The required O&M expenditures for the WTP option are projected to exceed the current O&M budget due to the increase in O&M costs for the WTP.

The required O&M expenditures for the West Bench Connection option are projected to be less than the current O&M budget due to a reduction in the number of reservoirs, booster stations, water intakes, and chlorine disinfections systems.

Estimated full time equivalent (FTE) staff required for each option are summarized in Table 36 below based on our recommended O&M plans (see Appendix G). Assumptions for Operations staffing estimates include 25 hours of dedicated O&M time in a 40-hour work week with the remaining time assumed to be planning, paperwork, or coordination meetings. There would be additional FTE requirements, approximately 0.15-0.2 FTE, for administration and finance which are anticipated to be similar in both upgrade options. Assumptions for administrative and finance support for the Sage Mesa Water System include 0.2 FTE per year in a 35-hour work week at $31/hour.

Table 36. Estimated Operator FTEs for Both Water Supply Options

Water Source Option	Number of Operator FTEs
New WTP	1.42
West Bench Connection	0.95

7.2. ANNUAL CAPITAL RENEWAL COSTS

Asset renewal is major capital work which does not significantly alter the original service provided by the asset, but restores, rehabilitates, replaces, or renews an existing asset to its original service potential. Examples of renewal work include relining of water mains, replacing water mains of similar size, and the replacement of equipment with an equivalent performance specification.

It is important to consider that any new assets will have to be replaced or rehabilitated in the future. A convenient method to determine the necessary annual contributions to reserves to afford a full asset replacement in the future is to amortize the replacement value of an asset over its useful life. If expected renewals are deferred due to lack of budget, it will be expected that the overall condition of the assets will progressively deteriorate, resulting in loss of level-of-service.

7.2.1. Assumed Upgrade Schedule

To develop the annual capital renewal expenditure projections, it was assumed that upgrade projects would be carried out annually, as outline in Table 37, barring any watermain breaks which might change the sequence.

It was assumed that no major works would be undertaken in 2024, and the first project would be construction related to the water supply source option in 2025, considered the priority project.

Table 37. Assumed Timing of System Upgrades

Year	Project
2024	None
2025	Water Source Option + New Upper Res + Booster Upgrades
2026	Forsyth + ½ Demo Res's
2027	Golf to Solana + ½ Demo Res's
2028	Solana & Sage Mesa
2029	Verano
2030	SM North Hydrant
2031	New WM's
2032	PRV Replacement
2033	1/5th Total Sys. Repl.

Year	Project
2034	1/5th Total Sys. Repl.
2035	1/5th Total Sys. Repl.
2036	1/5th Total Sys. Repl.
2037	1/5th Total Sys. Repl.
2038	None
2039	None
2040	None
2041	None
2042	None
2043	None

7.2.2. Long-Term Annual Renewal Costs

Projected annual capital renewal costs for the Sage Mesa asset portfolio for both options are shown in Figure 18. The projected costs shown in Figure 18 are the required annual contributions to reserves to ensure funding is available to replace assets when they reach the end of their useful lives. All values are in current (2023) dollars.

For the purposes of this assessment, projected annual capital renewal costs are only provided for new infrastructure as projects are completed (see Table 37) with the assumption that the entire Sage Mesa system will be replaced within the 20-year forecast. Annualized replacement costs include material prices, 40% contingency, and 15% engineering fees and are detailed in Appendix G.

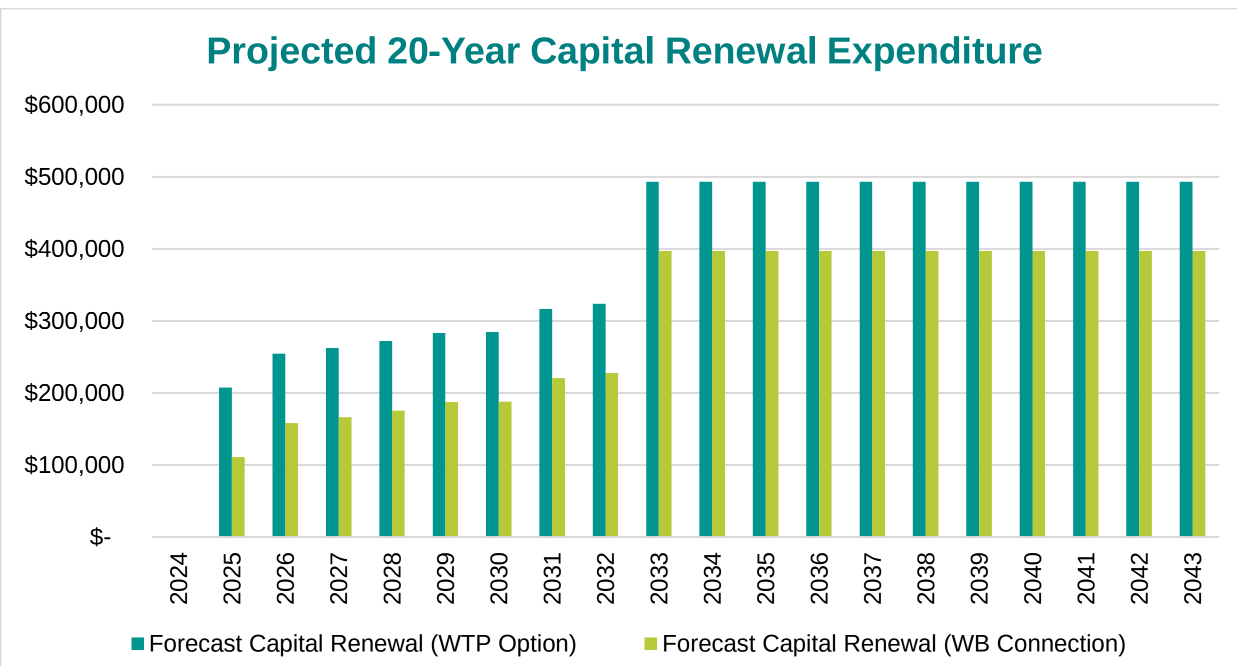


Figure 18. Projected 20-Year Annual Capital Renewal Expenditure for Both Source Options

7.3. ASSET OWNERSHIP FINANCIAL FORECAST

The total cost of asset ownership over a 20-year forecast including O&M, annual capital renewal costs, and new capital works over different lifecycle stages has been provided in Table 38 (WTP Option) and Table 39 (West Bench Supply Option) below.

For the purposes of this assessment, projected annual capital renewal costs are only provided for new infrastructure as projects are completed with the assumption that the entire Sage Mesa system will be replaced within the 20-year forecast following the assumed upgrade schedule outlined in Table 37 and the tables below.

Table 38. Annual O&M, New Works, and Capital Renewal Costs for WTP Option

Year	Project	WTP O&M	WTP Option New Works	WTP Annual Capital Renewal	WTP Total
2024	None	$369,989	$0	$0	$369,989
2025	Water Source Option + New Upper Res + Booster Upgrades	$454,534	$11,826,500	$207,264	$12,488,298
2026	Forsyth + ½ Demo Res's	$463,624	$3,243,000	$254,494	$3,961,118
2027	Golf to Solana + ½ Demo Res's	$472,897	$759,000	$262,244	$1,494,141
2028	Solana & Sage Mesa	$482,355	$586,500	$271,876	$1,340,731
2029	Verano	$492,002	$690,000	$283,488	$1,465,490
2030	SM North Hydrant	$501,842	$34,500	$284,089	$820,430
2031	New WM's	$511,879	$977,500	$316,672	$1,806,051
2032	PRV Replacement	$522,116	$287,500	$323,860	$1,133,476
2033	1/5th Total Sys. Repl.	$532,558	$2,920,000	$493,054	$3,945,612
2034	1/5th Total Sys. Repl.	$543,210	$2,920,000	$493,054	$3,956,263
2035	1/5th Total Sys. Repl.	$554,074	$2,920,000	$493,054	$3,967,127
2036	1/5th Total Sys. Repl.	$565,155	$2,920,000	$493,054	$3,978,209
2037	1/5th Total Sys. Repl.	$576,458	$2,920,000	$493,054	$3,989,512
2038	None	$587,988	$0	$493,054	$1,081,041
2039	None	$599,747	$0	$493,054	$1,092,801
2040	None	$611,742	$0	$493,054	$1,104,796
2041	None	$623,977	$0	$493,054	$1,117,031
2042	None	$636,457	$0	$493,054	$1,129,510
2043	None	$649,186	$0	$493,054	$1,142,239

Table 39. Annual O&M, New Works, and Capital Renewal Costs for West Bench Connection Option

Year	Project	WB Connection O&M	WB Connection New Works	WB Connection Annual Capital Renewal	WB Connection Total
2024	None	$369,989	$0	$0	$369,989
2025	Water Source Option + New Upper Res + Booster Upgrades	$176,973	$10,010,500	$111,021	$10,298,494
2026	Forsyth + ½ Demo Res's	$180,512	$3,243,000	$158,251	$3,581,763
2027	Golf to Solana + ½ Demo Res's	$184,123	$759,000	$166,001	$1,109,123
2028	Solana & Sage Mesa	$187,805	$586,500	$175,633	$949,938
2029	Verano	$191,561	$690,000	$187,245	$1,068,806
2030	SM North Hydrant	$195,392	$34,500	$187,845	$417,738
2031	New WM's	$199,300	$977,500	$220,429	$1,397,229
2032	PRV Replacement	$203,286	$287,500	$227,616	$718,403
2033	1/5th Total Sys. Repl.	$207,352	$2,920,000	$396,810	$3,524,162
2034	1/5th Total Sys. Repl.	$211,499	$2,920,000	$396,810	$3,528,310
2035	1/5th Total Sys. Repl.	$215,729	$2,920,000	$396,810	$3,532,540
2036	1/5th Total Sys. Repl.	$220,044	$2,920,000	$396,810	$3,536,854
2037	1/5th Total Sys. Repl.	$224,445	$2,920,000	$396,810	$3,541,255
2038	None	$228,933	$0	$396,810	$625,744
2039	None	$233,512	$0	$396,810	$630,323
2040	None	$238,182	$0	$396,810	$634,993
2041	None	$242,946	$0	$396,810	$639,756
2042	None	$247,805	$0	$396,810	$644,615
2043	None	$252,761	$0	$396,810	$649,571

The identified forecasted operations, maintenance, and capital renewal budgets for the Sage Mesa system are intended to help inform the RDOS of its funding requirements to provide services in a sustainable manner.

The forecasted expenditures can be compared to existing operating and capital budgets to identify any funding shortfalls. In general, a funding shortfall identified from this assessment will likely be from the annualized capital renewal requirements in order to maintain the system for future replacement.

A 20-year long-term forecast with O&M costs, annualized capital renewal costs, new capital works for both water source options, and current O&M budget have been provided in the figures below (Figure 19 and Figure 20).

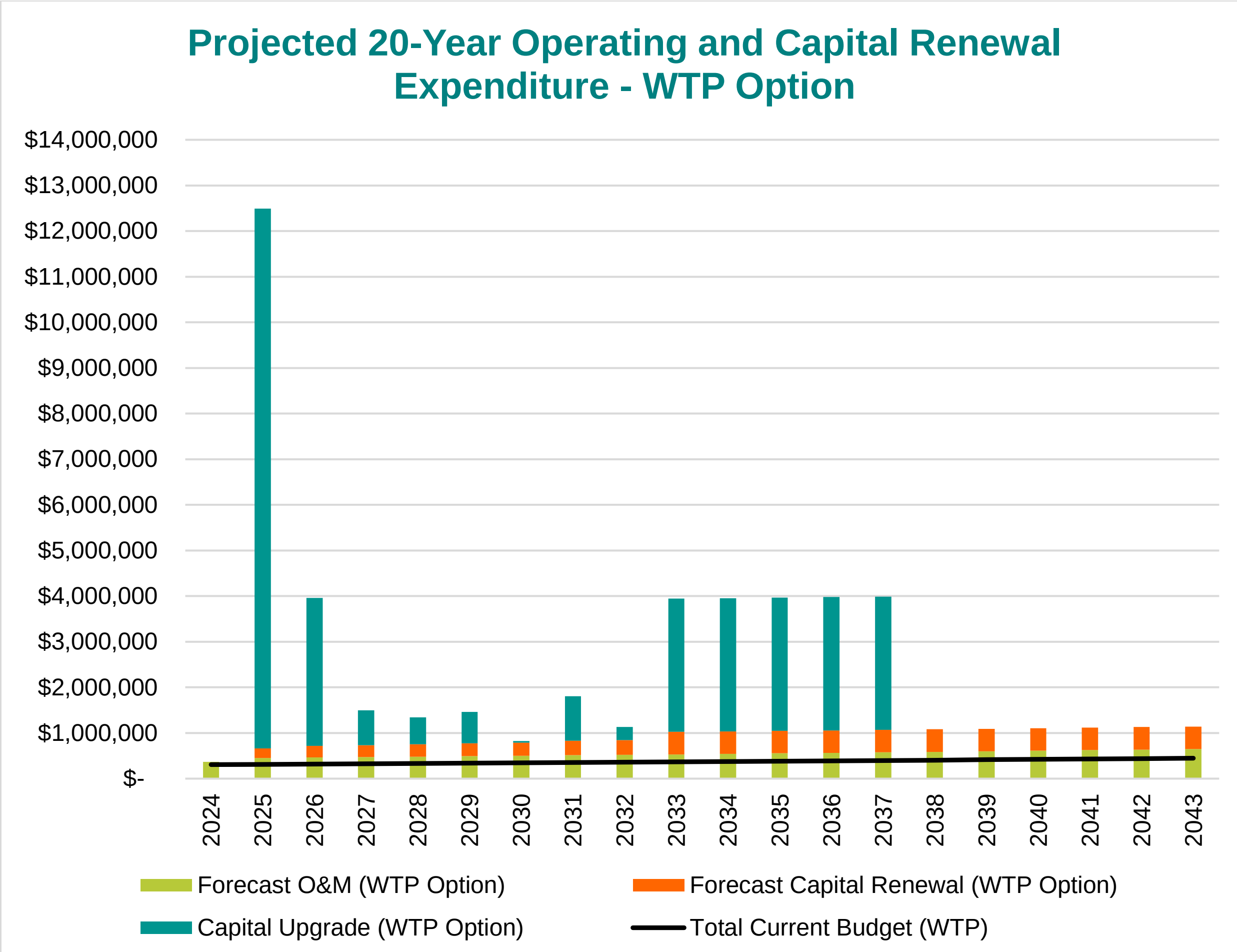


Figure 19. Projected 20-Year Expenditure Forecast for the WTP Option

The projected operations, maintenance, and annualized capital renewal expenditures for the fully built-out WTP option is $1,142,239 at the end of the 20-year planning period. These costs along with projected annual new works are shown in Figure 19.

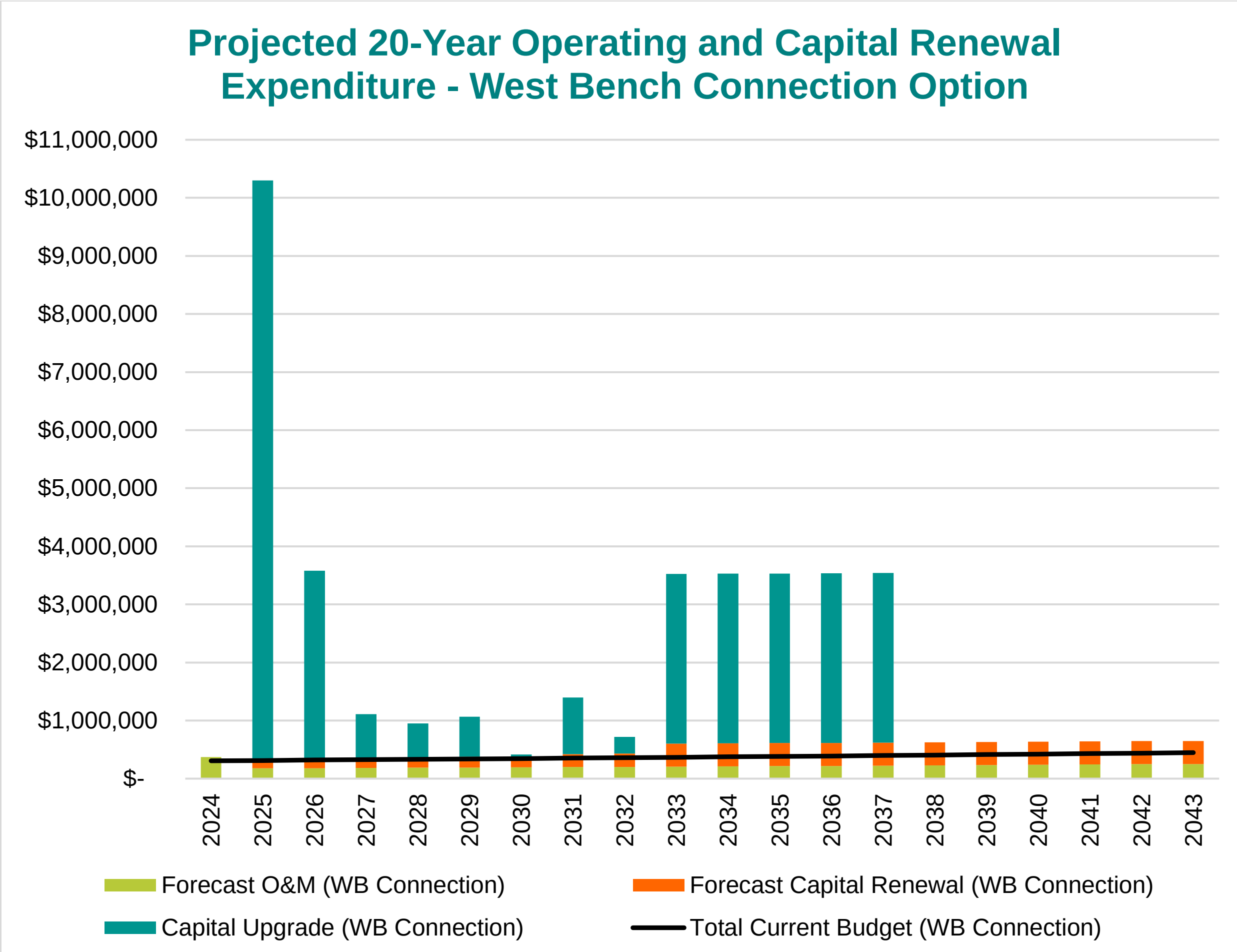


Figure 20. Projected 20-Year Expenditure Forecast for the West Bench Connection Option

The projected operations, maintenance, and annualized capital renewal expenditures for the fully built-out West Bench Connection option is $649,571 at the end of the 20-year planning period. These costs along with projected annual new works are shown in Figure 20.

Based on the above analysis, the West Bench Connection is the cheaper of the two options.

8. Closing

McElhanney is pleased to provide this Engineering and Financial Assessment Report for the Sage Mesa Water Supply Options Assessment. If there are any questions or concerns, please contact Lee Peltz.

Sincerely,

McElhanney Ltd.
Permit to Practice: 1003299

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APPENDIX A

Statement of Limitations

Statement of Limitations

Use of this Report. This report was prepared by McElhanney Ltd. ("**McElhanney**") for the particular site, design objective, development and purpose (the "**Project**") described in this report and for the exclusive use of the client identified in this report (the "**Client**"). The data, interpretations and recommendations pertain to the Project and are not applicable to any other project or site location. The Client may provide copies of this report to its affiliates, contractors, subcontractors and regulatory authorities for use in relation to and in connection with the Project provided that any reliance, unauthorized use, and/or decisions made based on the information contained within this report are at the sole risk of such parties. McElhanney will not be responsible for the use of this report on projects other than the Project, where this report or the contents hereof have been modified without McElhanney's consent, to the extent that the content is in the nature of an opinion, and if the report is preliminary or draft. This is a technical report and is not a legal representation or interpretation of laws, rules, regulations, or policies of governmental agencies.

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Effect of Changes. All evaluations and conclusions stated in this report are based on facts, observations, site-specific details, legislation and regulations as they existed at the time of the report preparation. Some conditions are subject to change over time and the Client recognizes that the passage of time, natural occurrences, discovery of additional information, and direct or indirect human intervention at or near the site may substantially alter such evaluations and conclusions. Construction activities can significantly alter soil, rock and other geologic conditions on the site. McElhanney should be requested to re-evaluate the conclusions of this report and to provide amendments as required prior to any reliance upon the information presented herein upon any of the following events: a) any changes (or possible changes) as to the site, purpose, or development plans upon which this report was based, b) any changes to applicable laws subsequent to the issuance of the report, c) new information is discovered in the future during site excavations, construction, building demolition or other activities, or d) additional subsurface assessments or testing conducted by others.

Independent Judgments. McElhanney will not be responsible for the independent conclusions, interpretations, interpolations and/or decisions of the Client, or others, who may come into possession of this report, or any part thereof. This restriction of liability includes decisions made to purchase, finance or sell land or with respect to public offerings for the sale of securities.

Construction Cost Estimates. This construction cost estimate has been prepared using the design and technical information currently available, and without the benefit of survey, geotechnical, environmental, and details of the existing infrastructure information. Furthermore, McElhanney cannot predict the competitive environment, weather or other unforeseen conditions that will prevail at the time that contractors will prepare their bids. The cost estimate is therefore subject to factors over which McElhanney has no control, and McElhanney does not guarantee or warranty the accuracy of such estimate.

APPENDIX B

Reference Documents

Reference Documents

The following documents were reviewed in preparing this report:

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18. *Sage Mesa Annual Water Quality Report* (pp. 1–6). (2019). Public Works Department. Regional District of the Okanagan Similkameen.
19. *Sage Mesa Bulk Water Supply* (pp. 1–27). (2015). Focus Corporation
20. *Sage Mesa Coliforms RWQ 2019 to 2021.xls*. (2022). Provided by the Regional District of the Okanagan Similkameen.
21. *Sage Mesa Dist Bacteriological 2021WW.xls*. (2021). Provided by the Regional District of the Okanagan Similkameen.
22. *SageMesaDistBact2021WW.xls*. (2022). Provided by the Regional District of the Okanagan Similkameen.

23. *SageMesaRWQ2021WW.xls*. (2022). Provided by the Regional District of the Okanagan Similkameen.
24. *SageMesaRWQAvgTotalMetals2018to2020WW.xls*. (2022). Provided by the Regional District of the Okanagan Similkameen.
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26. *Sage Mesa Water System Assessment Update Inspection Report*. (2019). Document provided by Regional District of the Okanagan Similkameen.
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28. *SM Anions 2010 to 2017.xls*. (2017). Provided by the Regional District of the Okanagan Similkameen.
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APPENDIX C

Infrastructure Inventory

Chlorination

Description	Location	Year Installed	Make/Model	Comments
Chlorine Dosing Pump	Lake Pumphouse	2020	ProMinent Gamma/x GMXA1604NPB2M 000UDG1300EN	
Chlorine Analyzer	Lake Pumphouse	2020	Severn Trent MicroChem2 Series 4000	
Turbidity Analyzer	Lake Pumphouse	2020	ABB 4690?	
Chlorine Dosing Pump	Booster Pumphouse	1995		Manual adjustment. No automation.

