CRD/IWS REPORT NO. 1186

Capital Regional District | Regional Water Supply 2022 Master Plan

MAY 2022

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Capital Regional District
Regional Water Supply Service

2022 Master Plan

IWS Report No. 1186

Stantec

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Sign-off Sheet

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ABBREVIATIONS

AC	Asbestos Cement
ACH	Aluminum Chlorohydrate
ADD	Average Day Demand
AEP	Annual Exceedance Probability
ALA	American Lifelines Alliance
AWWA	American Water Works Association
BC	British Columbia
BCBC	British Columbia Building Code
CDA	Canadian Dam Association
CFU	Colony Forming Units
CIP	Clean-in-place
CRD	Capital Regional District
CWH	Coastal Western Hemlock
DAF	Dissolved Air Flotation
DCS	District of Central Saanich
DGR	Deception Gulch Reservoir
DMF	Devil's Mountain Fault
DNS	District of North Saanich
DOC	Dissolved Organic Carbon
DWOs	Drinking Water Officers
DWOG	Drinking Water Officers' Guide
DWPA	Drinking Water Protection Act
DWPR	Drinking Water Protection Regulation
ECCC	Environment and Climate Change Canada
EDGM	Earthquake Design Ground Motion
EFNP	Environmental Flow Needs Policy (BC Water Sustainability Act)
EGBC	Engineers and Geoscientists BC
FCM	Federation of Canadian Municipalities
FLNRORD	Forests, Lands, Natural Resource Operations and Rural Development
FUS	Fire Underwriters Survey
GAC	Granular Activated Carbon
GDS	Goldstream Disinfection Facility
GVWSA	Greater Victoria Water Supply Area
GVWD	Greater Victoria Water District

HGL	Hydraulic Grade Line
HP	Horsepower
ID	Identification
IHA	Island Health Authority
ICI	Industrial/Commercial/Institutional
IESWTR	Interim Enhanced Surface Water Treatment Rule
IWS	Integrated Water Services
JDFWD	Juan De Fuca Water Distribution
JGDF	Japan Gulch Disinfection Facility
JGR	Japan Gulch Reservoir
KWL	Kerr Wood Leidal Consulting Engineers
L/c/d	Litres /capita/day
LRVF	Leech River Valley Fault
LOS	Level of Service
L/S	Litres Per Second
1994 Plan	Long Term Water Supply Plan (Greater Victoria Water District, Long Term Water Supply Plan, Montgomery Watson, and Dayton & Knight, 1994)
MAC	Maximum Acceptable Concentration
MAMP	Municipal Asset Management Program
MCL	Maximum Contaminant Level
MDD	Maximum Day Demand
MF	Microfiltration
ML	Million Litres
MLD	Megalitre Per Day (million litres per day)
MMCD	Master Municipal Construction Documents
MoE	Ministry of Environment
Mm^3Y	Million cubic metres Per Year
MTBM	Micro Tunnel Boring Machine
NBC	National Building Code
NOM	Natural Organic Matter
NPV	Net Present Value
NTU	Nephelometric Turbidity Unit
OD	Outside Diameter
ORP	Oxidation-Reduction Potential
OTC	Once-Through Cooling
PCIC	Pacific Climate Impacts Consortium – University of Victoria

PCS	Pressure Control Station
PCCP	Prestressed Concrete Cylinder Pipe
PHD	Peak Hour Demand
PRV	Pressure Reducing Valve
PS	Pump Station
PSHA	Probabilistic Seismic Hazard Analysis
PVC	Polyvinyl Chloride
QMRA	Quantitative Microbial Risk Assessment
RCP	Relative Concentration Pathway
RFP	Request for Proposal
RISC	Resources Information Standards Committee
RWS	Regional Water Supply
RWSC	Regional Water Supply Commission
SCADA	Supervisory Control and Data Acquisition
SDWA	Safe Drinking Water Act
SHR	Smith Hill Reservoir
SLR	Sooke Lake Reservoir
SRRDF	Sooke River Road Disinfection Facility
SUVA	Specific Ultraviolet Absorbance
SWTR	Surface Water Treatment Rule (USEPA)
TAD	Total Annual Demand
TBD	To Be Determined
TBM	Tunnel Boring Machine
TCU	Temperature Control Unit
TDH	Total Dynamic Head
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TP	Total Phosphorus
TSD	Total Summer Demand
TWL	Top Water Level
UF	Ultrafiltration
US	United States
USEPA	United States Environmental Protection Agency
UV	Ultraviolet
UVIC	University of Victoria

UVR	Ultraviolet Radiation
UVT	Ultraviolet Transmittance
WDD	Winter Day Demand
WFT	Water Filtration Plant
WSA(s)	Water Supply Area(s)
WTP	Water Treatment Plant

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EXECUTIVE SUMMARY

The CRD supplies bulk drinking water for residential, commercial, institutional, and agricultural uses to approximately 400,000 people throughout the Greater Victoria area by the Regional Water Supply (RWS) service. The RWS operates the watersheds, dams, reservoirs, treatment (disinfection) and transmission systems which supply municipal water systems at metered transfer points to each municipality and sub-regional water services. The CRD supplies water to sub-regional water services, including the Juan de Fuca Water Distribution Services, Saanich Peninsula Water Service, bulk water municipal customers, and eight First Nation communities. The overall organization of the RWS service and their major customers is shown in **Figure E.1.**