Intake

Description	Location	Distance from shore (m)	Size (mm)	Depth (m)	Year Installed	Condition	Material	Screen / bar info (size?)
Sage Mesa Intake Screen	Okanagan Lake (49.52188° N - 119.61554° W)	135 - 177	N/A	7 - 13.7	2005	Good	Stainless Steel	Stainless steel, 1.5mm mesh
Main from Intake to Lake Pumphouse		N/A	600mm / 300mm	N/A	CMP 1987 PVC 1980	PVC Portion Intact as of 2015	Mixture of PVC and CMP	N/A

Reservoirs

Reservoir ID	Description	Location	Capacity (m3)	TWL (m)	Floats?	SCADA Connection?	Year Installed	Material
LOWER_RESERVOIR	Lower Zone Reservoir (1490)	3610 Pine Hills Dr	272	454	Yes. High level.	Unknown	1962	Concrete
UPPER_RESERVOIR	Upper Zone Reservoir	East of 1714 Forsyth Pl	454	620	Unknown	At booster station.	1977	Concrete

Pumps

Location	Type	Year Installed	Age (Years)	Size (mm)	Power (hp)	Stages	Make / Model Pump	Make/Model Motor	Motor Speed (rpm)	Discharge Capacity (L/s)	TDH (m)	Efficiency Rating at Operating Point	BEP Efficiency	Rated / Norminal Flow (L/s)
Lake Pumphouse	Vertical Turbine Pump	2022	2	150	75	4	Simmons SM8H-4	General Electric	3500	37.88	115 (at nominal flow)	Unknown	Unknown	Unknown
Lake Pumphouse	Vertical Turbine Pump	1970	54	100	25	8	Johnson (model unknown)	Newman	3500	10.60	Unknown	Unknown	Unknown	Unknown
Lake Pumphouse	Submersible Pump	2012	12	Unknown	20	Unknown	Berkeley	Unknown	Unknown	10.22	Unknown	Unknown	Unknown	Unknown
Booster Station	Canned Vertical Booster Pump	2014	10	150	75	6	Goulds 7CLC	USEM Vertical	3500	20.1 - 24.2	194	79	80	22.1
Booster Station	Canned Vertical Booster Pump	1995	29	150	75	6	Goulds 7CLC	USEM Vertical	3500	20.1 - 24.2	194	79	80	22.1

Hydrants

Hydrant ID	Description	Location	Make	Model	Port Size / Type	Year Installed	Age (Years)	Last Inspection	Needs Paint? (As of most recent inspection)	Comments
SAGE1		2110 Tyron Place	Terminal City	C71P	100mm Outlet Cap	1977	47	10/21/2022	No	Put one new top flange gasket (H50). Put one new valve seat o ring (H45). (2018 Hydrant Test)
SAGE10		3019 Forsyth Drive	Terminal City	C71P	100mm Outlet Cap	1977	47	10/21/2022	No	
SAGE11		2818 Forsyth Drive	Terminal City	C71P	100mm Outlet Cap	1977	47	10/21/2022	No	Isolation valve box has 2 feet of water inside. Left gate valve in the fully open position. (2022 Hydrant Test) Isolation valve, the top square nut at the stem came off. Used spoons to put nut back on the brass stem. (2015 Hydrant Test)
SAGE12		2636 Forsyth Drive	Terminal City	C71P	100mm Storz	1977	47	9/20/2022	No	Water in valve box (2019 Hydrant Test)
SAGE13		Across from 2632 Forsyth Drive	Clow	Brigadier M-93	100mm Storz	1995	29	10/21/2022	No	
SAGE14		2623 Forsyth Drive	Terminal City	C71P	100mm Storz	1982	42	10/21/2022	No	Water in valve box (2019 Hydrant Test) One new valve seat O ring installed - H45 (2018 Hydrant Test)
SAGE15		2608 Forsth Drive	Terminal City	C71P	100mm Storz	1982	42	10/21/2022	Yes	
SAGE16		2591 Forsyth Drive	Clow	Brigadier M-93	100mm Storz	2005	19	10/25/2022	No	
SAGE17		1704 Estates Place	Clow	McAvity M-67	100mm Storz	1982	42	10/25/2022	No	ISSUE WITH HYDRANT VALVE NOT SEATING. HAD TO INSTALL WITH VALVE IN CLOSED POSITION (2017 Hydrant Test) Main valve seat threads took a long time to thread back in. (2015 Hydrant Test)
SAGE18		1910 Estates Place	Clow	McAvity M-67	100mm Storz	1982	42	10/25/2022	No	Put one new seat "o" ring bottom (no.34). Put one new seat "o" ring top (no.34a). (2015 Hydrant Test)
SAGE19		2009 Estates Place	Clow	McAvity M-67	100mm Storz	1982	42	10/25/2022	No	
SAGE2		3808 Forsyth Drive	Terminal City	C71P	100mm Outlet Cap	1977	47	10/21/2022	No	Isolation valve box has 2 feet of water inside. Left gate valve in the fully open position. (2022 Hydrant Test)
SAGE20		2425 Westwood Drive	Canada Valve	Century	100mm Outlet Cap	1994	30	10/25/2022	No	Removed metal bearings around operating nut. Replaced with one new Delrin bearing. Part #364378, (thrust bearing). (2015 Hydrant Test)
SAGE21		2456 Westwood Drive	Mueller	Modern Centurion	100mm Storz	1994	30	10/25/2022	No	
SAGE22		2206 Forsyth Drive	Clow	McAvity M-67	100mm Storz	1982	42	10/25/2022	No	
SAGE23		Across from 2218 Sandstone Drive	Clow	Brigadier M-93	100mm Outlet Cap	1994	30	10/25/2022	No	
SAGE24		2074 Sandstone Drive	Canada Valve	Century	100mm Outlet Cap	1994	30	10/25/2022	No	Removed metal bearings around operating nut. Replaced with one new Delrin bearing, part #364378, (thrust bearing). Put one new drip lever cotter pin, part #47414. (2015 Hydrant Test)
SAGE25		2000 Sandpiper Lane	Canada Valve	Century	100mm Outlet Cap	Unknown	Unknown	10/25/2022	No	
SAGE26		1881 Sandstone Drive	Canada Valve	Century	100mm Outlet Cap	Unknown	Unknown	10/25/2022	No	
SAGE27		1802 Sandstone Drive	Canada Valve	Century	100mm Outlet Cap	Unknown	Unknown	10/26/2022	No	
SAGE28		3630 Sage Mesa Drive	Terminal City	#20P	100mm Outlet Cap	1984	40	10/28/2022	No	Main valve slightly bypassing (2019 Hydrant Test)
SAGE29		3857 Sage Mesa Drive	Terminal City	#20P	100mm Outlet Cap	1984	40	10/28/2022	No	
SAGE3		3616 Forsyth Drive	Terminal City	C71P	100mm Outlet Cap	1977	47	10/21/2022	No	Isolation valve box has 2 feet of water inside. Left gate valve in the fully open position (2022 Hydrant Test)
SAGE30		Across from 4053 Salona Crescent	Terminal City	#20P	100mm Outlet Cap	1984	40	11/3/2022	No	
SAGE31		4441 Sage Mesa Drive	Terminal City	#20P	100mm Outlet Cap	1962	62	10/29/2022	No	
SAGE32		4458 Sage Mesa Drive	Terminal City	#20P	100mm Outlet Cap	1980	44	11/3/2022	No	Isolation valve full of water.Left gate valve fully open. (2022 Hydrant Test)
SAGE33		3827 Verano Place	Terminal City	C71P	100mm Outlet Cap	1998	26	11/3/2022	No	Fire hydrant does not self drain. Pumped out water. (2022 Hydrant Test)
SAGE34		4041 Verano Place	Terminal City	Unknown	N/A	1998	26	11/3/2022	No	The fire hydrant at Verano pl has a insufficient water flow as it is serviced by a 50mm pipe (2019 Inspection Report) Stand pipe was draining very slowly. Pumped out water. (2022 Hydrant Test) This is a self draining stand pipe. Isolation valve is a curb stop valve. (2016 Hydrant Test)
SAGE35	2" Ground Level Blow Off Pipe (2019 Hydrant Test)	2513 Pine Tree Place	N/A	N/A	N/A	1994	30	N/A	N/A	
SAGE36	2" Ground Level Blow Off Pipe (2019 Hydrant Test)	2505 Forsyth Drive	N/A	N/A	N/A	1994	30	N/A	N/A	
SAGE37	3" Blow Off Standpipe (2019 Hydrant Test)	Behind house 2001 Sandstone Drive	N/A	N/A	N/A	2000	24	N/A	N/A	
SAGE38	2" Blow Off Standpipe (2019 Hydrant Test)	South of booster station	N/A	N/A	N/A	Unknown	Unknown	N/A	N/A	
SAGE39	3/4" Ground Level Blow Off Pipe (2019 Hydrant Test)	2624 Estates Place	N/A	N/A	N/A	Unknown	Unknown	N/A	N/A	
SAGE4		3414 Forsyth Drive	Terminal City	C71P	100mm Outlet Cap	1977	47	10/21/2022	No	Fire hydrant does not self drain, pumped out water. (2022 Hydrant Test) NUT ON ISOLATION VALVE IS GETTING ROUNDED OFF, NEED TO USE A DIFFERENT KEY WITH TIGHTER SQUARE. (2017 Hydrant Test) Pumped water out of fire hydrant October 8 2015. (2015 Hydrant Test)
SAGE5		3216 Forsyth Drive	Terminal City	C71P	100mm Outlet Cap	Unknown	Unknown	10/21/2022	No	WATER IN VALVE BOX (2017 Hydrant Test)
SAGE6		2107 Ryan Road	Terminal City	C71P	100mm Outlet Cap	1981	43	10/21/2022	No	Isolation valve box is full of water.Left gate valve in the fully open position (2022 Hydrant Test) Put two new valve seat o ring (H45). (2015 Hydrant Test)
SAGE7		2111 Ryan Road	Terminal City	C71P	100mm Outlet Cap	1981	43	10/21/2022	No	Water in valve box (2019 Hydrant Test)

SAGE8		2127 Ryan Road	Terminal City	C71P	100mm Outlet Cap	1981	43	10/21/2022	No	Water in valve box (2019 Hydrant Test) REPLACED COMPRESSION PUCK (TCH44-92). WAS BULDGED AND COULD NOT RESEAT VALVE (2017 Hydrant Test)
SAGE9		Corner of Forsyth dr and Ryan Road	Terminal City	C71P	100mm Outlet Cap	1977	47	10/21/2022	No	Fire hydrant does not self drain, pumped out water. (2022 Hydrant Test)

Instruments/Electrical Equipment

Description	Location	Type	Year Installed	Condition	Make / Model	Comments
SAGE Mesa Control System	Lake Pump Station	PLC - Processor	2020	Almost New	Modicon M340 BMX P34 2020	2020 Control System Upgrade
SAGE Mesa Control System	Lake Pump Station	PLC - Analog Input Cards	2020	Almost New	Modicon X80 BMX AMI 0810	2020 Control System Upgrade
SAGE Mesa Control System	Lake Pump Station	PLC - Analog Output Cards	2020	Almost New	Modicon X80 BMX AMO 0410	2020 Control System Upgrade
SAGE Mesa Control System	Lake Pump Station	PLC - Digital Input Cards	2020	Almost New	Modicon X80 BMX DDI 1602	2020 Control System Upgrade
SAGE Mesa Control System	Lake Pump Station	PLC - Digital Output Cards	2020	Almost New	Modicon X80 BMX DRA 0805	2020 Control System Upgrade
SAGE Mesa Control System	Lake Pump Station	PLC - Power Supply	2020	Almost New	Modicon BMX CPS 2000	2020 Control System Upgrade
SAGE Mesa Control System	Booster Station	PLC - Processor	2020	Almost New	Modicon M340 BMX P34 2020	2020 Control System Upgrade
SAGE Mesa Control System	Booster Station	PLC - Analog Input Cards	2020	Almost New	Modicon X80 BMX AMI 0810	2020 Control System Upgrade
SAGE Mesa Control System	Booster Station	PLC - Analog Output Cards	2020	Almost New	Modicon X80 BMX AMO 0410	2020 Control System Upgrade
SAGE Mesa Control System	Booster Station	PLC - Digital Input Cards	2020	Almost New	Modicon X80 BMX DDI 1602	2020 Control System Upgrade
SAGE Mesa Control System	Booster Station	PLC - Digital Output Cards	2020	Almost New	Modicon X80 BMX DRA 0805	2020 Control System Upgrade
SAGE Mesa Control System	Booster Station	PLC - Power Supply	2020	Almost New	Modicon BMX CPS 2000	2020 Control System Upgrade
SAGE Mesa Instrumentation	Lake Pump Station	Pressure Transmitter Distribution Pressure	2020	Almost New	ABB 266HSH.P.S.B.A.1..E4..L5.B6	2020 Control System Upgrade
SAGE Mesa Instrumentation	Booster Station	Pressure Transmitter Suction Pressure	2020	Almost New	ABB 266HSH.P.S.B.A.1..E4..L5.B6	2020 Control System Upgrade
SAGE Mesa Instrumentation	Booster Station	Pressure Transmitter Discharge Pressure	2020	Almost New	ABB 266HSH.P.S.B.A.1..E4..L5.B6	2020 Control System Upgrade
SAGE Mesa Instrumentation	Lake Pump Station	Turbidity Sensor	2020	Almost New	ABB 4690 Series	2020 Control System Upgrade
SAGE Mesa Control System - SCADA	Booster Station	SCADA	2020	Almost New	Hardware: Unknown Software: VTSCADA	2020 Control System Upgrade. District was responsible for SCADA computer
SAGE Mesa Control System - SCADA	Booster Station	Firewall	2020	Almost New	SOPHOS XG 86 W	2020 Control System Upgrade
SAGE Mesa Control System - SCADA	Booster Station	Internet Router	2020	Unknown	Unknown	2020 Control System Upgrade
SAGE Mesa Electrical	Lake Pump Station	3-Phase Ground Fault Detection & Indication Panel	2020	Almost New	Unknown	2020 Control System Upgrade
SAGE Mesa Instrumentation	Lake Pump Station	Chlorine Residual Analyzer	2008		Severn Trent Model: T17MB41D214	Only provides Lo Cl2 residual alarming to shut the pumps off. There is no Hi Cl2 alarming. May not be the analyzer installed though after the 2020 upgrades identified in the 2020 SCADA O&M. Possibly now handled thorugh a Severn Trent MicroChem2 Series 4000 transmitter and controller
SAGE Mesa Electrical	Lake Pump Station	Backup Power				There is no back up power.
SAGE Mesa Electrical	Booster Station	Backup Power				There is no back up power.
SAGE Mesa Electrical	Lake Pump Station	UPS for Control System	2020		Liebert GXT3-1000MT120	2020 Control System Upgrade.
SAGE Mesa Electrical	Booster Station	UPS for Control System	2020		Liebert GXT3-1000MT120	2020 Control System Upgrade.
Sage Mesa Electrical	Booster Station	Booster Pumps Soft Starts	1995		Benshaw Model: Ready Start II	Some noises have been observed recently with the soft starts when the pumps are operating. Cause unknown. See IITS report from 2010 titled: Sage Mesa Water System – Electrical, Instrumentation and Control System Audit Report .
Sage Mesa Electrical	Lake Pump Station	25HP Starter	1970		Moller Model: DIL 2A M	See IITS report completed in 2010 titled: Sage Mesa Water System – Electrical, Instrumentation and Control System Audit Report
SAGE Mesa Control System	Lake Pump Station	Control System Unmanaged Network Switch	2020	Almost New	NTRON 104TX-MDR	2020 Control System Upgrade.

SAGE Mesa Control System	Booster Station	Control System Unmanaged Network Switch	2020	Almost New	NTRON 104TX-MDR	2020 Control System Upgrade.
SAGE Mesa Control System	Lake Pump Station	IO Link Radio to Booster Station	2020	Almost New	XETAWAVE 121MLFC	2020 Control System Upgrade.
SAGE Mesa Control System	Booster Station	IO Link Radio to Lake Pump Station	2020	Almost New	XETAWAVE 121MLFC	2020 Control System Upgrade.
SAGE Mesa Control System	Booster Station	IO Link Radio to Upper Reservoir			OMNEX	Existing at time of 2020 upgrade and re-used.
SAGE Mesa Control System	Booster Station	IO Link Radio to RDOS			MODPAC	Existing at time of 2020 upgrade and re-used.

Mains

Main ID	Description	Location	Year Installed	Age	Length (m)	Diameter (mm)	Material	Number of Breaks	Location of Break	Most Recent Break
<Null>		2204 Forsyth Dr to 2402 Westwood	1994	30	232.5	150	PVC			
SAGE1		Service for 2101 & 2103 Ryan Rd	1981	43	76.4	32	PVC			
SAGE10		2204 Forsyth Dr to PRV Station	1994	30	74.4	200	PVC			
SAGE11		Bartlett & Sandstone to 2204 Forsyth Dr	1994	30	393.8	200	PVC			
SAGE12		East of 3415 Pine Hills Dr to 305 Sage Mesa Dr	1998	26	228.6	250	PVC			
SAGE13	From Verano Main to Blowoff / Hydrant?	4041 Verano Pl	1998	26	8.1	100	PVC			
SAGE14		Between Solana Cres & Verano Pl	1962	62	177.6	50	PVC or Galvanized Iron			
SAGE15		3857 Solana Cres to 3877 Solana Cres	1962	62	128.0	100	Class 150 AC			
SAGE16		4055 Sage Mesa Dr to 3625 Sage Mesa Dr	1984	40	482.6	150	PVC (Class 150)			
SAGE17		Ladera Pl	1962	62	90.5	50	Class 150 AC			
SAGE18		4444 Sage Mesa Dr to 4241 Sage Mesa Dr	1962	62	162.5	150	Class 150 AC			
SAGE2		Service for 2104 & 2108 Ryan Rd	1981	43	54.7	50	PVC			
SAGE2		Between 2124 & 2128 Ryan Rd	1981	43	11.2	150	PVC			
SAGE20		Estates Pl & Forsyth Drive from 1700 Estates Pl to 3417 Forsyth Dr	1982	42	1943.8	150	PVC			
SAGE22		Tyrone Pl	1977	47	142.8	150	PVC			
SAGE23		Ryan Rd	1981	43	501.3	150	PVC			
SAGE24		Ponderosa Pl	1977	47	58.1	150	PVC			
SAGE25		Sandpiper Ln & 1892 Sandstone Cres to 1880 Sandstone Cres	Unknown	Unknown	322.5	150	PVC			
SAGE26		Pinetree Pl	Unknown	Unknown	49.7	150	PVC			
SAGE27		3417 Forsyth Dr to 3808 Forsyth Dr	1977	47	355.8	150	PVC			
SAGE28		2236 Sandstone Dr to 1983 Sandstone Dr	1994	30	355.4	150	PVC			
SAGE29		1983 Sandstone Dr to 1802 Sandstone Dr	1994	30	435.8	150	PVC			
SAGE3		Service for 2116 & 2120 Ryan Rd	1981	43	11.5	50	PVC			
SAGE30		1802 Sandstone Dr to West Side of Bartlett Dr	1994	30	19.6	200	PVC			
SAGE31		4055 Sage Mesa Dr to 3877 Solano Cres	1962	62	149.4	150	Class 150 AC			
SAGE32		4041 Verano Pl to 3828 Verano Pl	1998	26	125.0	100	PVC			
SAGE33	150mm to 100mm happens at hydrant	3828 Verano Pl to Sage Mesa Dr	1998	26	22.4	150	PVC			
SAGE34		4245 Solana Cres to 4055 Sage Mesa Dr	1962	62	58.3	100	Class 150 AC			
SAGE35		4448 Sage Mesa Dr to 4257 Solana Cres	1962	62	234.3	100	Class 150 AC			
SAGE36		4257 Solana Cres to 4245 Solana Cres	1991	33	24.5	150	PVC			
SAGE37		4668 Sage Mesa Dr to 4692 Sage Mesa Dr	1968	56	31.4	150	PVC			
SAGE39	DECOMMISSIONED (1997)	Between Lake Pumphouse and Sage Mesa Dr. On w	1962	62	2.1	100	Class 250 AC			
SAGE4		Service for 3019 Forsyth Dr	Unknown	Unknown	120.2	150	PVC	1		13-Jul-17
SAGE41		Lake Pumphouse to 4668 Sage Mesa Dr to 4448 Sage Mesa Dr	1980	44	529.0	200	CL250 PVC			10-Apr-14
SAGE42		Lower Reservoir to 4448 Sage Mesa Dr	1962	62	112.4	200	AC			
SAGE43		Valve Cluster Between Station and Lower Reservoir to Lower Reservoir	1962	62	15.2	200	DUCTILE IRON			
SAGE44		Booster Station to Valve Cluster Between Station and Lower Reservoir	1997	27	22.1	200	PVC			
SAGE45		Booster Station to Valve Cluster West of Booster Station	1997	27	11.1	200	Unknown			

SAGE46		Valve Cluster West of Booster Station to Vault for 100mm Service Between Booster Station and Upper Reservoir	1977	47	577.1	200	CL250 DUCTILE IRON			
SAGE47		Upper Reservoir to Vault for 100mm Service Between Booster Station and Upper Reservoir	1977	47	640.1	150	CL250 DUCTILE IRON			
SAGE48		Forsyth Pl (3616 Forsyth Dr to Upper Reservoir)	1977	47	413.5	200	PVC			
SAGE49	Reservoir Drain	Upper Reservoir	1977	47	23.5	150	PVC			
SAGE5		Service from 2631 Forsyth Dr to 2617 Forsyth Dr	1982	42	102.0	50	Unknown			
SAGE50		3625 Sage Mesa Dr to 3415 Pine Hills Dr	2013	11	64.8	150	PVC			
SAGE51		Service Extension for 316 and 320 Sage Mesa Dr	1971	53	44.4	50	PVC	1	49.51577° N - 119.62349° W	16-Dec-22
SAGE6		Service for 2591, 2589, & 2587 Forsyth Dr	2005	19	138.5	150	Unknown			
SAGE7		1905 Estates Place to PRV on Forsyth	1982	42	139.6	150	PVC			
SAGE8		Forsyth Dr (2402 Westwood Dr to 2502 Pinetree Pl	1982	42	165.7	150	PVC			
SAGE9		Westwood Dr	1994	30	260.9	150	PVC			

Meters

Meter ID	Address	Location Description	Pit or Meter	Corresponding Pit / Meter	Type	Register Type	RFid Number	Meter Number	Size (mm)	Year Installed	Age (Years)
		Lake Pumphouse			Neptune Trident Turbine					1970	54
		Booster Station	Meter		ABB Model 10DX4300					1995	29
	3415 Pine Hills Dr	For WOW Golf	Meter						50	Unknown?	
SAGE1	2636 Forsyth Dr		Pit	SAGE_1						2020	4
SAGE2	2109 Tyrone Pl		Pit	SAGE_27						2020	4
SAGE3	1700 Estates Pl		Pit	SAGE_15						2020	4
SAGE4	2108 Tyrone Pl		Pit	SAGE_26						2020	4
SAGE5	2131 Ryan Rd	Irrigation Box	Pit	SAGE_25						2020	4
SAGE6	3413 Forsythe Dr		Pit	SAGE_20						2020	4
SAGE7	1704 Estates Pl	Irrigation Box	Pit	SAGE_16						Unknown	Unknown
SAGE8	2010 Estates Pl	Irrigation Box	Pit	SAGE_17						Unknown	Unknown
SAGE9	2128 Ryan Rd	Irrigation Box	Pit	SAGE_24						Unknown	Unknown
SAGE10	2587 Forsythe Pl		Pit	SAGE_18						2020	4
SAGE11	2609 Forsythe Dr		Pit	SAGE_19						2020	4
SAGE12	3607 Forsythe Dr		Pit	SAGE_21						2020	4
SAGE13	3608 Forsythe Dr		Pit	SAGE_22						2020	4
SAGE14	3613 Forsythe Dr		Pit	SAGE_23						2020	4
SAGE16	3004 Forsyth Dr		Pit	SAGE_29						Unknown	Unknown
SAGE17	2018 Sandpiper Ln		Pit	SAGE_30						Unknown	Unknown
SAGE18	2104 Ryan Rd		Pit	Unknown						Unknown	Unknown
SAGE19	2402 Westwood Dr		Pit	SAGE_31						Unknown	Unknown
SAGE20	3201 Forsyth Dr		Pit	SAGE_33						Unknown	Unknown
SAGE21	3417 Forsyth Dr		Pit	SAGE_34						Unknown	Unknown
SAGE15	1839 Sandstone Dr		Pit	Unknown						2021	3
SAGE17	1947 Sandstone Dr		Pit	SAGE_28						Unknown	Unknown
SAGE_1	2636 Forsythe Dr	In Pit	Meter	SAGE1	T10	R900i New Style	1566103856	54248836	19	2020	4
SAGE_2	2009 Estates Pl	Inside - Downstairs beside hot water tank	Meter	N/A	T10	R900i New Style	1566087562	54315630	19	2020	4
SAGE_3	1915 Estates Pl	Inside - Downstairs Storage Room	Meter	N/A	T10	R900i New Style	1566089170	54315557	19	2020	4
SAGE_4	1905 Estates Pl	Inside - Crawl Space, under front door closet	Meter	N/A	T10	R900i New Style	1566089168	54315559	19	2020	4
SAGE_5	2127 Ryan Rd	Inside - Crawl Space	Meter	N/A	T10	R900i New Style	1566089160	54640077	19	2020	4
SAGE_6	3408 Forsythe Dr	Inside - Under sink by washing machine	Meter	N/A	T10	R900i New Style	1566100992	54315632	19	2020	4
SAGE_7	3012 Forsythe Dr	Inside - Downstairs	Meter	N/A	T10	R900i New Style	1566088850	54315560	19	2021	3
SAGE_8	3808 Forsythe Dr	Inside - downstairs laundry room	Meter	N/A	T10	R900i New Style	1566087264	54640076	19	2020	4
SAGE_9	3016 Forsythe Dr	Inside - Downstairs utility room	Meter	N/A	T10	R900i New Style	1565408470	54315629	19	2020	4
SAGE_10	1720 Forsythe Pl	Inside - Downstairs utility room	Meter	N/A	T10	R900i New Style	1566086818	54315579	19	2020	4
SAGE_11	2623 Forsythe Dr	Inside - Crawlspace	Meter	N/A	T10	R900i New Style	1566088950	54315604	19	2020	4
SAGE_12	1910 Ponderosa Pl	Inside - Dowstairs	Meter	N/A	T10	R900i New Style	1566080166	54315558	19	2020	4
SAGE_13	2110 Tyrone Pl	Inside - Downstairs storage room	Meter	N/A	T10	R900i New Style	1565502734	54315583	19	2020	4
SAGE_14	2103 Tyrone Pl	Inside - Crawlspace	Meter	N/A	T10	R900i New Style	1566088924	54315608	19	2020	4
SAGE_15	1700 Estates Pl	Pit	Meter	SAGE3	T10	R900i New Style	1566104854	54302831	19	2020	4
SAGE_16	1704 Estates Pl	Pit (Irrigation Box)	Meter	SAGE7	T10	R900i New Style	1566094506	54302833	19	2020	4
SAGE_17	2010 Estates Pl	Pit (Irrigation Box)	Meter	SAGE8	T10	R900i New Style	1566119508	54302832	19	2020	4
SAGE_18	2587 Forsythe Dr	Pit	Meter	SAGE10	T10	R900i New Style	1566103988	54248834	19	2020	4
SAGE_19	2609 Forsythe Dr	Pit	Meter	SAGE11	T10	R900i New Style	1566105294	54302836	19	2020	4
SAGE_20	3413 Forsythe Dr	Pit	Meter	SAGE6	T10	R900i New Style	1566105924	54248826	19	2020	4
SAGE_21	3607 Forsythe Dr	Pit	Meter	SAGE12	T10	R900i New Style	1566112902	54248788	19	2020	4
SAGE_22	3608 Forsythe Dr	Pit	Meter	SAGE13	T10	R900i New Style	1566119724	54248823	19	2020	4
SAGE_23	3613 Forsythe Dr	Pit	Meter	SAGE14	T10	R900i New Style	1566094102	54248841	19	2020	4
SAGE_24	2128 Ryan Rd	Pit (Irrigation Box)	Meter	SAGE9	T10	R900i New Style	1566111254	54302811	19	2020	4
SAGE_25	2131 Ryan Rd	Pit (Irrigation Box)	Meter	SAGE5	T10	R900i New Style	1566103918	54302835	19	2020	4
SAGE_26	2108 Tyrone Pl	Pit	Meter	SAGE4	T10	R900i New Style	1566111480	54248780	19	2020	4
SAGE_27	2109 Tyrone Pl	Pit	Meter	SAGE2	T10	R900i New Style	1566105300	54248806	19	2020	4
SAGE_28	1947 Sandstone Dr	Pit	Meter	SAGE 17	T10	R900i New Style	1562774102	54315621	19	2021	3
SAGE_29	3004 Forsyth Dr	Pit	Meter	SAGE16	T10	R900i New Style	1566094104	54248791	19	2021	3
SAGE_30	2018 Sandpiper Ln	In existing pit	Meter	SAGE17	T10	R900i New Style	1566833320	54248824	19	2021	3
SAGE_31	2402 Westwood Dr	Existing Pit	Meter	SAGE19	Mach 10	R900i New Style	1571246436	12161698	19	2022	2
SAGE_32	2591,2589 Forsyth Dr	Utilities Room	Meter	N/A	Mach 10	R900i New Style	1572129548	12747098	19	2022	2
SAGE_33	3201 Forsyth Dr	Existing Pit	Meter	SAGE20	Mach 10	R900i New Style	1571233736	12161697	19	2022	2
SAGE_34	3417 Forsyth Dr	Existing Pit	Meter	SAGE21	T10	R900i New Style	1566123724	54248833	19	2022	2
SAGE_35	2510 Pinetree Pl	Pit	Meter	Unknown	Mach 10	R900i New Style	1572654466	13034383	19	2022	2
SAGE_36	2617 Forsythe Dr	In meter pit	Meter	Unknown	Mach 10	R900i New Style	1572669318	13034389	19	2023	1
SAGE_37	2612 Forsyth Dr	meter pit	Meter	Unknown	Mach 10	R900i New Style	1572703898	13034380	19	2022	2
SAGE_38	2628 Forsyth Dr	meter pit	Meter	Unknown	Mach 10	R900i New Style	1572745598	13034390	19	2022	2
SAGE_39	1893 Sandstone Dr	meter pit	Meter	Unknown	Mach 10	R900i New Style	1572736094	13034387	19	2022	2

Valves

Valve ID	Description	Location	Type	Size (mm) *Main Size from GIS	Year Installed	Age (Years)	Setting	Make / Model
	Upper Zone PRV #2	Belowground vault with manhole lid access near 2204 Forsyth Dr	PRESSURE REDUCING	100mm, 50mm	1982	42	100mm = 80psi 50mm = 95psi	ClaVal (both)
	Upper Zone PRV #1	Concrete Vault with aluminum lid near 2619 Forsyth Dr	PRESSURE REDUCING	200mm, 100mm, 50mm	Unknown	Unknown	200mm = 45 psi 100mm = 60psi 50mm = 80psi	ClaVal (all 3)
	Lower Zone PRV	Small concrete chamber near 3877 Solana Crescent	PRESSURE REDUCING	Uknown. Possibly 38mm or 50mm	Unknown	Unknown	Unknown	Unknown
SAGE43		Solana Cres	GATE VALVE - RW	50	2012	12		
SAGE1		Ponderosa Pl	GATE - MAINLINE	200	2012	12		
SAGE10		Forsyth Dr	GATE - MAINLINE	200	1977	47		
SAGE11		Forsyth Dr	GATE - MAINLINE	200	1977	47		
SAGE12		Forsyth Dr@ Ryan Rd	GATE - MAINLINE	150	2012	12		
SAGE13		Forsyth Dr@ Ryan Rd	GATE - MAINLINE	150	2012	12		
SAGE14		Ryan Rd @ Forsyth Dr	GATE - MAINLINE	150	2012	12		
SAGE15		Forsyth Dr@ Ryan Rd	GATE - MAINLINE	150	2012	12		
SAGE16		Ryan Rd	GATE - MAINLINE	150	2012	12		
SAGE17		Ryan Rd	GATE - MAINLINE	150	2014	10		
SAGE19		Forsyth Dr	GATE - MAINLINE	150	2012	12		
SAGE2		Sandstone Dr	GATE - MAINLINE	150	Unknown	Unknown		
SAGE20		Forsyth Dr	GATE - MAINLINE	150	2012	12		
SAGE21		Forsyth Dr	GATE - MAINLINE	150	2012	12		
SAGE22		Estates Pl @ Forsyth Dr	GATE - MAINLINE	150	2012	12		
SAGE23		Forsyth Dr @ Pinetree Pl	GATE - MAINLINE	150	2012	12		
SAGE24		Estates Pl @ Forsyth Dr	GATE - MAINLINE	150	2012	12		
SAGE25		Pinetree Pl	GATE - MAINLINE	150	2012	12		
SAGE26		Estates Pl	GATE - MAINLINE	150	2012	12		
SAGE27		Estates Pl	GATE - MAINLINE	150	2012	12		
SAGE28		Forsyth Dr	GATE - MAINLINE	150	2012	12		
SAGE29		Forsyth Dr	GATE - MAINLINE	200	2012	12		
SAGE3		Forsyth Dr @ Ponderosa Pl	GATE - MAINLINE	200	2012	12		
SAGE30		Sandstone Dr @ Bartlett Dr	GATE - MAINLINE	150	2012	12		
SAGE31		Bartlett Dr @ Sandstone Dr	GATE - MAINLINE	200	2012	12		
SAGE32		Sandstone Dr	GATE - MAINLINE	150	2012	12		
SAGE33		Sandstone Dr	GATE - MAINLINE	150?	2012	12		
SAGE34		Sandpiper Ln @ Sandstone Dr	GATE - MAINLINE	150	2013	11		
SAGE35		Sandstone Dr @ Sandpiper Ln	GATE - MAINLINE	150	2013	11		
SAGE36		Sandstone Dr @ Sandstone Cres	GATE - MAINLINE	150	2013	11		
SAGE37		Sandstone Dr @ Sandstone Cres	GATE - MAINLINE	150	2013	11		
SAGE38		Bartlett Dr @ Sandstone Dr	GATE - MAINLINE	200	2013	11		
SAGE39		Sandstone Dr @ Bartlett Dr	GATE - MAINLINE	150	2013	11		
SAGE4		Forsyth Dr @ Ponderosa Pl	GATE - MAINLINE	200	2012	12		
SAGE40		Bartlett Dr @ Sandstone Dr	GATE - MAINLINE	200	2013	11		
SAGE41		Solana Cres@ Sage Mesa Dr	GATE - MAINLINE	100	2012	12		
SAGE42		Sage Mesa Dr @ Solana Cres	GATE - MAINLINE	150	2012	12		
SAGE44		Solana Cres	GATE - MAINLINE	150	2013	11		
SAGE45		Solana Cres	GATE - MAINLINE	100	2013	11		
SAGE46		Solana Cres	GATE - MAINLINE	100	2012	12		
SAGE47		Sage Mesa Dr	GATE - MAINLINE	200	2012	12		
SAGE48		Between Sage Mesa Dr & Lake Pumphouse	GATE - MAINLINE	200	2013	11		
SAGE5		Forsyth Dr	GATE - MAINLINE	150	1982	42		

SAGE50		Between Sage Mesa Dr & Lake Pumphouse	GATE - MAINLINE	200	2013	11			
SAGE51		Between Sage Mesa Dr & Lake Pumphouse	GATE - MAINLINE	200	2013	11			
SAGE52		Between Sage Mesa Dr & Lake Pumphouse	GATE - MAINLINE	100	2013	11			
SAGE53		Between Sage Mesa Dr & Lake Pumphouse	GATE - MAINLINE	200	2013	11			
SAGE54		Golf Course Access Rd	GATE - MAINLINE	200	2013	11			
SAGE55		Golf Course Access Rd	GATE - MAINLINE	200	2013	11			
SAGE56		Golf Course Access Rd	GATE - MAINLINE	200	2013	11			
SAGE59		Between Golf Course Access Rd & Forsyth Pl	GATE - MAINLINE	200	1962	62			
SAGE6		Forsyth Dr@ Tyrone Pl	GATE - MAINLINE	150	1977	47			
SAGE61		Upper Reservoir	GATE - MAINLINE	150	2013	11			
SAGE63		Upper Reservoir	GATE - MAINLINE	200	2013	11			
SAGE64	Gate valve for reservoir drain.	Upper Reservoir	GATE - MAINLINE	150	1977	47			
SAGE65		Forsyth Dr	GATE - MAINLINE	150	2012	12			
SAGE66		Sage Mesa Dr	GATE - MAINLINE	150	2012	12			
SAGE67		Ladera Pl	GATE - MAINLINE	50	2012	12			
SAGE68		Solana Cres @ Sage Mesa Dr	GATE - MAINLINE	100	2012	12			
SAGE69		Sage Mesa Dr	GATE - MAINLINE	150	2012	12			
SAGE7		Tyrone Pl	GATE - MAINLINE	150	1977	47			
SAGE70		Sage Mesa Dr	GATE - MAINLINE	150	2012	12			
SAGE71		Pine Hills Dr	GATE - MAINLINE	150	2012	12			
SAGE72		Sage Mesa Dr	GATE - MAINLINE	150	2012	12			
SAGE73		Verano Pl	GATE - MAINLINE	50	2012	12			
SAGE74		Sage Mesa Dr @ Verano Pl	GATE - MAINLINE	150	2012	12			
SAGE75		Sage Mesa Dr @ Verano Pl	GATE - MAINLINE	250	2012	12			
SAGE76		Westwood Dr	GATE - MAINLINE	150	1994	30			
SAGE77	Normally Closed	Forsyth Dr @ Westwood Dr	GATE - MAINLINE	150	1994	30			
SAGE8		Forsyth Dr@ Tyrone Pl	GATE - MAINLINE	150	1977	47			
SAGE9		Forsyth Dr	GATE - MAINLINE	150	1977	47			
SAGE18	Curbstop	Ryan Rd	CURBSTOP-MAINLIN	50	Unknown	Unknown			
SAGE78		Ryan Rd	CURBSTOP-MAINLIN	50	Unknown	Unknown			
SAGE49		Between Sage Mesa Dr & Lake Pumphouse	CHECK	200	2013	11			
SAGE58	In box for 100mm service stub north	Between Lower and Upper Reservoir	CHECK	200	2013	11			
SAGE60		North side of Upper Reservoir	AIR RELEASE VALVE	150	2013	11			
SAGE62		South side of Upper Reservoir	AIR RELEASE VALVE	200	2013	11			

APPENDIX D

Water Quality Monitoring Report

2021

ANNUAL WATER QUALITY MONITORING REPORT

SAGE MESA WATER SYSTEM

Sage Mesa Lake Pump Station

Regional District of Okanagan-Similkameen

December, 2022

2021 ANNUAL WATER QUALITY MONITORING REPORT
SAGE MESA WATER SYSTEM
PENTICTON, B.C.

Copy prepared for:

INTERIOR HEALTH AUTHORITY (IHA)

Interior Health Drink Water Program

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Environmental Technologist

Table of Contents

TABLES

FIGURES

1. Introduction

The Regional District of Okanagan-Similkameen is the Operations contractor for the Sage Mesa water system and therefore is responsible for the following Annual Report summarizing the results from the 2021 *Water Quality Monitoring Program*. The report is a conditional requirement of the *Permit to Operate* issued by the Interior Health Authority (IHA) and the *BC Drinking Water Protection Act and Regulation*.

2. System Description

The Sage Mesa water system is located within Electoral Area F, northwest of Penticton. The Sage Mesa system is a privately owned water system which is currently under the management of the British Columbia *Ministry of Forest Lands and Natural Resource Operations and Rural Development (FLNRORD)*. The RDOS provides Operation and Maintenance under a contract agreement with the *FLNRORD*.

The Sage Mesa water system is supplied by Okanagan Lake. The system supplies treated water to approximately 242 domestic connections and irrigation water to two golf courses. Water is pumped from the Lake Pump Station into the distribution system and to an elevated storage reservoir (Lower Reservoir). The only treatment of the raw Lake water is chlorination through the addition of sodium hypochlorite at the Lake Pump Station. A Booster Station located at the Lower Reservoir and provides for re-chlorination of the treated water as it is boosted to the Upper Reservoir at a higher elevation which supplies the Sandstone, Westwood and Husula Highlands areas.

3. System Classification and Operator Certifications

3.1. System Classification

The *British Columbia Environmental Operators Certification Program (BC EOCP)* is responsible for classifying potable water systems in BC.

The Sage Mesa Lake Pump Station remained classified as *Water Treatment II* in 2021.

The Sage Mesa distribution system remained classified as *Water Distribution II* in 2021.

3.2. Operator Certification

The *British Columbia Environmental Operators Certification Program (BC EOCP)* is also responsible for certification of all water system operators. Operators may hold certification(s) in the disciplines of Water Distribution and/or Water Treatment with four levels of certification achievable within each discipline. RDOS Operators annually attend courses, seminars and complete online training required to maintain their levels of certification. In addition, all operators annually continue to work on augmenting and furthering their levels of certification. All RDOS Operators are certified through the BC EOCP as indicated in the Table 1 below.

OPERATOR EOCP CERTIFICATION No.	WATER DISTRIBUTION CERTIFICATION LEVELS				WATER TREATMENT CERTIFICATION LEVELS			
	IV	**III**	**II**	**I**	**IV**	**III**	**II**	**I**
1162	X						X	
4194			X					
4840			X				X	
4839		X						X
6926			X					X
8761			X					X
9322		X						X

Table 1: RDOS Operator Certifications for 2021

4. Annual Water Usage

The source water for the Sage Mesa water system is Okanagan Lake. In 2021, a total of 259,080 m^3 was pumped from Okanagan Lake, up from 220,422 m^3 in 2020.

4.1. Consumption Records

	Cubic Meters (m^3)	US Gallons	
Annual Total Usage	259,080	68,441,695	**Date**
Minimum Daily Flow	62	16,379	Feb 12/22
Maximum Daily Flow	2,092	552,648	Jun 29/22

Table 2: Annual Water Usage for 2015

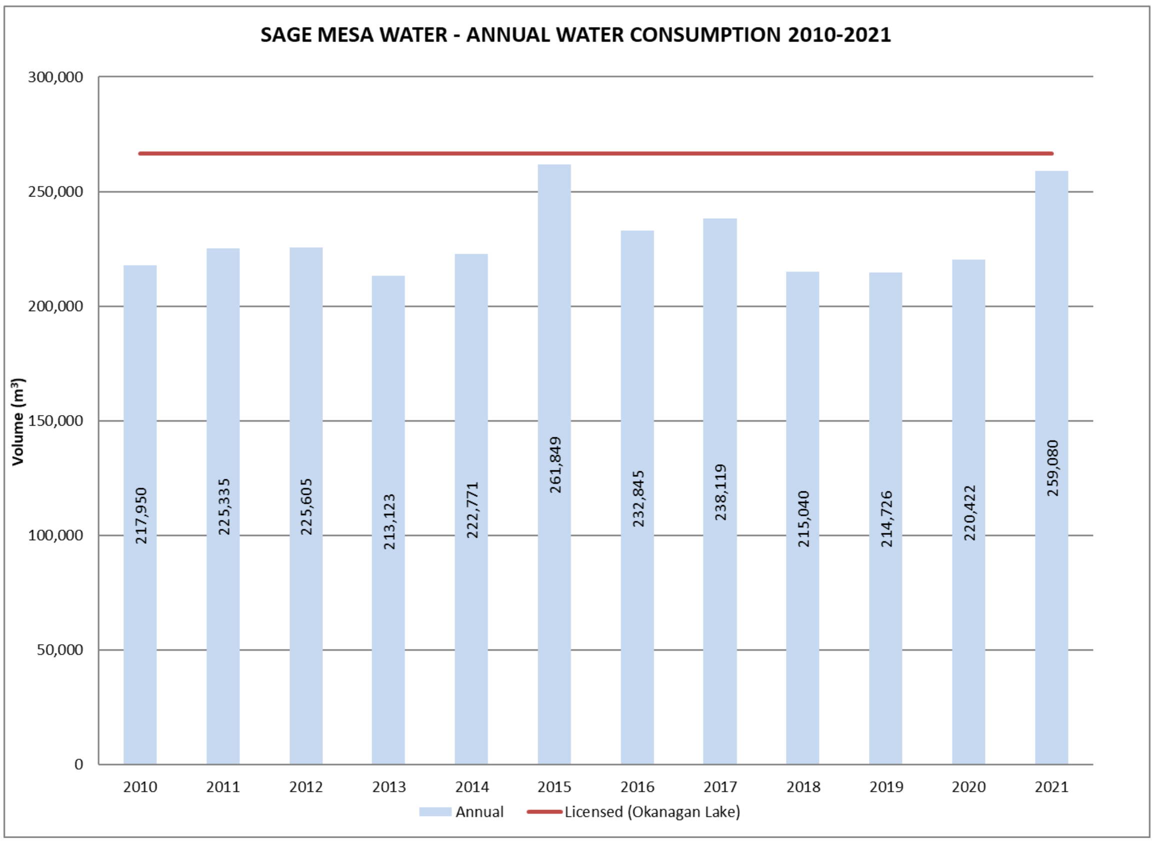


Figure 1: Annual Water Consumption 2010 to 2021

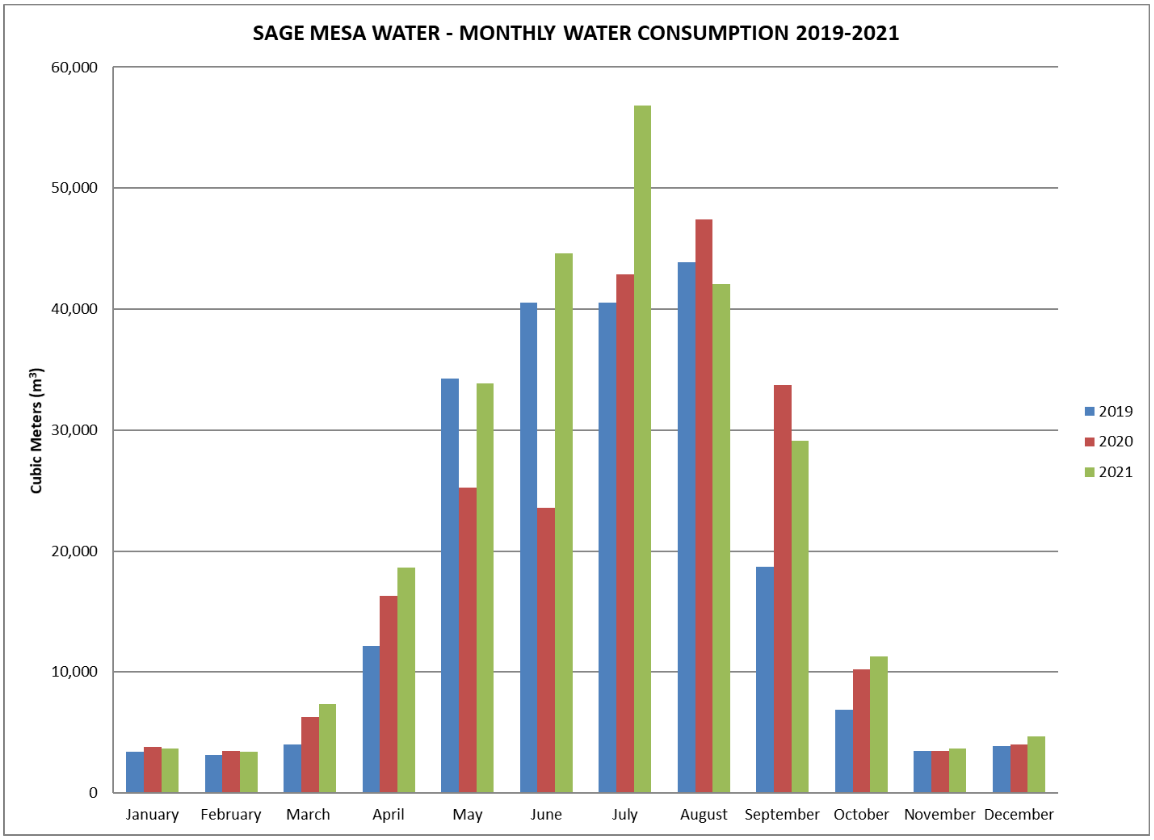


Figure 2: Monthly Water Consumption 2019 to 2021

4.2. Water Conservation Program

The Sage Mesa water system started under Stage "Normal" water restrictions in 2021. The "Heat Dome" of 2021 was over the Okanagan from late June to mid-July. During this period users were asked to voluntarily reduce their water consumption by 30%. By the end of July, with the heat continuing, the decision was made to move all RDOS water systems to Stage 1, which limited watering to two days per week.

5. Source Water Quality

All untreated source water quality parameters are compared to the applicable criteria set out in the *British Columbia Drinking Water Protection Act and Regulation* (*DWPA*), the *Guidelines for Canadian Drinking Water Quality* (*GCDWQ*), Interior Health Authority programs and Operational Guidelines (OG). The *DWPA* and *GCDWQ* define these parameters and set Aesthetic Objectives (AO) and Maximum Acceptable Concentrations (MAC).

All 2021 accredited laboratory tests were performed by Caro Analytical Services (Kelowna, B.C.).

5.1. Source Water Turbidity Monitoring

Turbidity is a measure of the relative clarity or cloudiness of water measured in Nephelometric Turbidity Units (NTU). Turbidity is measured by passing light through a sample and measuring how light reflects off of the suspended particles within the sample.

The Interior Health Authority requires source water turbidity values to be evaluated against the following criteria. Exceedances of the criteria, typically compared to the average 24 hour turbidity value, will require a level of public notification as described below.

Source Water Quality	Turbidity Range	Public Notification Required
Good	NTU < 1	None
Fair	1 < NTU < 5	Water Quality Advisory (WQA)
Poor	5 =< NTU	Boil Water Notice (BWN)

Online continuous turbidity monitoring and trending of the Okanagan Lake source water is part of the SCADA (Supervisory Control and Data Acquisition) system. In addition to the online monitoring, grab samples are drawn on a weekly basis and measured using portable field test kits to verify the operation of the online instrumentation.

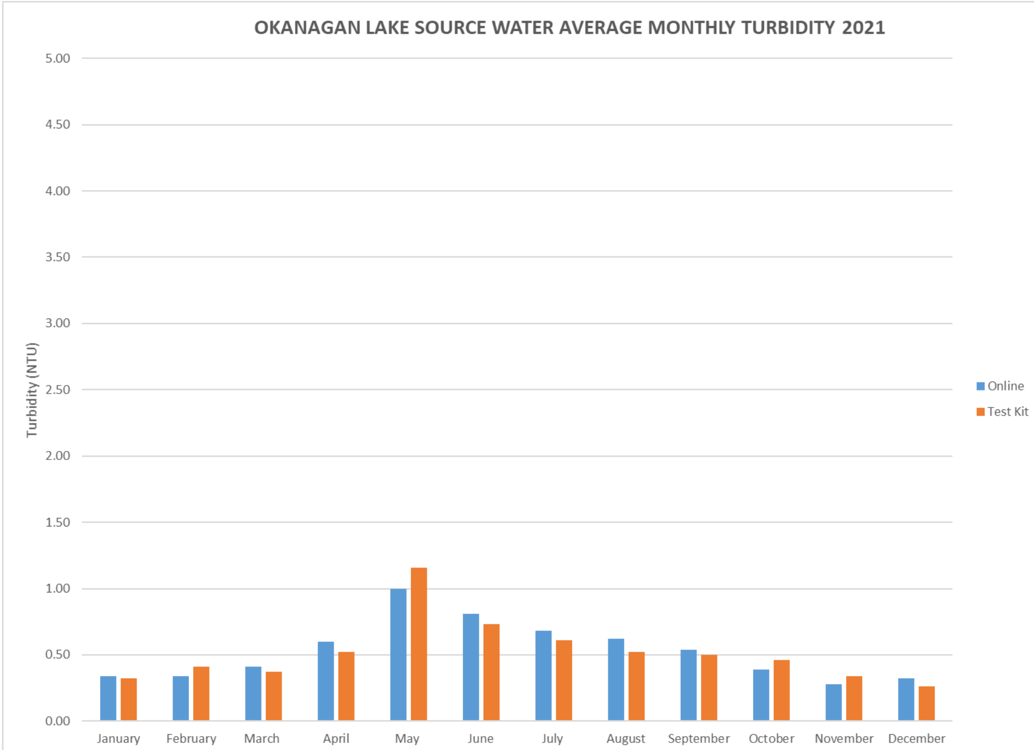


Figure 3: Okanagan Lake Average Monthly Turbidity 2021

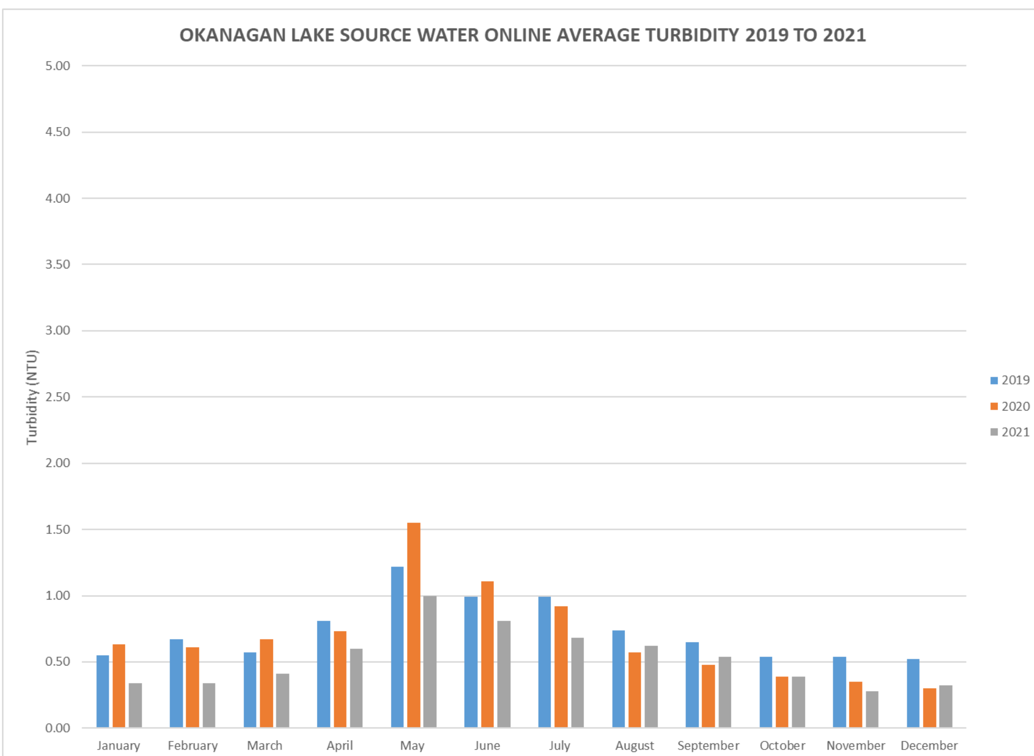


Figure 4: Okanagan Lake Online Average Turbidity 2019 to 2021

5.2. Source Water Weekly/Bi-Weekly Monitoring

Various parameters are monitored weekly and bi-weekly on the source water. These parameters provide support for operational decisions. These parameters are monitored by both field kits and grab samples that are sent to the laboratory for analysis.

Analyte	Unit	Average	Minimum	Maximum	Number of Results
Field Results					
Reading Type: Test Kit					
Conductivity	µS/cm	301	256	391	50
pH		8.31	7.68	8.64	50
Total dissolved solids	mg/L	214	182	271	50
Temperature	°C	11.8	4.6	24.9	50
Turbidity	NTU	0.53	0.2	1.76	51
Reading Type: Online Instrument					
Turbidity	NTU	0.54	0.27	1.8	44
Lab Results					
General					
Alkalinity (total, as CaCO3)	mg/L	119.3	89.3	178	26
Total organic carbon	mg/L	4.21	3.67	5.11	26
Colour	CU	4.1	<5.0	15	51
Hardness (as CaCO3), from total Ca/Mg	mg/L	122	113	139	26
UV transmittance at 254 nm - unfiltered	%	84.9	77.2	88.4	50
Microbiological					
E. coli (MPN)	MPN/100 mL	1	<1	8	51
Total coliforms (MPN)	MPN/100 mL	101	<1	>2420	51
Total Metals					
Calcium (total)	mg/L	32.4	30	36.6	26
Magnesium (total)	mg/L	10.06	9.2	11.5	26

Table 3: Weekly/Bi-Weekly Source Water Parameter Summary 2021

The following graph shows the three year trend for Total Coliforms and *E.coli* from the Okanagan Lake intake. Note, the laboratory changed analytical methods for the raw water bacteriological testing from Membrane Filtration (MF CFU/100ml) to Most Probable Number (MPN) in late 2019. Only the MPN data was graphed for 2019.

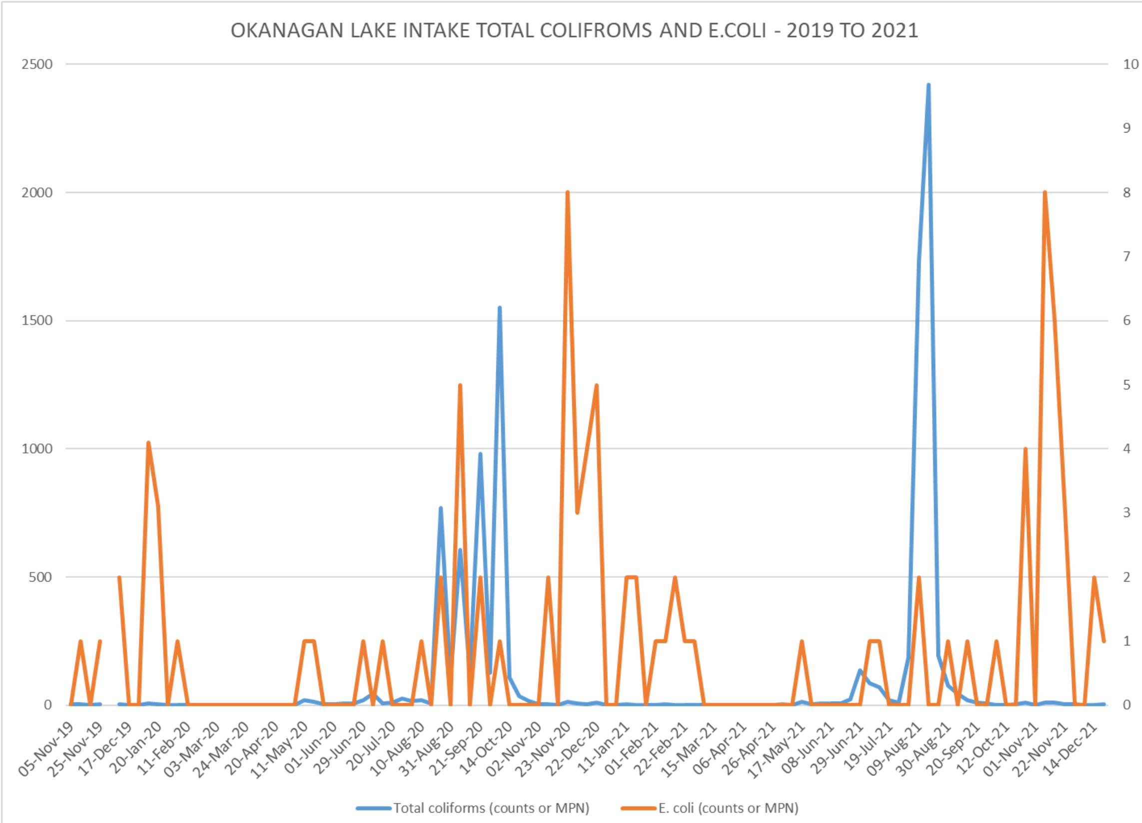


Figure 5: Okanagan Lake Monthly Total Coliform and *E.coli* 2019 to 2021

5.3. Source Water Potable Water Testing

Annually, the RDOS submits a sample of the untreated water from the Okanagan Lake intake to an accredited lab for comprehensive potable water testing. The results of these test are compared against the *Guidelines for Canadian Drinking Water Quality*. The *GCDWQ* establishes Maximum Acceptable Concentrations (MAC), Interim Maximum Acceptable Concentrations (IMAC) and Aesthetic Objectives (AO) for parameters if applicable. In 2021, there were no exceedances of the guidelines in the Sage Mesa source water sample.

This comprehensive test includes physical parameters (e.g. color, turbidity, temperature, ultraviolet transmittance), chemical parameters (e.g. hardness, total metals and nutrients). Changes in these parameters may result in the need for water notifications for customers (i.e. Boil Water Notice or Water Quality Advisory) or the requirement for treatment processes to be implemented. The following tables display the results for the respective comprehensive potable water tests along with summaries of the previous three (3) years of data for comparison.

5.3.1. Source Water General Potability Parameters 2021

Analyte	Unit	Guideline		Sampling Location: Lake Pump Station
				Date Sampled: 28-Sep-21
		GCDWQ MAC	GCDWQ AO	
Lab Results				
General				
Alkalinity (total, as CaCO3)	mg/L	NG	NG	121
Total organic carbon	mg/L	NG	NG	3.94
Chloride	mg/L	NG	250	5.42
Colour	CU	NG	15	<5.0
Conductivity	µS/cm	NG	NG	270
Total cyanide	mg/L	0.2 [1.1]	NG	<0.0020
Fluoride	mg/L	1.5	NG	0.19
Hardness (as CaCO3), from total Ca/Mg	mg/L	NG	NG	120
Langelier Index		NG	NG	0.3
pH		NG	7.0 - 10.5 [2.1]	8.16
Total dissolved solids (computed)	mg/L	NG	500	166
Sulphate	mg/L	NG	500 [2.2]	30.2
Sulphide (total, as S)	mg/L	NG	0.047 [2.3]	<0.020
Turbidity	NTU	N [1.2]	NG	0.37
Nutrients				
Ammonia (total, as N)	mg/L	NG	NG	<0.050
Nitrate (as N)	mg/L	10	NG	0.036
Nitrite (as N)	mg/L	1	NG	<0.010

See Guideline Notes in Section 5.3.3

Table 4: Okanagan Lake General Potability Parameters 2021

5.3.2. Source Water General Potability Parameters Summary 2018 to 2020

Analyte	Unit	Average	Minimum	Maximum	Number of Results
Lab Results					
General					
Alkalinity (total, as CaCO3)	mg/L	113.4	95.9	135	84
Total organic carbon	mg/L	4.44	2.72	8.46	85
Chloride	mg/L	4.68	4.46	4.89	2
Colour	CU	< 5.0	< 5.0	21	149
Conductivity	µS/cm	273	268	277	2
Total cyanide	mg/L	<0.0020	<0.0020	<0.0050	2
Fluoride	mg/L	0.16	0.15	0.17	2
Hardness (as CaCO3), from total Ca/Mg	mg/L	119.3	89.1	136	83
Langelier Index		0.4	0.3	0.4	2
pH		8.20	8.18	8.22	2
Total dissolved solids (computed)	mg/L	160	157	163	2
Sulphate	mg/L	29.2	28.6	29.7	2
Sulphide (total, as S)	mg/L	<0.020	<0.020	<0.020	2
Turbidity	NTU	0.75	0.53	0.97	2
Nutrients					
Ammonia (total, as N)	mg/L	0.047	0.032	0.062	2
Nitrate (as N)	mg/L	<0.010	<0.010	<0.010	2
Nitrite (as N)	mg/L	<0.010	<0.010	<0.010	2

See Guideline Notes in Section 5.3.3

Table 5: Okanagan Lake General Potability Parameters 2018 to 2020 Summary

5.3.3. Guideline Notes for General Potability Parameters

1. **Notes for Guidelines for Canadian Drinking Water Quality - Maximum Acceptable Concentrations (GCDWQ MAC)**

   Note 1.1 for Total cyanide:
   The MAC for free cyanide is 0.2 mg/L. A maximum of 0.2 mg/L was used, in this report, to identify exceedances for total cyanide as a means for determining the potential for exceeding the free cyanide guideline.

   Note 1.2 for Turbidity:
   "Waterworks systems that use a surface water source or a groundwater source under the direct influence of surface water should filter the source water to meet health-based turbidity limits, as defined for specific treatment technologies. Where possible, filtration systems should be designed and operated to reduce turbidity levels as low as possible, with a treated water turbidity target of less than 0.1 NTU at all times. Where this is not achievable, the treated water turbidity levels from individual filters should meet the requirements described in GCDWQ.
   For systems that use groundwater that is not under the direct influence of surface water, which are considered less vulnerable to faecal contamination, turbidity should generally be below 1.0 NTU.
   For effective operation of the distribution system, it is good practice to ensure that water entering the distribution system has turbidity levels below 1.0 NTU."

2. **Notes for Guidelines for Canadian Drinking Water Quality - Aesthetic Objectives (GCDWQ AO)**

   Note 2.1 for pH:
   The operational guideline for pH is a range of 7.0 to 10.5 in finished drinking water.

   Note 2.2 for Sulphate:
   There may be a laxative effect in some individuals when sulphate levels exceed 500 mg/L. Health authorities should be notified of drinking water sources containing above 500 mg/L.

   Note 2.3 for Sulphide (total, as S):
   The aesthetic objective for sulphide (as H_2S) is 0.05 mg/L. This is equivalent to 0.047 mg/L sulphide (as S).

5.3.4. Source Water Total Metals 2021

Analyte	Unit	Guideline		Lake Pump Station
		GCDWQ MAC	GCDWQ AO	28-Sep-21
Lab Results				
Nutrients				
Potassium (total)	mg/L	NG	NG	2.42
Total Metals				
Aluminum (total)	mg/L	2.9 [1.1]	0.100 [2.1]	0.0140
Antimony (total)	mg/L	0.006	NG	<0.00020
Arsenic (total)	mg/L	0.010 [1.2]	NG	<0.00050
Barium (total)	mg/L	2.0 [1.3]	NG	0.0219
Boron (total)	mg/L	5	NG	<0.0500
Cadmium (total)	mg/L	0.007 [1.4]	NG	<0.000010
Calcium (total)	mg/L	NG	NG	32.4
Chromium (total)	mg/L	0.05	NG	<0.00050
Cobalt (total)	mg/L	NG	NG	<0.00010
Copper (total)	mg/L	2 [1.5]	1	0.00149
Iron (total)	mg/L	NG	0.3	0.015
Lead (total)	mg/L	0.005 [1.6]	NG	<0.00020
Magnesium (total)	mg/L	NG	NG	9.52
Manganese (total)	mg/L	0.12 [1.7]	0.02 [2.2]	0.00162
Mercury (total)	mg/L	0.001	NG	<0.000010
Molybdenum (total)	mg/L	NG	NG	0.00365
Nickel (total)	mg/L	NG	NG	0.00070
Selenium (total)	mg/L	0.05	NG	<0.00050
Sodium (total)	mg/L	NG	200	11.8
Strontium (total)	mg/L	7.0 [1.8]	NG	0.264
Uranium (total)	mg/L	0.02	NG	0.00259
Zinc (total)	mg/L	NG	5.0	<0.0040

See Guideline Notes in Section 5.3.6

Table 6: Okanagan Lake Total Metals Potability 2021

5.3.5. Source Water Total Metals Summary 2018 to 2020

Analyte	Unit	Average	Minimum	Maximum	Number of Results	Number of Results with Exceedances
Lab Results						
Nutrients						
Potassium (total)	mg/L	2.55	2.43	2.67	2	0
Total Metals						
Aluminum (total)	mg/L	0.0328	0.0245	0.0411	2	0
Antimony (total)	mg/L				2	0
Arsenic (total)	mg/L	0.00065	0.00059	0.00071	2	0
Barium (total)	mg/L	0.0238	0.0230	0.0245	2	0
Boron (total)	mg/L	0.0409	<0.0500	0.0568	2	0
Cadmium (total)	mg/L	0.000008	<0.000010	0.000011	2	0
Calcium (total)	mg/L	32.1	24.4	36.6	83	0
Chromium (total)	mg/L	0.00040	<0.00050	0.00055	2	0
Cobalt (total)	mg/L				2	0
Copper (total)	mg/L	0.00245	0.00178	0.00313	2	0
Iron (total)	mg/L	0.024	0.013	0.036	2	0
Lead (total)	mg/L	0.00072	<0.00020	0.00134	2	0
Magnesium (total)	mg/L	9.52	6.79	10.9	83	0
Manganese (total)	mg/L	0.00151	0.00112	0.00191	2	0
Mercury (total)	mg/L				2	0
Molybdenum (total)	mg/L	0.00377	0.00374	0.00381	2	0
Nickel (total)	mg/L	0.00181	0.00136	0.00225	2	0
Selenium (total)	mg/L	0.00041	<0.00050	0.00056	2	0
Sodium (total)	mg/L	11.9	11.5	12.3	2	0
Strontium (total)	mg/L	0.294	0.289	0.298	2	0
Uranium (total)	mg/L	0.00262	0.00247	0.00277	2	0
Zinc (total)	mg/L				2	0

See Guideline Notes in Section 5.3.6

Table 7: Okanagan Lake Total Metals Potability 2018-2020 Summary

5.3.6. Guideline Notes for Total Metals Potability

1. **Notes for Guidelines for Canadian Drinking Water Quality - Maximum Acceptable Concentrations (GCDWQ MAC)**

Note 1.1 for Aluminum (total): The maximum acceptable concentration (MAC) for total aluminum in drinking water is 2.9 mg/L (2 900 µg/L) based on a locational running annual average of a minimum of quarterly samples taken in the distribution system. (Update March 5, 2021)

Note 1.2 for Arsenic (total): Every effort should be made to maintain arsenic levels in drinking water as low as reasonably achievable.

Note 1.3 for Barium (total): Update January 24, 2020. The MAC was revised from 1.0 mg/L to 2.0 mg/L.

Note 1.4 for Cadmium (total): A maximum acceptable concentration (MAC) of 0.007 mg/L (7 µg/L) is established for total cadmium in drinking water, based on a sample of water taken at the tap. (Update July 14, 2020).

Note 1.5 for Copper (total): A maximum acceptable concentration (MAC) of 2 mg/L is established for total copper in drinking water, based on a sample of water taken at the tap. Guidelines for Canadian Drinking Water Quality - Guideline Technical Document on Copper, June 2019.

Note 1.6 for Lead (total): The maximum acceptable concentration (MAC) for total lead in drinking water is 0.005 mg/L (5 µg/L), based on a sample of water taken at the tap and using the appropriate protocol for the type of building being sampled. Every effort should be made to maintain lead levels in drinking water as low as reasonably achievable (or ALARA). (GCDWQ: Guideline Technical Document; March, 2019)

Note 1.7 for Manganese (total): Guidelines for Canadian Drinking Water Quality - Guideline Technical Document on manganese, May 2019.

Note 1.8 for Strontium (total): Guidelines for Canadian Drinking Water Quality - Guideline Technical Document on strontium, May 2019.

6. Distribution System Water Quality

All treated distribution water quality parameters are compared to the applicable criteria set out in the *British Columbia Drinking Water Protection Act and Regulation* (*DWPA*), the *Guidelines for Canadian Drinking Water Quality* (*GCDWQ*), Interior Health Authority programs and Operational Guidelines (OG). The *DWPA* and *GCDWQ* define these parameters and set Aesthetic Objectives (AO) and Maximum Acceptable Concentrations (MAC).

All 2021 accredited laboratory tests were performed by Caro Analytical Services (Kelowna, B.C.).

6.1. Distribution System Bacteriological Results

The following is a summary of the bacteriological testing results from the treated water distribution system. There are two regular sampling sites (dedicated sample stations) throughout the distribution system that are alternated between weekly.

Schedule A of the B C *Drinking Water Protection Regulation* provides bacteriological testing criteria as given below.

Schedule A

Water Quality Standards for Potable Water
(sections 2 and 9)

Parameter:	Standard:
Fecal coliform bacteria	No detectable fecal coliform bacteria per 100 ml
Escherichia coli	No detectable *Escherichia coli* per 100 ml
Total coliform bacteria	
(a) 1 sample in a 30 day period	No detectable total coliform bacteria per 100 ml
(b) more than 1 sample in a 30 day period	At least 90% of samples have no detectable total coliform bacteria per 100 ml and no sample has more than 10 total coliform bacteria per 100 ml

In 2021, all distribution samples reported no detections for Total Coliforms and *E.coli*. The following is a summary of the laboratory bacteriological results from the treated water distribution system.

Analyte	Unit	Average	Minimum	Maximum	Number of Results	Number of Results with Exceedances
Lab Results						
Microbiological						
E. coli (counts)	CFU/100 mL	<1	<1	<1	52	0
Total coliforms (counts)	CFU/100 mL	<1	<1	<1	52	0

Table 8: Annual Distribution Water Bacteriological Testing Summary for 2021

6.2. Distribution System Free Chlorine Residuals

The following is a summary of the field free chlorine residual measurements from the distribution system. Free chlorine residuals are required to be maintained between 0.2 mg/L and 2.0 mg/L.

Typically, one to two monitoring sites were monitored on a weekly basis.

Flushing of water mains occurred at all locations when measured residual levels were below the MAC.

Analyte	Sampling Location	Unit	Average	Minimum	Maximum	Number of Results
Field Results						
Chlorine (free)	Booster Station	mg/L	1.16	0.82	1.52	24
	Lower Zone	mg/L	1.45	1.45	1.45	1
	Sandstone Dr.	mg/L	0.8	0.41	1.16	31

Table 9: Annual Distribution Free Chlorine Residual Summary for 2021

6.3. Distribution System Water Quality Field Parameter Testing

The following is a summary of the field parameters that are measured routinely in the distribution system. There are two regular sampling sites throughout the distribution system. Typically one site was monitored on a weekly basis in conjunction with the bacteriological sampling.

Analyte	Unit	Average	Minimum	Maximum	Number of Results
Field Results					
Conductivity	µS/cm	311	256	351	48
pH		8.29	7.67	8.61	49
Total dissolved solids	mg/L	217	22	249	48
Temperature	°C	12.3	5.1	24.5	49
Turbidity	NTU	0.5	0.2	1.72	51

Table 10: Annual Field Water Quality Parameter Testing Summary for 2021

6.4. Water Quality Complaints

No water quality complaints were received in 2021 for the Sage Mesa water system.

7. Water System Notifications

The Interior Health Authority's team of drinking water officers are responsible for providing the oversight to ensure compliance and drinking water safety. The IHA is responsible for issuing *Permits to Operate* to drinking water systems. The Interior Health Authority has four types of water notifications to inform users of negative impacts to water quality.

7.1. Water Quality Advisory (WQA)

There is some level of risk associated with consuming the drinking water but a Boil Water Notice is not needed. The risk is elevated for people with weakened immune systems, the elderly and infants and young children.

On May 16th, a Water Quality Advisory for Okanagan Lake intake turbidity greater than 1 NTU was issued for the Upper Zone of Sage Mesa (the Lower Zone remained on the permanent Boil Water Notice, see next section). The WQA was rescinded July 15th when Lake turbidity levels were consistently below 1 NTU.

7.2. Boil Water Notices (BWN)

There are organisms in the water that can make you sick. To safely consume (swallow) the water, you must bring it to a rolling boil for at least 60 seconds, or use a safe alternate source of water.

A permanent Boil Water Notice (BWN) was issued in 2019 for the Lower Zone of the Sage Mesa system which remained in effect for 2021. This BWN is in response to insufficient contact time between the added chlorine and the source water from Okanagan Lake before the water reaches the first customers in the lower portion of the system. With insufficient contact time there is the potential for inadequate pathogen reduction in the water supplied to the properties in the Lower Zone year round. This BWN will remain in effect until the appropriate engineered upgrades are in place to meet the Provincial drinking water treatment standards. Permanent metal Boil Water Notice signs with high visibility post covers were installed at the entrances to the Lower Zone.

7.3. Do Not Consume (DNC)

There are harmful chemicals or other bad things in the water that can make you sick. You cannot make the water safe by boiling. The water can make you sick if you consume (swallow) it. You cannot used the water for drinking, brushing teeth, washing/preparing/cooking food or pet's drinking water. You can bath, shower and water plants and gardens with the water.

No DNCs issued in 2021.

7.4. Do Not Use (DNU)

There are known microbial, chemical or radiological contaminants in the water and that any contact with the water with the skin, lungs or eyes can be dangerous. Do not turn on your tap for any reason and do not use your water. You CANNOT make the water safe by boiling it.

No DNUs issued in 2021.

8. Program Updates and Status

8.1. Capital Works

No capital works were completed in 2021.

8.2. Emergency Response Plan

The Emergency Response Plan is scheduled to be updated in 2022.

8.3. Water Quality Monitoring Program

The Water Quality Monitoring Program is scheduled to be updated in 2022.

8.4. Future System Upgrades

In 2020 both the Upper and Lower water storage reservoirs were cleaned, disinfected and inspected by a structural engineer. Both reservoirs are showing signs of deteriorating structural integrity however, the Upper Reservoir is more pronounced. As a result the roof of the Upper Reservoir has been cordoned off to any access. The RDOS continued work in

2021 with the Province and engineering consultants to determine the best plan for addressing the concerns identified in the structural engineer's report.

8.5. System Maintenance/Upgrades

On November 3rd, Pump No.1 (75HP) was removed from service for inspection. A new wet end was order to replace the aging existing wet end of the pump and was reinstalled in January 2022.

On December 27th a failed electrical transformer at the Lake Pump Station resulted in the loss of 120V power. A portable generator was setup to allow for manual starting of the Lake Pumps. This resulted in the loss of online measurements (free chlorine and turbidity) from December 27th to January 7th. A message was sent to residents requesting that they conserve water until the necessary repairs were completed.

9. Summary

All tested source water parameters from the Okanagan Lake supplying the Sage Mesa water system met the applicable criteria with the exception of turbidity which resulted in a Water Quality Advisory being issued for the Upper Zone. While all tested treated distribution water parameters met the applicable criteria in 2021, the Lower Zone remained on a permanent Boil Water Notice due to insufficient chlorine contact time. The RDOS continues to work with the *Ministry of Forests, Lands and Natural Resource Operations and Rural Development* on reviewing and upgrading the various programs that support facilitating the highest quality of water possible.

APPENDIX E

Water Model Standards and Operation

Water Model Standards and Operation

The Infowater Pro model was developed so that users can run the scenarios with minimal instruction. Any alteration of the model will void the integrity of the model and the relationship of the model to this report. This model operations instruction is directed towards users with an entry level experience for the operation of the model to review specific information, not the alteration. The InfoWater Pro provides a full and general description on how to use InfoWater Pro. Project specific details of the model set up and operation are included in Appendix E.

MODEL FIELD INFORMATION

All watermain information provided by the RDOS was retained with the import of the watermains into the model. This includes the year of installation, material, system ID, global ID, and diameter. Additional fields that were added are the following:

Table 40 - Model Field Information

Created Fields	Description
Zone / ZoneID	Identifies the zone that the pipe or junction is in.
Pipe Age	Calculated from install date to 2023.
Scenario	Indicates what scenario the component is a part of.
Original System ID and Original Global ID	If a watermain is split, a new ID needs to be created. This field identifies what the pipe originally was.
Upgrade	If this is an existing watermain that requires an upgrade, this filed states “Yes”
Diam_2023 Rough_2023	This is the original diameter and Hazen-Williams roughness of the pipe since the roughness and diameter tend to change for pipes being upgraded.

Naming Convention

Watermain

The naming used in the GIS information provided by the RDOS. The Naming for the watermains is SAGE#, i.e., SAGE10. If the watermain was split, as is necessary for the model to connect, the split watermain would be SAGE10 and SAGE10-1. New watermain has an ID designation NEW_SAGE# to differentiate from existing watermain. An upsized watermain maintains its original ID. Watermain that was included in the GIS provided by the RDOS that did not have an ID was given a default ID of P#, i.e., P25. When an ID is assigned, these pipes can easily be with a new ID.

Junctions

Junctions are points in the system that split watermain or connect watermain tees or any kind of change in the system such as a dead end or Hydrant. They are also points to provide results and apply demands. Note that junctions are not valves, reservoirs, or pumps as these are different components in the model. Junctions are non-physical elements and were autogenerated at the ends of watermains. A default naming of J# such as J101 was given to the junction. Junctions that are hydrants have a field that states "Yes" they are a hydrant.

Valves, Reservoirs and Pumps

The valves are given the same as listed in Table 30. Reservoirs and valves are named similar to how they are shown on the figures, however, without spaces as that is not permitted for ID's.

Elevations and Lengths

Elevations at junctions were assigned based on freely accessible BC Lidar with a 2m level of detail. The junctions are automatically assigned the elevation associated with the DEM at that point. The valves, pumps and reservoirs were assigned elevations based on record drawings available. With the model being georeferenced to UTM NAD83 Zone 11N, the watermain lengths are automatically calculated by the software from junction to junction.

Tank Data

Tanks colloquial referred to as reservoirs by most water utilities include the Upper and Lower Reservoir. The data, such as the area, depth and elevation of the tanks were inputted based on provided record drawings.

Pump Data

The pumps at the water intake were assigned a constant power input to provide the necessary power for the model to function. Pump curves were not inputted for these pumps. Immediately downstream of the pumps a flow control valve was added to set the flow to the stated combined pump flows of 49 l/s. As the model is an instantaneous/static model, the pump and reservoir does not significantly impact the results of the model.

With pump curves provided by the RDOS for the booster station pumps from the Lower to the Upper Reservoir, the pump curves were entered. The pump curves match the expectations of the pump performance.

Fire Flow Demand

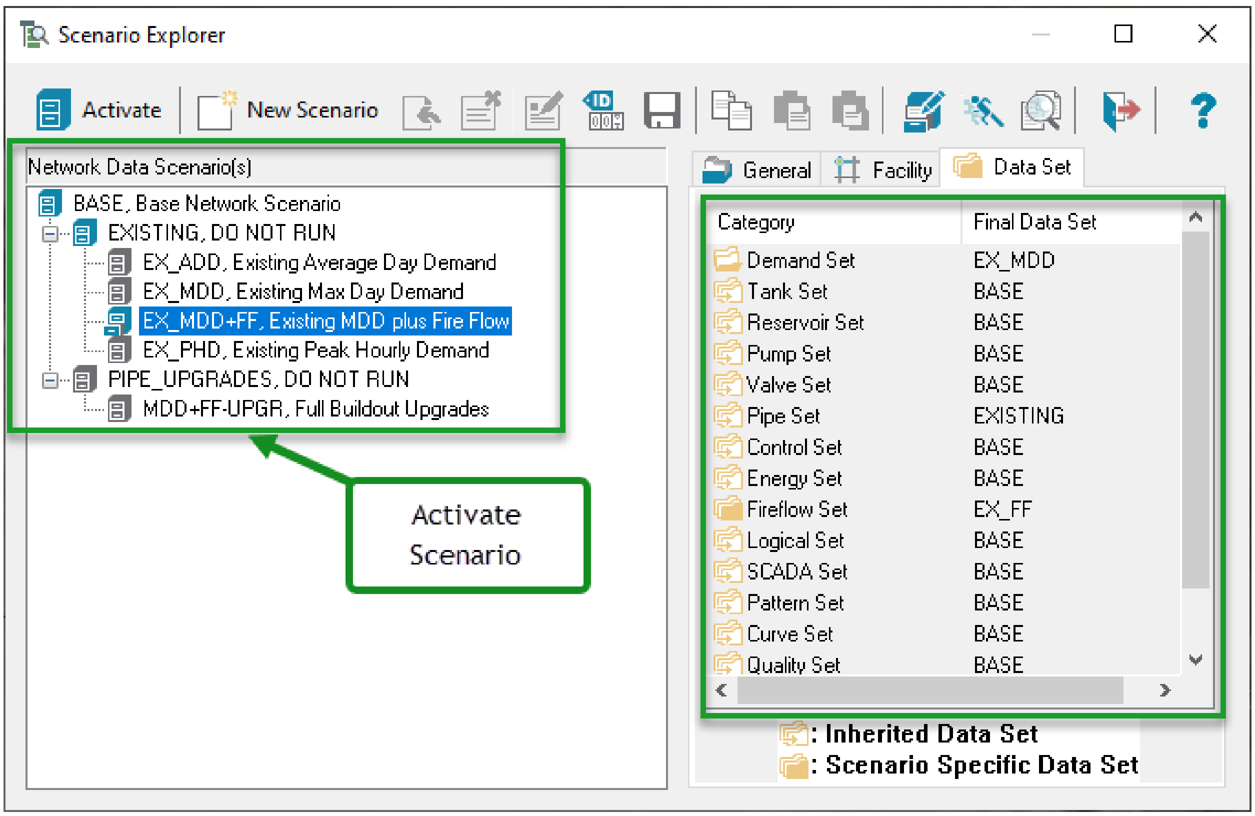
A fire flow demand of 60 l/s was applied to nodes closest to a hydrant. If no node existed, then a node was created. Fire flow simulations only occur at these nodes.

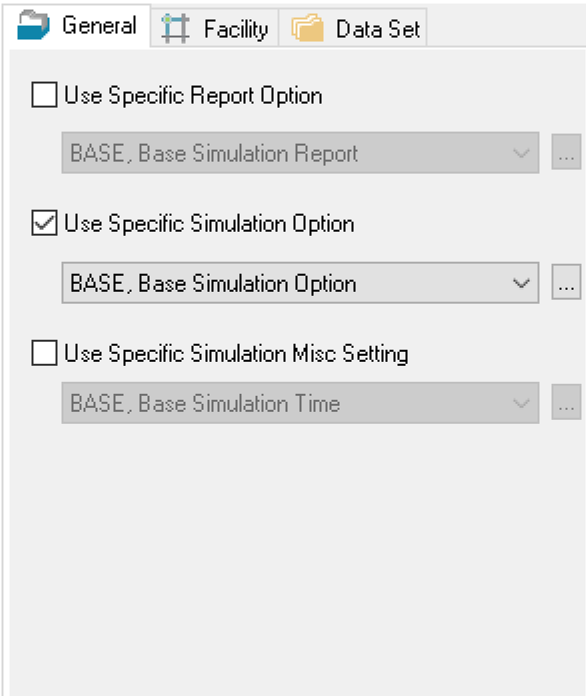
OPERATION OF THE WATER MODEL

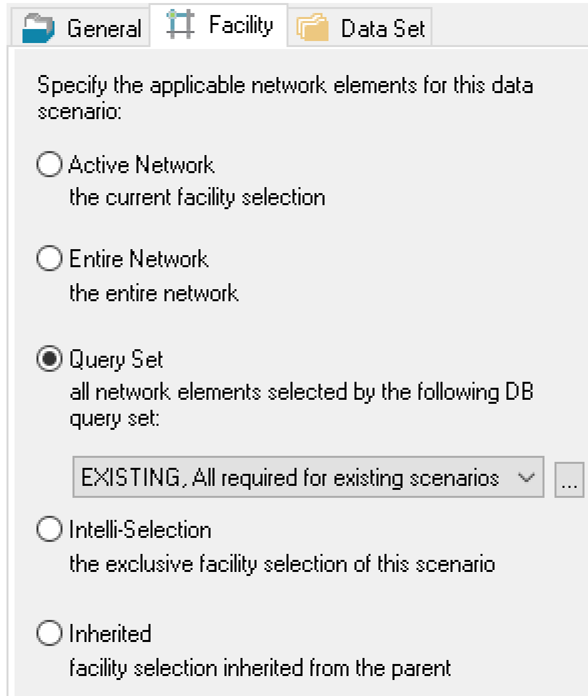
The model is build using the tools provided by the software so it is easy to use and limits the potential for errors when running the model but eliminating steps required to run the model.

The scenarios are run by simply selection the scenario and clicking the run button. No additional steps are required. This is done by setting up the general settings, facilities, and data sets for the model and assigning them to the scenario:

- **The General tab** simply indicates the model run settings which were set to static conditions.
- **The Facility tab** specifies the activated network elements. This is primarily used when running scenario options, so the correct pipes, valves and reservoir are toggled on when running the specific scenario.
- **The Data Set tab** dictates the data assigned to the components in the model, such as the flow assigned to the Junctions, such as ADD, MDD or PHD.
- **Query sets** were used to accomplish the facility activation.

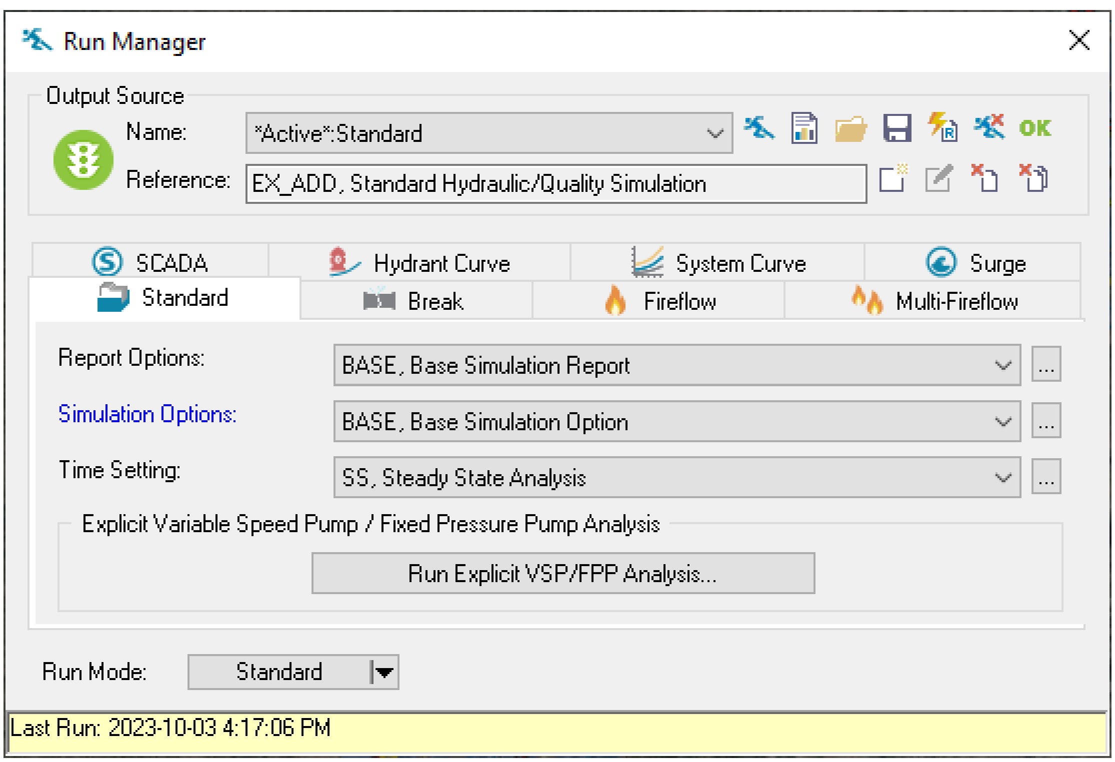






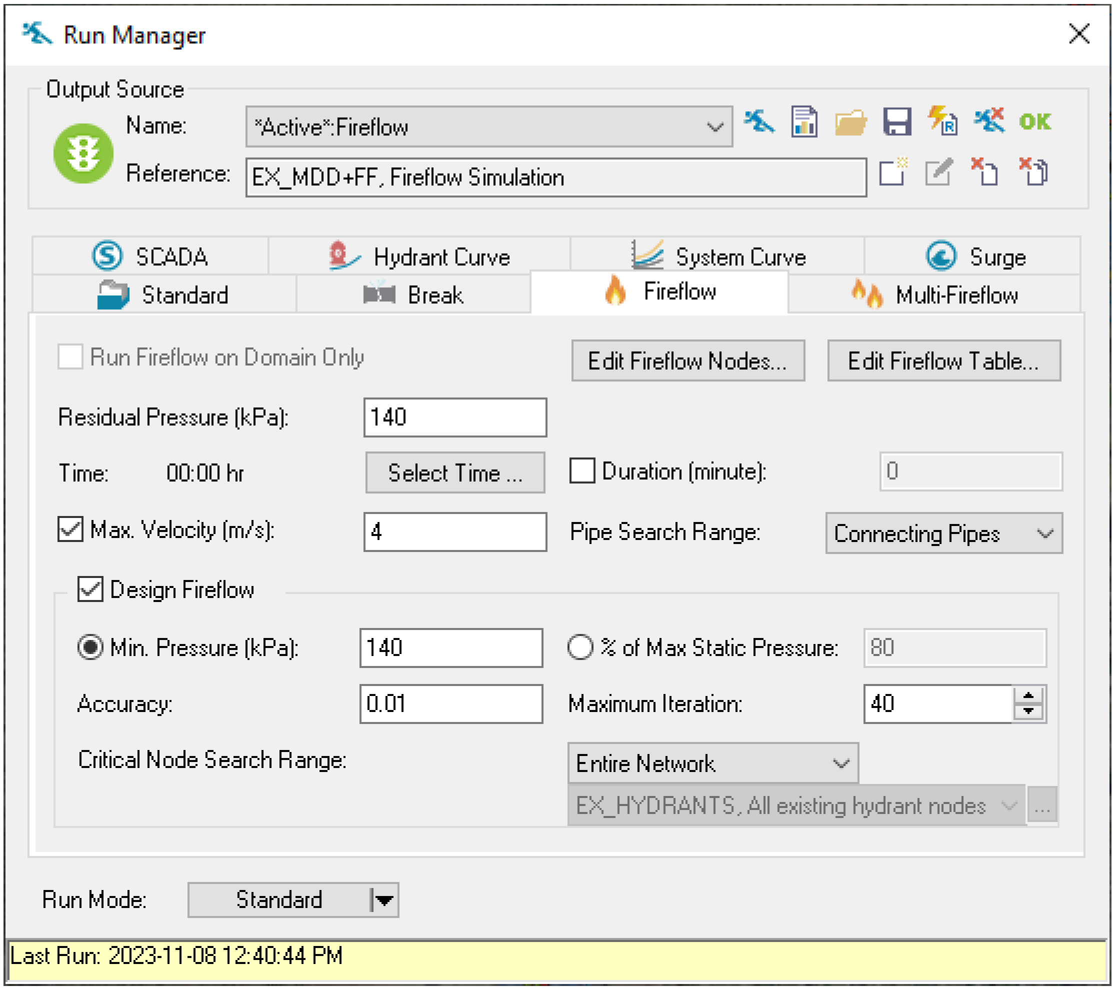
Standard Model Run

After the scenario has been selected, the model is run from the Run Manager. There are three possible “runs” that function for the static model. The Standard, Fireflow and Multi-Fireflow. The standard setting for the ADD, MDD and PHD scenarios should be run to determine the instantaneous results of the model for those scenarios. This may also be run on the MDD+FF-UPGR scenario.



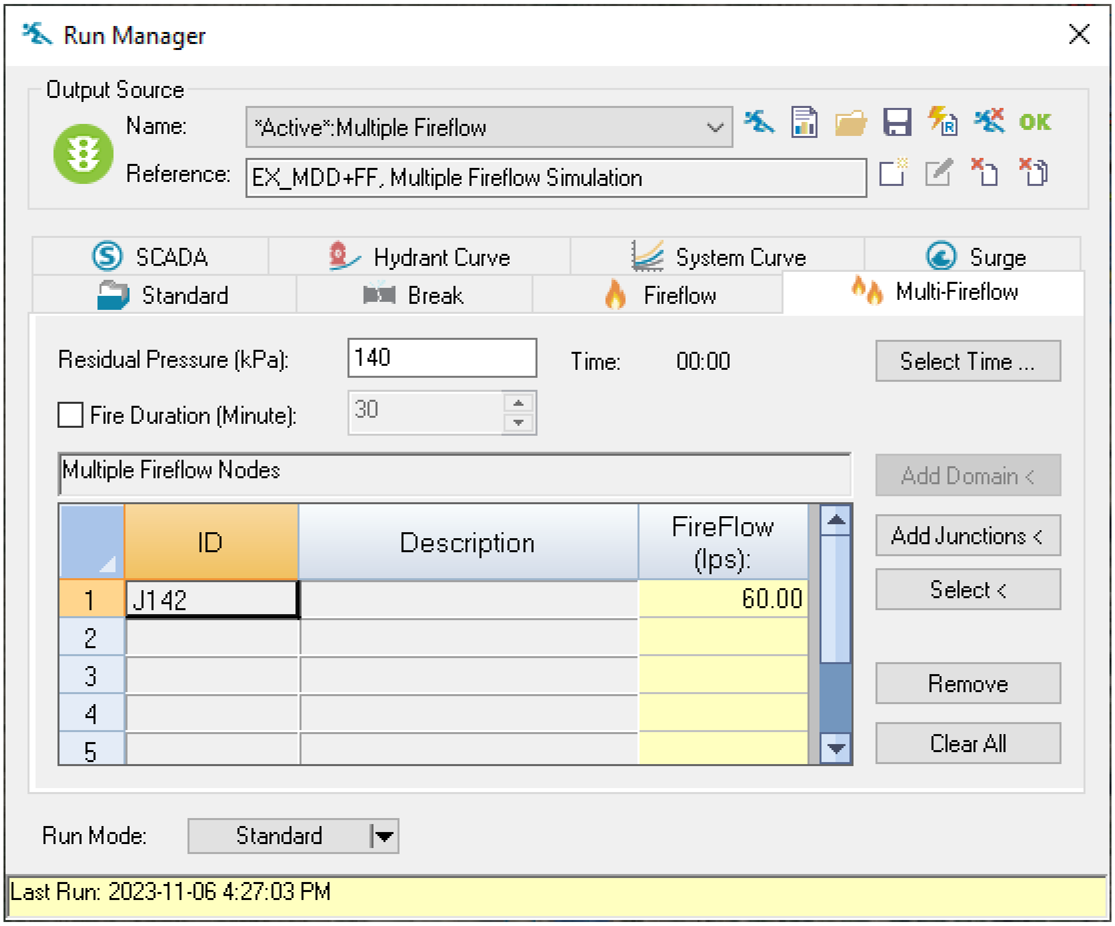
Fire Flow Model Run

After setting the model to either the EX_MDD+FF or MDD+FF-UPGR scenario, the fireflow tab is selected prior to running the model. The following setting shown in the screen clip indicate the settings used when completing the analysis for this report.



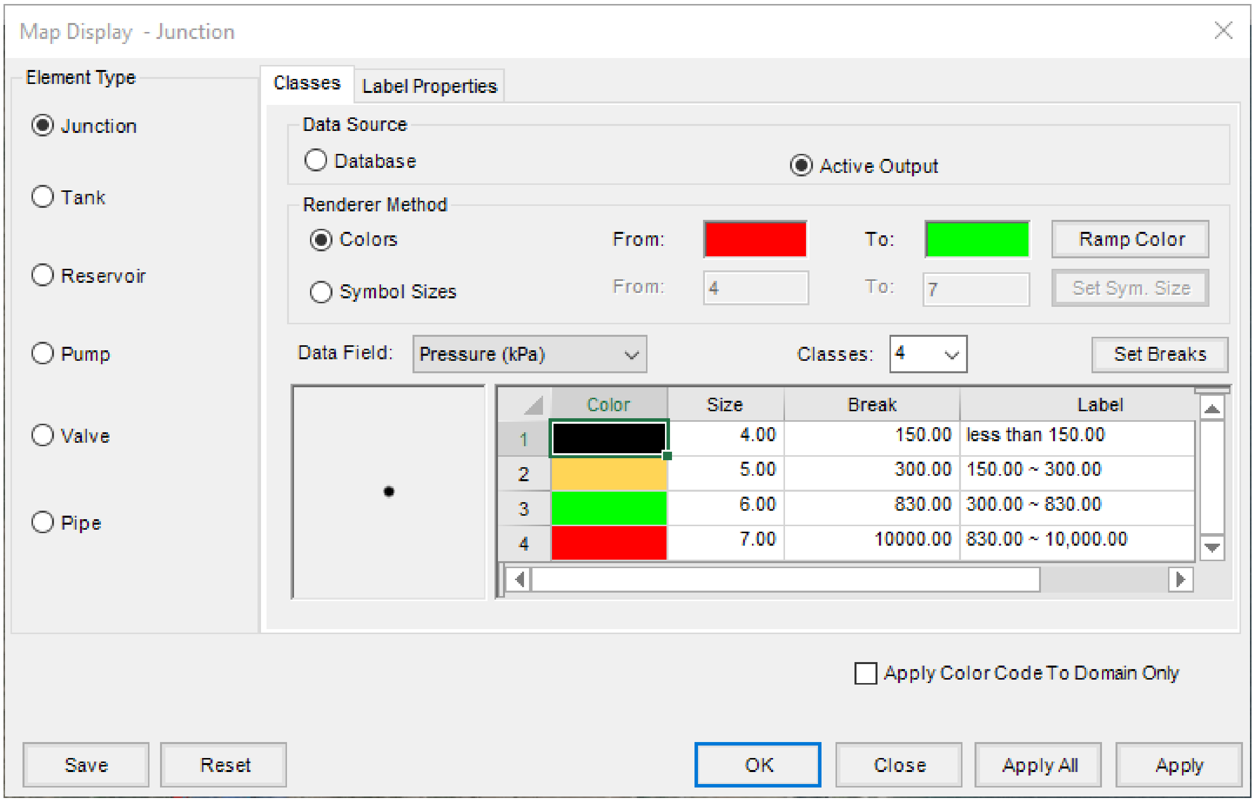
Multi Fire Flow Model Run

Since a fire flow model run is technically a separate model run for every node, the multi fire flow model run allows the user to run a fire scenario at a single node to see how it impacts the system. Some model users choose to apply the fire flow to the junction as a regular demand, but this introduces the potential for adding and forgetting a demand that was entered, therefor this method is not recommended and the multi fire flow tab in the run manager is used. The example below permits the user to run a single fire flow model run at junction J142.



REVIEWING RESULTS

There are two primary methods of reviewing results. Method 1 is to generate a report which can be done by selecting the Report Manager button under the view tab. Or the results you want to view can be generated visually using "map display" also located in the view tab. The map display allows you to generate results based on the database data or results data. This can be done for all components (junctions, pipes, tanks, reservoirs, valves, and pumps). The screenshot below shows the pressure being labelled at the junction and colour coded based on the result. The size of the junction also varies based on the result.


Map Display - Junction
Element Type
Junction
Tank
Reservoir
Pump
Valve
Pipe
Classes
Label Properties
Data Source
Database
Active Output
Renderer Method
Colors
From:
To:
Ramp Color
Symbol Sizes
From:
4
To:
7
Set Sym. Size
Data Field:
Pressure (kPa)
Classes:
4
Set Breaks
Color
Size
Break
Label
1
4.00
150.00
less than 150.00
2
5.00
300.00
150.00 ~ 300.00
3
6.00
830.00
300.00 ~ 830.00
4
7.00
10000.00
830.00 ~ 10,000.00
Apply Color Code To Domain Only
Save
Reset
OK
Close
Apply All
Apply

APPENDIX F

Detailed Cost Estimates

RDOS

McElhanney

OPINION OF PROBABLE COST		Schedule of Approximate Quantities and Unit Prices	
Project No:	2422-20427-00	Date:	12/14/2023
Project Name:	Sage Mesa Upgrades - Forsyth	By:	E.Sandberg P.Eng

Item#	Description of Work	Unit of Measure	Approx. Quantity	Unit Price	Extended Amount
	Section 1: General				
1.01	Mobilization and Demobilization	L.S.	1	$ 50,000	$ 50,000
1.02	Survey Layout & Project Documentation	L.S.	1	$ 15,000	$ 15,000
1.03	Erosion and Sediment Control	L.S.	1	$ 5,000	$ 5,000
1.04	Quality Control	L.S.	1	$ 15,000	$ 15,000
1.05	Traffic Control / Resident Access	L.S.	1	$ 125,000	$ 125,000
				SUBTOTAL	$ 210,000
	Section 2: Tie Ins				
2.01	Pinetree Pl (Start of Upgrade)	L.S.	1	$ 1,800	$ 2,000
2.02	Service to 2591 Forsyth Dr	L.S.	1	$ 9,100	$ 9,000
2.03	Ryan Road & 3019 Forsyth Dr Service	L.S.	1	$ 31,600	$ 32,000
2.04	Ponderosa Pl	L.S.	1	$ 22,500	$ 23,000
2.05	Forsyth Pl	L.S.	1	$ 25,400	$ 25,000
2.06	3808 Forsyth Dr Dead End	L.S.	1	$ 23,440	$ 23,000
2.07	Residential Service Connections - Includes saddle, corp stop, service connection between main and curb stop, and curb stop	Ea.	51	$ 2,200	$ 112,000
				SUBTOTAL	$ 226,000
	Section 3: Watermain Upgrades				
3.01	200mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration	lm	1890	$ 700	$ 1,323,000
3.02	New Hydrant Assembly incl. gate valve & tee in main.	Ea.	12	$ 10,000	$ 120,000
3.03	200mm Ø AWWA C509 Gate Valve c/w Valve Riser and Nelson Box	Ea.	3	$ 4,900	$ 15,000
3.04	200mm Ø Water Pipeline, Fittings	Ea.	29	$ 1,800	$ 52,000
3.05	New PRV station. Assumed to include 3 control valves and related components in an aboveground enclosed kiosk.	L.S.	1	$ 250,000	$ 250,000
				SUBTOTAL	$ 1,510,000

Notes: Quantities are based high level conceptual designs of the expected upgrade work. These quantities are subject to change at the detailed design stage.	SUBTOTAL	$ 1,946,000
	CONTINGENCY (40%)	$ 778,000
	ESTIMATED TOTAL PROJECT COST	**$ 2,720,000**

RDOS

McElhanney

OPINION OF PROBABLE COST Schedule of Approximate Quantities and Unit Prices

Project No:	2422-20427-00	Date:	12/14/2023
Project Name:	Sage Mesa Upgrades - Golf Course to Solana	By:	E.Sandberg P.Eng

Item#	Description of Work	Unit of Measure	Approx. Quantity	Unit Price	Extended Amount
	Section 1: General				
1.01	Mobilization and Demobilization	L.S.	1	$ 12,000	$ 12,000
1.02	Survey Layout & Project Documentation	L.S.	1	$ 8,000	$ 8,000
1.03	Erosion and Sediment Control	L.S.	1	$ 2,500	$ 3,000
1.04	Quality Control	L.S.	1	$ 5,000	$ 5,000
1.05	Traffic Control / Resident Access	L.S.	1	$ 35,000	$ 35,000
				SUBTOTAL	$ 63,000
	Section 2: Tie Ins				
2.01	Hydrant Near Pine Hills Golf Entrance (Start of Upgrade)	L.S.	1	$ 1,800	$ 2,000
2.02	Sage Mesa Drive & Solana Intersection (End of Upgrade)	L.S.	1	$ 7,840	$ 8,000
2.03	50mm service connection for near 3635 Sage Mesa Dr	L.S.	1	$ 3,000	$ 3,000
2.04	Residential Service Connections - Includes saddle, corp stop, and service connection between main and existing curb stop (curb stop not incl.)	Ea.	11	$ 2,200	$ 24,000
				SUBTOTAL	$ 37,000
	Section 3: Watermain Upgrades				
3.01	200mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration	lm	370	$ 700	$ 259,000
3.02	New Hydrant Assembly incl. gate valve & tee in main.	Ea.	3	$ 10,000	$ 30,000
3.03	200mm Ø AWWA C509 Gate Valve c/w Valve Riser and Nelson Box	Ea.	1	$ 4,900	$ 5,000
3.04	200mm Ø Water Pipeline, Fittings	Ea.	5	$ 1,800	$ 9,000
				SUBTOTAL	$ 303,000

Notes:
Quantities are based high level conceptual designs of the expected upgrade work. These quantities are subject to change at the detailed design stage.

SUBTOTAL	$ 403,000
CONTINGENCY (40%)	$ 161,000
ESTIMATED TOTAL PROJECT COST	**$ 560,000**

RDOS

McElhanney

OPINION OF PROBABLE COST	Schedule of Approximate Quantities and Unit Prices
Project No: 2422-20427-00	Date: 12/14/2023
Project Name: Sage Mesa Upgrades - Solana & Sage Mesa	By: E.Sandberg P.Eng

Item#	Description of Work	Unit of Measure	Approx. Quantity	Unit Price	Extended Amount
	Section 1: General				
1.01	Mobilization and Demobilization	L.S.	1	$ 10,000	$ 10,000
1.02	Survey Layout & Project Documentation	L.S.	1	$ 8,000	$ 8,000
1.03	Erosion and Sediment Control	L.S.	1	$ 2,500	$ 3,000
1.04	Quality Control	L.S.	1	$ 5,000	$ 5,000
1.05	Traffic Control / Resident Access	L.S.	1	$ 35,000	$ 35,000
				SUBTOTAL	$ 61,000
	Section 2: Tie Ins				
2.01	Middle of Solana (Start of Upgrade)	L.S.	1	$ 12,440	$ 12,000
2.02	Solana & Sage Mesa Intersection South	L.S.	1	$ 9,840	$ 10,000
2.03	Solana & Sage Mesa Intersection North	L.S.	1	$ 4,200	$ 4,000
2.04	Sage Mesa Corner (End of Upgrade)	L.S.	1	$ 15,800	$ 16,000
2.05	50mm service connection for Ladera Pl	L.S.	1	$ 3,000	$ 3,000
2.06	Residential Service Connections - Includes saddle, corp stop, and service connection between main and existing curb stop (curb stop not incl.)	Ea.	9	$ 2,200	$ 20,000
				SUBTOTAL	$ 65,000
	Section 3: Watermain Upgrades				
3.01	200mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration	lm	90	$ 700	$ 63,000
3.02	150mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration	lm	217	$ 600	$ 130,000
3.03	New Hydrant Assembly incl. gate valve & tee in main.	Ea.	3	$ 10,000	$ 30,000
3.04	150mm Ø AWWA C509 Gate Valve c/w Valve Riser and Nelson Box	Ea.	1	$ 3,800	$ 4,000
3.05	200mm Ø Water Pipeline, Fittings	Ea.	1	$ 1,800	$ 2,000
3.06	150mm Ø Water Pipeline, Fittings	Ea.	4	$ 1,500	$ 6,000
				SUBTOTAL	$ 235,000

Notes:		
Quantities are based high level conceptual designs of the expected upgrade work. These quantities are subject to change at the detailed design stage.	SUBTOTAL	$ 361,000
	CONTINGENCY (40%)	$ 144,000
	ESTIMATED TOTAL PROJECT COST	**$ 510,000**

RDOS

McElhanney

OPINION OF PROBABLE COST Schedule of Approximate Quantities and Unit Prices

Project No:	2422-20427-00	Date:	12/14/2023
Project Name:	Sage Mesa Upgrades - Verano	By:	E.Sandberg P.Eng

Item#	Description of Work	Unit of Measure	Approx. Quantity	Unit Price	Extended Amount
	Section 1: General				
1.01	Mobilization and Demobilization	L.S.	1	$ 12,000	$ 12,000
1.02	Survey Layout & Project Documentation	L.S.	1	$ 5,000	$ 5,000
1.03	Erosion and Sediment Control	L.S.	1	$ 2,500	$ 3,000
1.04	Quality Control	L.S.	1	$ 2,500	$ 3,000
1.05	Traffic Control / Resident Access	L.S.	1	$ 17,500	$ 18,000
				SUBTOTAL	$ 41,000
	Section 2: Tie Ins				
2.01	Solana Corner Connection	L.S.	1	$ 20,550	$ 21,000
2.02	Connect to Ex. 250mm in Sage Mesa Drive	L.S.	1	$ 1,400	$ 1,000
2.03	Verano Tie In at Hydrant	L.S.	1	$ 1,400	$ 1,000
2.04	Residential Service Connections - Includes saddle, corp stop, and service connection between main and existing curb stop (curb stop not incl.)	Ea.	9	$ 2,200	$ 20,000
				SUBTOTAL	$ 43,000
	Section 3: Watermain Upgrades				
3.01	150mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration. Asphalt.	lm	114	$ 700	$ 80,000
3.02	250mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration. Bareland.	lm	115	$ 425	$ 49,000
3.03	New Hydrant Assembly incl. gate valve & tee in main.	Ea.	3	$ 10,000	$ 30,000
3.04	New PRV station. Assumed to include 2 control valves and related components in an aboveground enclosed kiosk.	L.S.	1	$ 175,000	$ 175,000
3.05	150mm Ø Water Pipeline, Fittings	Ea.	1	$ 1,500	$ 2,000
3.06	250mm Ø Water Pipeline, Fittings	Ea.	2	$ 2,300	$ 5,000
				SUBTOTAL	$ 341,000

Notes:
Quantities are based high level conceptual designs of the expected upgrade work. These quantities are subject to change at the detailed design stage.

SUBTOTAL	$ 425,000
CONTINGENCY (40%)	$ 170,000
ESTIMATED TOTAL PROJECT COST	**$ 600,000**

RDOS

McElhanney

OPINION OF PROBABLE COST	Schedule of Approximate Quantities and Unit Prices

Project No: 2422-20427-00 Date: 12/14/2023

Project Name: Sage Mesa Upgrades - Sage Mesa Hydrant By: E.Sandberg P.Eng

Item#	Description of Work	Unit of Measure	Approx. Quantity	Unit Price	Extended Amount
	Section 1: General				
1.01	Mobilization and Demobilization	L.S.	1	$ 5,000	$ 5,000
1.02	Quality Control	L.S.	1	$ 2,500	$ 3,000
				SUBTOTAL	$ 8,000
	Section 2: Watermain Upgrades				
2.01	New Hydrant Assembly incl. gate valve & tee in main.	Ea.	1	$ 10,000	$ 10,000
				SUBTOTAL	$ 10,000

Notes:		
Quantities are based high level conceptual designs of the expected upgrade work. These quantities are subject to change at the detailed design stage.	SUBTOTAL	$ 18,000
	CONTINGENCY (40%)	$ 7,000
	ESTIMATED TOTAL PROJECT COST	**$ 30,000**

RDOS

McElhanney

OPINION OF PROBABLE COST Schedule of Approximate Quantities and Unit Prices

Project No:	2422-20427-00	Date:	12/14/2023
Project Name:	Sage Mesa Upgrades - Upper Reservoir Replacement (Single Reservoir Scenario)	By:	E.Sandberg P.Eng

Item#	Description of Work	Unit of Measure	Approx. Quantity	Unit Price	Extended Amount
	Section 1: General				
1.01	Mobilization and Demobilization	L.S.	1	$ 50,000	$ 50,000
1.02	Survey Layout & Project Documentation	L.S.	1	$ 15,000	$ 15,000
1.03	Erosion and Sediment Control	L.S.	1	$ 5,000	$ 5,000
1.04	Quality Control	L.S.	1	$ 10,000	$ 10,000
1.05	Environmental Management	L.S.	1	$ 10,000	$ 10,000
				SUBTOTAL	$ 90,000
	Section 2: Removals				
2.01	Demolition & Disposal of Existing Upper Reservoir (Incl. Optional Cost of Demo of Lower Reservoir)	L.S.	1	$ 200,000	$ 200,000
2.02	Clearing and Grubbing, Offsite Disposal	m^2	850	$ 5	$ 4,000
2.03	200mm Stripping and stockpiling	m^2	685	$ 5	$ 3,425
				SUBTOTAL	$ 207,425
	Section 3: Surface Work				
3.01	Bulk Earthworks Allowance, Offsite Disposal	m^3	2000	$ 30	$ 60,000
3.02	Subgrade Preparation	m^2	685	$ 6	$ 4,000
3.03	Reservoir Foundation - 150mm Granular Base	m^2	685	$ 16	$ 11,000
3.04	Reservoir Foundation - 500mm Drain Rock	m^2	685	$ 60	$ 41,100
3.05	Reservoir Foundation - 75mm Sand	m^2	685	$ 10	$ 7,000
3.06	Reservoir Foundation - Non-woven geotextile	m^2	850	$ 7	$ 5,950
				SUBTOTAL	$ 129,050
	Section 4: Reservoir				
4.01	Concrete Floor	m^3	250	$ 900	$ 225,000
4.02	Concrete Walls	m^3	120	$ 2,200	$ 264,000
4.03	Concrete Suspended Slab Roof	m^3	125	$ 1,900	$ 238,000
4.04	Roofing incl. Insulation	m^2	630	$ 375	$ 236,000
4.05	Wall Insulation	m^2	200	$ 250	$ 50,000
4.06	Roof Hatches	Ea.	2	$ 6,500	$ 13,000
4.07	Roof Guardrails	lm	100	$ 300	$ 30,000
4.08	Interior Ladder	Ea.	2	$ 1,100	$ 2,000
4.09	External Ladder	Ea.	1	$ 1,400	$ 1,000
4.10	Outlet Pipe Vortex Plate	Ea.	2	$ 1,000	$ 2,000
4.11	Reservoir Level Instruments and Intrusion Switches	Ea.	1	$ 10,000	$ 10,000
				SUBTOTAL	$ 1,071,000
	Section 5: Utilities				
5.01	CCTV Inspection of Drainage Piping	lm	185	$ 20	$ 4,000
5.02	200mm Ø Drainage Piping, Solid, SDR35 PVC	lm	10	$ 300	$ 3,000
5.03	200mm Ø Drainage Piping, Perforated, SDR35 PVC	lm	175	$ 350	$ 61,000
5.04	Drainage Outfall (Drywell or Armoured Outlet)	Ea.	1	$ 15,000	$ 15,000
5.05	200mm Ø Water Pipeline, Reservoir Inlet	lm	50	$ 400	$ 20,000
5.06	200mm Ø Water Pipeline, Reservoir Outlet	lm	25	$ 400	$ 10,000
5.07	200mm Ø Water Pipeline, Reservoir Drain	lm	10	$ 400	$ 4,000
5.08	200mm Ø Water Pipeline, Reservoir Overflow	lm	20	$ 400	$ 8,000
5.09	200mm Ø Water Pipeline, Reservoir Inlet, Outlet, and Drain Gate Valve	Ea.	9	$ 4,900	$ 44,000
5.10	200mm Ø Water Reservoir, Check Valve and Supports	Ea.	2	$ 13,600	$ 27,000
5.11	Water Reservoir, Flow Meter c/w Manhole	Ea.	1	$ 18,000	$ 18,000
5.12	Reservoir Instruments & Switches, Conduit and Cabling	L.S.	1	$ 10,000	$ 10,000
5.13	Water Pipeline, Tie-in to Existing Mains	Ea.	3	$ 1,900	$ 6,000
5.14	Water Reservoir, NDE, Disinfection and Bacterial Testing	L.S.	1	$ 6,000	$ 6,000

				SUBTOTAL	$ 236,000
Section 6: Landscaping and Final Restoration					
6.01	200mm Stripping re-use and final grading	m^2	220	$ 10	$ 2,200
6.02	Seeding	m^2	220	$ 5	$ 1,100
				SUBTOTAL	$ 3,300

Notes: Quantities are based high level conceptual designs of the expected upgrade work. These quantities are subject to change at the detailed design stage.	SUBTOTAL	$ 1,736,775
	CONTINGENCY (40%)	$ 695,000
	ESTIMATED TOTAL PROJECT COST	**$ 2,430,000**

RDOS

McElhanney

	OPINION OF PROBABLE COST	Schedule of Approximate Quantities and Unit Prices	
Project No:	2422-20427-00	Date:	12/14/2023
Project Name:	Sage Mesa Upgrades - Piping Upgrades to Accommodate Single Reservoir	By:	E.Sandberg P.Eng

Item#	Description of Work	Unit of Measure	Approx. Quantity	Unit Price	Extended Amount
	Section 1: General				
1.01	Mobilization and Demobilization	L.S.	1	$ 8,000	$ 8,000
1.02	Survey Layout & Project Documentation	L.S.	1	$ 10,000	$ 10,000
1.03	Erosion and Sediment Control	L.S.	1	$ 2,500	$ 3,000
1.04	Quality Control	L.S.	1	$ 10,000	$ 10,000
				SUBTOTAL	$ 31,000
	Section 2: Tie Ins				
2.01	Tie In to bypass booster station on discharge side. Assuming existing tee with closed valve can be used (replacing gate valve)	L.S.	1	$ 1,500	$ 2,000
2.02	Tie In to bypass booster station on suction side.	L.S.	1	$ 14,000	$ 14,000
2.03	Tie Ins for bypass old Lower Reservoir	Ea.	2	$ 900	$ 2,000
2.03	Tie In at existing vault where pipe between reservoirs switches from a 150mm to a 200mm.	Ea.	1	$ 5,900	$ 6,000
				SUBTOTAL	$ 24,000
	Section 3: Watermain Upgrades				
3.01	200mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration	lm	45	$ 700	$ 32,000
3.02	200mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration. Bareland	lm	640	$ 275	$ 176,000
3.03	New FCV station. Assumed to include 1 control valve and related components in an aboveground enclosed kiosk.	Ea.	1	$ 250,000	$ 250,000
				SUBTOTAL	$ 458,000

Notes: Quantities are based high level conceptual designs of the expected upgrade work. These quantities are subject to change at the detailed design stage.	SUBTOTAL	$ 513,000
	CONTINGENCY (40%)	$ 205,000
	ESTIMATED TOTAL PROJECT COST	**$ 720,000**

RDOS

McElhanney

	OPINION OF PROBABLE COST	Schedule of Approximate Quantities and Unit Prices			
Project No:	2422-20427-00	Date:		12/14/2023	
Project Name:	Sage Mesa Upgrades - Lake Pumphouse Upgrade Incl. Intake	By:		E.Sandberg P.Eng	

Item#	Description of Work	Unit of Measure	Approx. Quantity	Unit Price	Extended Amount
	Section 1: Pumphouse Upgrades				
1.01	General Costs Incl. Commissioning	L.S.	1	$ 50,000	$ 50,000
1.02	Pump Skid (3 pumps assumed)	L.S.	1	$ 90,000	$ 90,000
1.03	Pump Control System Incl. Soft Starters	L.S.	1	$ 17,500	$ 18,000
1.04	Chlorine System Adjustments	L.S.	1	$ 2,500	$ 3,000
1.05	New Interior Piping & Components Incl. New Pump Pedestal	L.S.	1	$ 100,000	$ 100,000
1.06	Building Air Conditioning	L.S.	1	$ 6,000	$ 6,000
1.07	New Wet Well	L.S.	1	$ 75,000	$ 75,000
2.01	Electrical Service Upgrade	L.S.	1	$ 80,000	$ 80,000
2.02	Backup Generator	L.S.	1	$ 150,000	$ 150,000
2.03	Sodium Hypo Barrel Lift	L.S.	1	$ 5,000	$ 5,000
				SUBTOTAL	$ 577,000
	Section 3: Intake				
3.01	Lake Intake Replacement (All In Cost)	Ea.	1	$ 750,000	$ 750,000
				SUBTOTAL	$ 750,000

Notes: Quantities are based high level conceptual designs of the expected upgrade work. These quantities are subject to change at the detailed design stage.	SUBTOTAL	$ 1,327,000
	CONTINGENCY (40%)	$ 531,000
	ESTIMATED TOTAL PROJECT COST	**$ 1,860,000**

RDOS

McElhanney

OPINION OF PROBABLE COST	Schedule of Approximate Quantities and Unit Prices	
Project No:	2422-20427-00	Date: 12/14/2023
Project Name:	Sage Mesa Upgrades - Dedicated Main to WTP	By: E.Sandberg P.Eng

Item#	Description of Work	Unit of Measure	Approx. Quantity	Unit Price	Extended Amount
	Section 1: General				
1.01	Mobilization and Demobilization	L.S.	1	$ 10,000	$ 10,000
1.02	Survey Layout & Project Documentation	L.S.	1	$ 8,000	$ 8,000
1.03	Erosion and Sediment Control	L.S.	1	$ 2,500	$ 3,000
1.04	Quality Control	L.S.	1	$ 5,000	$ 5,000
1.05	Traffic Control / Resident Access	L.S.	1	$ 35,000	$ 35,000
				SUBTOTAL	$ 61,000
	Section 2: Tie Ins				
2.01	Connection to existing main from lake pumphouse.	L.S.	1	$ 1,450	$ 1,000
2.02	Connection to main near Lower Reservoir	L.S.	1	$ 1,500	$ 2,000
2.03	Connection to new Treatment Plant	Ea.	2	$ 3,500	$ 7,000
				SUBTOTAL	$ 10,000
	Section 3: Watermain Upgrades				
3.01	200mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration. Asphalt	lm	400	$ 700	$ 280,000
3.02	200mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration. Bareland	lm	65	$ 275	$ 18,000
3.03	200mm Ø Water Pipeline, Fittings	Ea.	7	$ 1,800	$ 13,000
				SUBTOTAL	$ 311,000

Notes: Quantities are based high level conceptual designs of the expected upgrade work. These quantities are subject to change at the detailed design stage.	SUBTOTAL	$ 382,000
	CONTINGENCY (40%)	$ 153,000
	ESTIMATED TOTAL PROJECT COST	**$ 540,000**

RDOS

McElhanney

	OPINION OF PROBABLE COST	Schedule of Approximate Quantities and Unit Prices	
Project No:	2422-20427-00	Date:	12/14/2023
Project Name:	Sage Mesa Upgrades - West Bench Connection	By:	E.Sandberg P.Eng

Item#	Description of Work	Unit of Measure	Approx. Quantity	Unit Price	Extended Amount
	Section 1: General				
1.01	Mobilization and Demobilization	L.S.	1	$ 35,000	$ 35,000
1.02	Survey Layout & Project Documentation	L.S.	1	$ 15,000	$ 15,000
1.03	Erosion and Sediment Control	L.S.	1	$ 5,000	$ 5,000
1.04	Quality Control	L.S.	1	$ 10,000	$ 10,000
1.05	Traffic Control / Resident Access	L.S.	1	$ 75,000	$ 75,000
				SUBTOTAL	$ 140,000
	Section 2: Tie Ins				
2.01	Hyslop & Sage Mesa Intersection	L.S.	1	$ 16,000	$ 16,000
2.02	End of West Bench Dr	L.S.	1	$ 3,800	$ 4,000
2.03	Sage Mesa & West Bench Dr Connection	L.S.	1	$ 9,800	$ 10,000
2.04	Tie In at Lower Reservoir	L.S.	1	$ 1,500	$ 2,000
				SUBTOTAL	$ 32,000
	Section 3: Watermain Upgrades				
3.01	200mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration	lm	1200	$ 700	$ 840,000
3.02	150mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration	lm	50	$ 600	$ 30,000
3.03	New FCV station. Assumed to include 1 control valve and related components in an aboveground enclosed kiosk.	Ea.	1	$ 250,000	$ 250,000
3.04	New Water Meter Kiosk. Assumed to include meter and related components in an aboveground kiosk.	L.S.	1	$ 100,000	$ 100,000
3.05	200mm Ø Water Pipeline, Fittings	Ea.	7	$ 1,800	$ 13,000
3.06	150mm Ø Water Pipeline, Fittings	Ea.	1	$ 1,500	$ 2,000
				SUBTOTAL	$ 1,235,000

Notes: Quantities are based high level conceptual designs of the expected upgrade work. These quantities are subject to change at the detailed design stage.	SUBTOTAL	$ 1,407,000
	CONTINGENCY (40%)	$ 563,000
	ESTIMATED TOTAL PROJECT COST	**$ 1,970,000**

RDOS

McElhanney

OPINION OF PROBABLE COST	Schedule of Approximate Quantities and Unit Prices

Project No:	2422-20427-00	Date:	12/14/2023
Project Name:	Sage Mesa Upgrades - Additional Costs to Replace Entire Network	By:	E.Sandberg P.Eng

Item#	Description of Work	Unit of Measure	Approx. Quantity	Unit Price	Extended Amount
1.01	General Costs (Mob, Traffic Control, Quality Control etc.)	L.S.	1	$ 1,150,000	$ 1,150,000
1.02	50mm service connections	L.S.	3	$ 3,000	$ 9,000
1.03	Residential Service Connections	Ea.	157	$ 2,200	$ 345,000
1.04	Hydrants	Ea.	20	$ 10,000	$ 200,000
1.05	100 Valve	L.S.	4	$ 3,500	$ 14,000
1.06	150 Valve	L.S.	22	$ 3,800	$ 84,000
1.07	200 Valve	L.S.	23	$ 4,900	$ 113,000
1.08	50 Pipe	lm	557	$ 350	$ 195,000
1.09	100 Pipe	lm	201	$ 500	$ 101,000
1.10	150 Pipe	lm	4425	$ 600	$ 2,655,000
1.11	200 Pipe	lm	4585	$ 700	$ 3,210,000
1.12	250 Pipe	lm	250	$ 800	$ 200,000
1.13	Pipe Fittings	Ea.	150	$ 1,500	$ 225,000
1.14	Remainder of Booster Station Overhaul	L.S.	1	$ 300,000	$ 300,000

Notes:	SUBTOTAL	$ 8,801,000
Quantities are based high level conceptual designs of the expected upgrade work. These quantities are subject to change at the detailed design stage.	CONTINGENCY (40%)	$ 3,520,000
Does not include Connection to West Bench, New WTP Connection, or any connection work / adjustments between the reservoirs. Intended to cover replacing the rest of the network beyond the upgrades already included in the main report cost summary table.	**ESTIMATED TOTAL PROJECT COST**	**$ 12,320,000**

APPENDIX G

Detailed Financial Assessment

Annualized Renewal Costs for Capital Projects

Applies to both options	
New WTP Option	
WB Option	

Capital Project

Total System Replacement						
Component	**Unit of Measure**	**Approx. Quantity**	**Unit Price**	**Extended Amount**	**Useful Life**	**Annualized Replacement Cost**
50mm service connections	L.S.	3	$ 3,000	$ 13,950	80	$ 174
Residential Service Connections	Ea.	157	$ 2,200	$ 534,750	30	$ 17,825
Hydrants	Ea.	20	$ 10,000	$ 310,000	40	$ 7,750
100 Valve	L.S.	4	$ 3,500	$ 21,700	50	$ 434
150 Valve	L.S.	22	$ 3,800	$ 130,200	50	$ 2,604
200 Valve	L.S.	23	$ 4,900	$ 175,150	50	$ 3,503
50 Pipe	lm	557	$ 350	$ 302,250	80	$ 3,778
100 Pipe	lm	201	$ 500	$ 156,550	80	$ 1,957
150 Pipe	lm	4425	$ 600	$ 4,115,250	80	$ 51,441
200 Pipe	lm	4585	$ 700	$ 4,975,500	80	$ 62,194
250 Pipe	lm	250	$ 800	$ 310,000	80	$ 3,875
Pipe Fittings	Ea.	150	$ 1,500	$ 348,750	80	$ 4,359
Remainder of Booster Station Overhaul	L.S.	1	$ 300,000	$ 465,000	50	$ 9,300
				$ 11,859,050		**$ 169,194**

Forsyth						
Component	**Unit of Measure**	**Approx. Quantity**	**Unit Price**	**Extended Amount**	**Useful Life**	**Annualized Replacement Cost**
Residential Service Connections - Includes saddle, corp stop, service connection between main and curb stop, and curb stop	Ea.	51	$ 2,200	$ 173,600	30	$ 5,787
200mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration	lm	1890	$ 700	$ 2,050,650	80	$ 25,633
New Hydrant Assembly incl. gate valve & tee in main.	Ea.	12	$ 10,000	$ 186,000	40	$ 4,650
200mm Ø AWWA C509 Gate Valve c/w Valve Riser and Nelson Box	Ea.	3	$ 4,900	$ 23,250	50	$ 465
200mm Ø Water Pipeline, Fittings	Ea.	29	$ 1,800	$ 80,600	80	$ 1,008
New PRV station. Assumed to include 3 control valves and related components in an aboveground enclosed kiosk.	L.S.	1	$ 250,000	$ 387,500	40	$ 9,688
				$ 2,901,600		**$ 47,230**

Extended Amount includes unit price, 40% contingency, and 15% engineering fees.
Annualized Replacement Cost calculated from Extended Amount over Useful Life.

Annualized Renewal Costs for Capital Projects

Applies to both options
New WTP Option
WB Option

Capital Project

Golf Course to Solana						
Component	**Unit of Measure**	**Approx. Quantity**	**Unit Price**	**Extended Amount**	**Useful Life**	**Annualized Replacement Cost**
Residential Service Connections - Includes saddle, corp stop, and service connection between main and existing curb stop (curb stop not incl.)	Ea.	11	$ 2,200	$ 37,200	30	$ 1,240
200mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration	lm	370	$ 700	$ 401,450	80	$ 5,018
New Hydrant Assembly incl. gate valve & tee in main.	Ea.	3	$ 10,000	$ 46,500	40	$ 1,163
200mm Ø AWWA C509 Gate Valve c/w Valve Riser and Nelson Box	Ea.	1	$ 4,900	$ 7,750	50	$ 155
200mm Ø Water Pipeline, Fittings	Ea.	5	$ 1,800	$ 13,950	80	$ 174
				$ 506,850		**$ 7,750**
Solana & Sage Mesa						
Component	**Unit of Measure**	**Approx. Quantity**	**Unit Price**	**Extended Amount**	**Useful Life**	**Annualized Replacement Cost**
Residential Service Connections - Includes saddle, corp stop, and service connection between main and existing curb stop (curb stop not incl.)	Ea.	9	$ 2,200	$ 31,000	30	$ 1,033
200mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration	lm	90	$ 700	$ 97,650	80	$ 1,221
150mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration	lm	217	$ 600	$ 201,500	80	$ 2,519
New Hydrant Assembly incl. gate valve & tee in main.	Ea.	3	$ 10,000	$ 46,500	40	$ 1,163
150mm Ø AWWA C509 Gate Valve c/w Valve Riser and Nelson Box	Ea.	1	$ 3,800	$ 6,200	50	$ 124
200mm Ø Water Pipeline, Fittings	Ea.	1	$ 1,800	$ 3,100	80	$ 39
150mm Ø Water Pipeline, Fittings	Ea.	4	$ 1,500	$ 9,300	80	$ 116
				$ 395,250		**$ 6,214**
Verano						
Component	**Unit of Measure**	**Approx. Quantity**	**Unit Price**	**Extended Amount**	**Useful Life**	**Annualized Replacement Cost**
Residential Service Connections - Includes saddle, corp stop, and service connection between main and existing curb stop (curb stop not incl.)	Ea.	9	$ 2,200	$ 31,000	30	$ 1,033
150mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration. Asphalt.	lm	114	$ 700	$ 124,000	80	$ 1,550
250mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration. Bareland.	lm	115	$ 425	$ 75,950	80	$ 949
New Hydrant Assembly incl. gate valve & tee in main.	Ea.	3	$ 10,000	$ 46,500	40	$ 1,163
New PRV station. Assumed to include 2 control valves and related components in an aboveground enclosed kiosk.	L.S.	1	$ 175,000	$ 271,250	40	$ 6,781
150mm Ø Water Pipeline, Fittings	Ea.	1	$ 1,500	$ 3,100	80	$ 39
250mm Ø Water Pipeline, Fittings	Ea.	2	$ 2,300	$ 7,750	80	$ 97
				$ 559,550		**$ 11,612**

Extended Amount includes unit price, 40% contingency, and 15% engineering fees.
Annualized Replacement Cost calculated from Extended Amount over Useful Life.

Annualized Renewal Costs for Capital Projects

Legend
Applies to both options
New WTP Option
WB Option

Capital Project

Sage Mesa North Hydrant						
Component	**Unit of Measure**	**Approx. Quantity**	**Unit Price**	**Extended Amount**	**Useful Life**	**Annualized Replacement Cost**
New Hydrant Assembly incl. gate valve & tee in main.	Ea.	1	$ 10,000	$ 15,500	40	$ 388
				$ 15,500		**$ 388**

Upper Reservoir (Single)						
Component	**Unit of Measure**	**Approx. Quantity**	**Unit Price**	**Extended Amount**	**Useful Life**	**Annualized Replacement Cost**
New Upper Reservoir. Includes connection and PRV/FCV kiosk to bypass Booster Station & Lower Reservoir	Ea.	1	$ 1,307,000	$ 2,025,850	70	$ 28,941
						$ 28,941

Reservoir Connection						
Component	**Unit of Measure**	**Approx. Quantity**	**Unit Price**	**Extended Amount**	**Useful Life**	**Annualized Replacement Cost**
200mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration	lm	45	$ 700	$ 49,600	80	$ 620
200mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration. Bareland	lm	640	$ 275	$ 272,800	80	$ 3,410
New FCV station. Assumed to include 1 control valve and related components in an aboveground enclosed kiosk.	Ea.	1	$ 250,000	$ 387,500	40	$ 9,688
				$ 709,900		**$ 13,718**

New WM's						
Component	**Unit of Measure**	**Approx. Quantity**	**Unit Price**	**Extended Amount**	**Useful Life**	**Annualized Replacement Cost**
Residential Meters (Assuming 1 per property)	Ea.	242	$ 2,900	$ 1,087,790	30	$ 36,260
Golf Course Meters	Ea.	2	$ 75,000	$ 232,500	30	$ 7,750
						$ 44,010

PRV Replacement						
Component	**Unit of Measure**	**Approx. Quantity**	**Unit Price**	**Extended Amount**	**Useful Life**	**Annualized Replacement Cost**
PRV station in Upper Zone	Ea.	1	$ 250,000	$ 387,500	40	$ 9,688
						$ 9,688

Extended Amount includes unit price, 40% contingency, and 15% engineering fees.
Annualized Replacement Cost calculated from Extended Amount over Useful Life.

Annualized Renewal Costs for Capital Projects

Applies to both options
New WTP Option
WB Option

Capital Project

Booster Upgrades

Component	Unit of Measure	Approx. Quantity	Unit Price	Extended Amount	Useful Life	Annualized Replacement Cost
Booster Station Upgrades Incl. Backup Power	Ea.	1	$ 200,000	$ 310,000	40	$ 7,750
						$ 7,750

Dedicated Treatment Main

Component	Unit of Measure	Approx. Quantity	Unit Price	Extended Amount	Useful Life	Annualized Replacement Cost
200mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration. Asphalt	lm	400	$ 700	$ 434,000	80	$ 5,425
200mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration. Bareland	lm	65	$ 275	$ 27,900	80	$ 349
200mm Ø Water Pipeline, Fittings	Ea.	7	$ 1,800	$ 20,150	80	$ 252
						$ 6,026

Lakeside Pump House

Component	Unit of Measure	Approx. Quantity	Unit Price	Extended Amount	Useful Life	Annualized Replacement Cost
Pump Skid (3 pumps assumed)	L.S.	1	$ 90,000	$ 139,500	20	$ 6,975
Pump Control System Incl. Soft Starters	L.S.	1	$ 17,500	$ 27,900	20	$ 1,395
New Interior Piping & Components Incl. New Pump Pedestal	L.S.	1	$ 100,000	$ 155,000	40	$ 3,875
Building Air Conditioning	L.S.	1	$ 6,000	$ 9,300	30	$ 310
New Wet Well	L.S.	1	$ 75,000	$ 116,250	70	$ 1,661
Electrical Service Upgrade	L.S.	1	$ 80,000	$ 124,000	30	$ 4,133
Backup Generator	L.S.	1	$ 150,000	$ 232,500	25	$ 9,300
Sodium Hypo Barrel Lift	L.S.	1	$ 5,000	$ 7,750	40	$ 194
						$ 27,843

WTP

Component	Unit of Measure	Approx. Quantity	Unit Price	Extended Amount	Useful Life	Annualized Replacement Cost
New WTP	Ea.	1	$ 3,360,000	$ 5,208,000	50	$ 104,160
						$ 104,160

Extended Amount includes unit price, 40% contingency, and 15% engineering fees.
Annualized Replacement Cost calculated from Extended Amount over Useful Life.

Annualized Renewal Costs for Capital Projects

Applies to both options
New WTP Option
WB Option

Capital Project

West Bench Connection						
Component	**Unit of Measure**	**Approx. Quantity**	**Unit Price**	**Extended Amount**	**Useful Life**	**Annualized Replacement Cost**
200mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration	lm	1200	$ 700	$ 1,302,000	80	$ 16,275
150mm Ø AWWA C900 Water Pipeline, Distribution. Includes excavation, and surface restoration	lm	50	$ 600	$ 46,500	80	$ 581
New FCV station. Assumed to include 1 control valve and related components in an aboveground enclosed kiosk.	Ea.	1	$ 250,000	$ 387,500	40	$ 9,688
New Water Meter Kiosk. Assumed to include meter and related components in an aboveground kiosk.	L.S.	1	$ 100,000	$ 155,000	30	$ 5,167
200mm Ø Water Pipeline, Fittings	Ea.	7	$ 1,800	$ 20,150	80	$ 252
150mm Ø Water Pipeline, Fittings	Ea.	1	$ 1,500	$ 3,100	80	$ 39
Wet Well / Sump for Suction Booster Station Pumps	Ea.	1	$ 105,000	$ 162,750	70	$ 2,325
Hypochlorite Top-Up System	Ea.	1	$ 60,000	$ 93,000	20	$ 4,650
						$ 38,976

Extended Amount includes unit price, 40% contingency, and 15% engineering fees.
Annualized Replacement Cost calculated from Extended Amount over Useful Life.

REGIONAL DISTRICT OF OKANAGAN SIMILKAMEEN

ENGINEERING AND FINANCIAL ASSESSMENT OF THE SAGE MESA SYSTEM

ANNUAL MAINTENANCE BUDGET - EXISTING SAGE MESA WATER SYSTEM

COMMUNITY INFRASTRUCTURE SUMMARY

TOTAL WATERMAINS	10.3	km
TOTAL HYDRANTS	39	
TOTAL VALVES	75	

SYSTEM COMPONENT	QUANTITY
Reservoir	2
PRV	3
Boost Station	3
Chlorine Disinfection	2

Maintenance Task				Crew Hours per Year		Costs per Task				
Asset Group	Asset Component	Task Description	Frequency	Operator	Truck	Contractor	Equipment	Parts & Materials	Annual Energy Cost	Annual Budget
WATER	Boost Station	Weekly or Daily boost station inspection	Weekly	120	120	$ -	$ -	$ 5.00	$ -	$ 11,862.86
WATER	Boost Station	Monthly booster station inspection and Maintenance	Monthly	132	33	$ -	$ 10.00	$ 50.00	$ -	$ 12,832.50
WATER	Boost Station	Annual Boost Station Inspection and Maintenance	Annual	18	3	$ -	$ 50.00	$ 100.00	$ 7,500.00	$ 9,406.60
WATER	Main	Distribution System Inspection	Monthly	312	312	$ -	$ 50.00	$ 50.00	$ -	$ 30,355.15
WATER	Main	Annual Valve Inspection and Maintenance	Annual	31	31	$ -	$ 50.00	$ 150.00	$ -	$ 3,109.57
WATER	Main	Watermain Flushing	Annual	70	70	$ -	$ 100.00	$ 50.00	$ -	$ 6,691.84
WATER	Main	Hydrant Inspection, Maintenance, and Flushing	Annual	28	28	$ -	$ 100.00	$ 50.00	$ -	$ 2,732.95
WATER	Main	Watermain Spot Repairs	As Required	0	0	$ -	$ -	$ 50.00	$ -	$ -
WATER	Main	Curb Box and Curb Stop Repairs	As Required	0	0	$ -	$ -	$ 25.00	$ -	$ -
WATER	Main	Fire Hydrant and Standpipe Test	3 Times per Year	179	179	$ -	$ -	$ -	$ -	$ 16,753.50
WATER	Main	Valve Repair	As Required	0	0	$ -	$ -	$ 25.00	$ -	$ -
WATER	Main	Hydrant Repair (General)	As Required	0	0	$ -	$ -	$ 25.00	$ -	$ -
WATER	Main	Hydrant Painting	As Required	0	0	$ -	$ 10.00	$ 25.00	$ -	$ -
WATER	Reservoir	Weekly Inspection of Water Storage Facility	Weekly	80	80	$ -	$ -	$ -	$ -	$ 7,508.57
WATER	Reservoir	Monthly Inspection and Maintenance of Storage Facility	Monthly	48	16	$ -	$ 10.00	$ 50.00	$ -	$ 4,968.45
WATER	Reservoir	Quarterly inspection and Maintenance of Storage Facility	Quarterly	18	6	$ -	$ 10.00	$ 50.00	$ -	$ 1,863.17
WATER	Reservoir	Annual Inspection and Maintenance of Water Storage Facility	Annual	8	2	$ -	$ 10.00	$ 100.00	$ -	$ 877.73
WATER	Reservoir	Three to Five year inspection and Maintenance of Storage Facility	Every 3 Years	5	1	$ -	$ 50.00	$ 200.00	$ -	$ 594.80
WATER	PRV	PRV Inspection	Weekly	156	78	$ -	$ -	$ -	$ -	$ 13,431.03
WATER	Chlorine Disinfection	Daily Inspection of Chlorine Disinfection Treatment System	Daily	360	360	$ -	$ 1.00	$ 5.00	$ -	$ 38,108.58
WATER	Chlorine Disinfection	Quarterly inspection and Maintenance of Chlorine System	Quarterly	12	6	$ -	$ 25.00	$ 2,400.00	$ -	$ 15,583.16
WATER	Chlorine Disinfection	Annual Inspection and Maintenance of Chlorine System	Annual	8	2	$ -	$ 50.00	$ 200.00	$ -	$ 1,157.73
				1584						
				1.22	FTEs					

Labour Rates		
Labour	$	78.34
Truck	$	15.52

Based on 2023 O&M wage and benefits budget ($124,090) and estimated 1584 Operator hours for existing system

MAINTENANCE TRUCK ASSUMPTIONS

Monthly Lease	$ 800.00	
Annual Insurance	$ 2,500.00	
Gas Price	$ 1.67	
Tank Size	136	l
Annual Working Hours	1160	hrs
Maintenance Truck Hourly Rate	$ 15.52	

TOTAL ANNUAL BUDGET		
Operator	*$*	*124,064.00*
Truck	*$*	*20,567.52*
Contractor	*$*	*-*
Equipment	*$*	*2,523.33*
Parts & Materials	*$*	*23,183.33*
Energy Requirements	*$*	*7,500.00*
TOTAL O&M	**$**	**177,838.18**

REGIONAL DISTRICT OF OKANAGAN SIMILKAMEEN
ENGINEERING AND FINANCIAL ASSESSMENT OF THE SAGE MESA SYSTEM
ANNUAL MAINTENANCE BUDGET - FUTURE TOTAL SYSTEM REPLACEMENT AND WEST BENCH CONNECTION

COMMUNITY INFRASTRUCTURE SUMMARY

TOTAL WATERMAINS	11.6	km
TOTAL HYDRANTS	40	
TOTAL VALVES	72	

SYSTEM COMPONENT	QUANTITY
Reservoir	1
PRV	5
Boost Station	1
Chlorine Disinfection	1

Maintenance Task				Crew Hours per Year		Costs per Task				
Asset Group	Asset Component	Task Description	Frequency	Operator	Truck	Contractor	Equipment	Parts & Materials	Annual Energy Cost	Annual Budget
WATER	Boost Station	Weekly or Daily boost station inspection	Weekly	40	40	$ -	$ -	$ 5.00	$ -	$ 3,954.29
WATER	Boost Station	Monthly booster station inspection and Maintenance	Monthly	44	11	$ -	$ 10.00	$ 133.00	$ -	$ 5,190.50
WATER	Boost Station	Annual Boost Station Inspection and Maintenance	Annual	6	1	$ -	$ 50.00	$ 133.00	$ 2,500.00	$ 3,168.53
WATER	Main	Distribution System Inspection	Monthly	311	311	$ -	$ 50.00	$ 50.00	$ -	$ 30,323.67
WATER	Main	Annual Valve Inspection and Maintenance	Annual	30	30	$ -	$ 50.00	$ 150.00	$ -	$ 2,996.94
WATER	Main	Watermain Flushing	Annual	69	69	$ -	$ 100.00	$ 50.00	$ -	$ 6,626.14
WATER	Main	Hydrant Inspection, Maintenance, and Flushing	Annual	28	28	$ -	$ 100.00	$ 50.00	$ -	$ 2,796.77
WATER	Main	Watermain Spot Repairs	As Required	0	0	$ -	$ -	$ 50.00	$ -	$ -
WATER	Main	Curb Box and Curb Stop Repairs	As Required	0	0	$ -	$ -	$ 25.00	$ -	$ -
WATER	Main	Fire Hydrant and Standpipe Test	3 Times per Year	183	183	$ -	$ -	$ -	$ -	$ 17,175.86
WATER	Main	Valve Repair	As Required	0	0	$ -	$ -	$ 25.00	$ -	$ -
WATER	Main	Hydrant Repair (General)	As Required	0	0	$ -	$ -	$ 25.00	$ -	$ -
WATER	Main	Hydrant Painting	As Required	0	0	$ -	$ 10.00	$ 25.00	$ -	$ -
WATER	Reservoir	Weekly Inspection of Water Storage Facility	Weekly	40	40	$ -	$ -	$ -	$ -	$ 3,754.29
WATER	Reservoir	Monthly Inspection and Maintenance of Storage Facility	Monthly	24	8	$ -	$ 10.00	$ 50.00	$ -	$ 2,484.23
WATER	Reservoir	Quarterly inspection and Maintenance of Storage Facility	Quarterly	9	3	$ -	$ 10.00	$ 50.00	$ -	$ 931.58
WATER	Reservoir	Annual Inspection and Maintenance of Water Storage Facility	Annual	4	1	$ -	$ 10.00	$ 100.00	$ -	$ 438.86
WATER	Reservoir	Three to Five year inspection and Maintenance of Storage Facility	Every 3 Years	3	0	$ -	$ 50.00	$ 200.00	$ -	$ 297.40
WATER	PRV	PRV Inspection	Weekly	260	130	$ -	$ -	$ -	$ -	$ 22,385.04
WATER	Chlorine Disinfection	Daily Inspection of Chlorine Disinfection Treatment System	Daily	180	180	$ -	$ 1.00	$ 5.00	$ -	$ 19,054.29
WATER	Chlorine Disinfection	Quarterly inspection and Maintenance of Chlorine System	Quarterly	6	3	$ -	$ 25.00	$ 5,333.33	$ -	$ 16,591.58
WATER	Chlorine Disinfection	Annual Inspection and Maintenance of Chlorine System	Annual	4	1	$ -	$ 50.00	$ 200.00	$ -	$ 578.86
				1241						
				0.95	FTEs					

Labour Rates	
Labour	$ 78.34
Truck	$ 15.52

Based on 2023 O&M wage and benefits budget ($124,090) and estimated 1584 Operator hours for existing system

MAINTENANCE TRUCK ASSUMPTIONS

Monthly Lease	$ 800.00	
Annual Insurance	$ 2,500.00	
Gas Price	$ 1.67	
Tank Size	136	l
Annual Working Hours	1160	hrs
Maintenance Truck Hourly Rate	$ 15.52	

TOTAL ANNUAL BUDGET	
Operator	*$ 97,216.70*
Truck	*$ 16,137.81*
Contractor	*$ -*
Equipment	*$ 1,581.67*
Parts & Materials	*$ 21,312.67*
Energy Requirements	*$ 2,500.00*
TOTAL O&M	**$ 138,748.84**

REGIONAL DISTRICT OF OKANAGAN SIMILKAMEEN

ENGINEERING AND FINANCIAL ASSESSMENT OF THE SAGE MESA SYSTEM

ANNUAL MAINTENANCE BUDGET - FUTURE TOTAL SYSTEM REPLACEMENT AND NEW WTP

COMMUNITY INFRASTRUCTURE SUMMARY

TOTAL WATERMAINS	10.4	km
TOTAL HYDRANTS	40	
TOTAL VALVES	72	

SYSTEM COMPONENT	QUANTITY
Water Treatment Plant	1
Reservoir	1
PRV	3
Boost Station	2
Chlorine Disinfection	1

Maintenance Task				Crew Hours per Year		Costs per Task				
Asset Group	Asset Component	Task Description	Frequency	Operator	Truck	Contractor	Equipment	Parts & Materials	Annual Energy Cost	Annual Budget
WATER	Boost Station	Weekly or Daily boost station inspection	Weekly	80	80	$ -	$ -	$ 5.00	$ -	$ 7,908.57
WATER	Boost Station	Monthly booster station inspection and Maintenance	Monthly	88	22	$ -	$ 10.00	$ 133.00	$ -	$ 10,381.00
WATER	Boost Station	Annual Boost Station Inspection and Maintenance	Annual	12	2	$ -	$ 50.00	$ 133.00	$ 5,000.00	$ 6,337.07
WATER	Main	Distribution System Inspection	Monthly	308	308	$ -	$ 50.00	$ 50.00	$ -	$ 30,001.03
WATER	Main	Annual Valve Inspection and Maintenance	Annual	30	30	$ -	$ 50.00	$ 150.00	$ -	$ 2,996.94
WATER	Main	Watermain Flushing	Annual	69	69	$ -	$ 100.00	$ 50.00	$ -	$ 6,626.14
WATER	Main	Hydrant Inspection, Maintenance, and Flushing	Annual	28	28	$ -	$ 100.00	$ 50.00	$ -	$ 2,796.77
WATER	Main	Watermain Spot Repairs	As Required	0	0	$ -	$ -	$ 50.00	$ -	$ -
WATER	Main	Curb Box and Curb Stop Repairs	As Required	0	0	$ -	$ -	$ 25.00	$ -	$ -
WATER	Main	Fire Hydrant and Standpipe Test	3 Times per Year	183	183	$ -	$ -	$ -	$ -	$ 17,175.86
WATER	Main	Valve Repair	As Required	0	0	$ -	$ -	$ 25.00	$ -	$ -
WATER	Main	Hydrant Repair (General)	As Required	0	0	$ -	$ -	$ 25.00	$ -	$ -
WATER	Main	Hydrant Painting	As Required	0	0	$ -	$ 10.00	$ 25.00	$ -	$ -
WATER	Reservoir	Weekly Inspection of Water Storage Facility	Weekly	40	40	$ -	$ -	$ -	$ -	$ 3,754.29
WATER	Reservoir	Monthly Inspection and Maintenance of Storage Facility	Monthly	24	8	$ -	$ 10.00	$ 50.00	$ -	$ 2,484.23
WATER	Reservoir	Quarterly inspection and Maintenance of Storage Facility	Quarterly	9	3	$ -	$ 10.00	$ 50.00	$ -	$ 931.58
WATER	Reservoir	Annual Inspection and Maintenance of Water Storage Facility	Annual	4	1	$ -	$ 10.00	$ 100.00	$ -	$ 438.86
WATER	Reservoir	Three to Five year inspection and Maintenance of Storage Facility	Every 3 Years	3	0	$ -	$ 50.00	$ 200.00	$ -	$ 297.40
WATER	PRV	PRV Inspection	Weekly	156	78	$ -	$ -	$ -	$ -	$ 13,431.03
WATER	Chlorine Disinfection	Daily Inspection of Chlorine Disinfection Treatment System	Daily	180	180	$ -	$ 1.00	$ 5.00	$ -	$ 19,054.29
WATER	Chlorine Disinfection	Quarterly inspection and Maintenance of Chlorine System	Quarterly	6	3	$ -	$ 25.00	$ 5,333.33	$ -	$ 16,591.58
WATER	Chlorine Disinfection	Annual Inspection and Maintenance of Chlorine System	Annual	4	1	$ -	$ 50.00	$ 200.00	$ -	$ 578.86
WATER	Water Treatment Plant	Water Treatment Plant Daily Inspection	Daily	365	365	$ -	$ 120.00	$ 44.00	$ 24,000.00	$ 118,117.86
WATER	Water Treatment Plant	Water Treatment Plant Periodic Inspections and Testing	Weekly	104	52	$ -	$ 165.00	$ -	$ -	$ 17,534.02
WATER	Water Treatment Plant	Water Treatment Plant Filter Scraping	6 times/year	96	12	$ -	$ 165.00	$ 8,333.33	$ -	$ 58,696.47
WATER	Water Treatment Plant	Water Treatment Plant Media Addition	Annual	60	20	$ -	$ 165.00	$ 75,000.00	$ -	$ 80,175.56
				1849						
				1.42	FTEs					

Labour Rates	
Labour	$ 78.34
Truck	$ 15.52

Based on 2023 O&M wage and benefits budget ($124,090) and estimated 1584 Operator hours for existing system

MAINTENANCE TRUCK ASSUMPTIONS		
Monthly Lease	$ 800.00	
Annual Insurance	$ 2,500.00	
Gas Price	$ 1.67	
Tank Size	136	l
Annual Working Hours	1160	hrs
Maintenance Truck Hourly Rate	$ 15.52	

TOTAL ANNUAL BUDGET	
Operator	*$ 144,810.41*
Truck	*$ 23,053.68*
Contractor	*$ -*
Equipment	*$ 55,276.67*
Parts & Materials	*$ 164,168.67*
Energy Requirements	*$ 29,000.00*
TOTAL O&M	**$ 416,309.42**

McElhanney

CANADA BEST MANAGED COMPANIES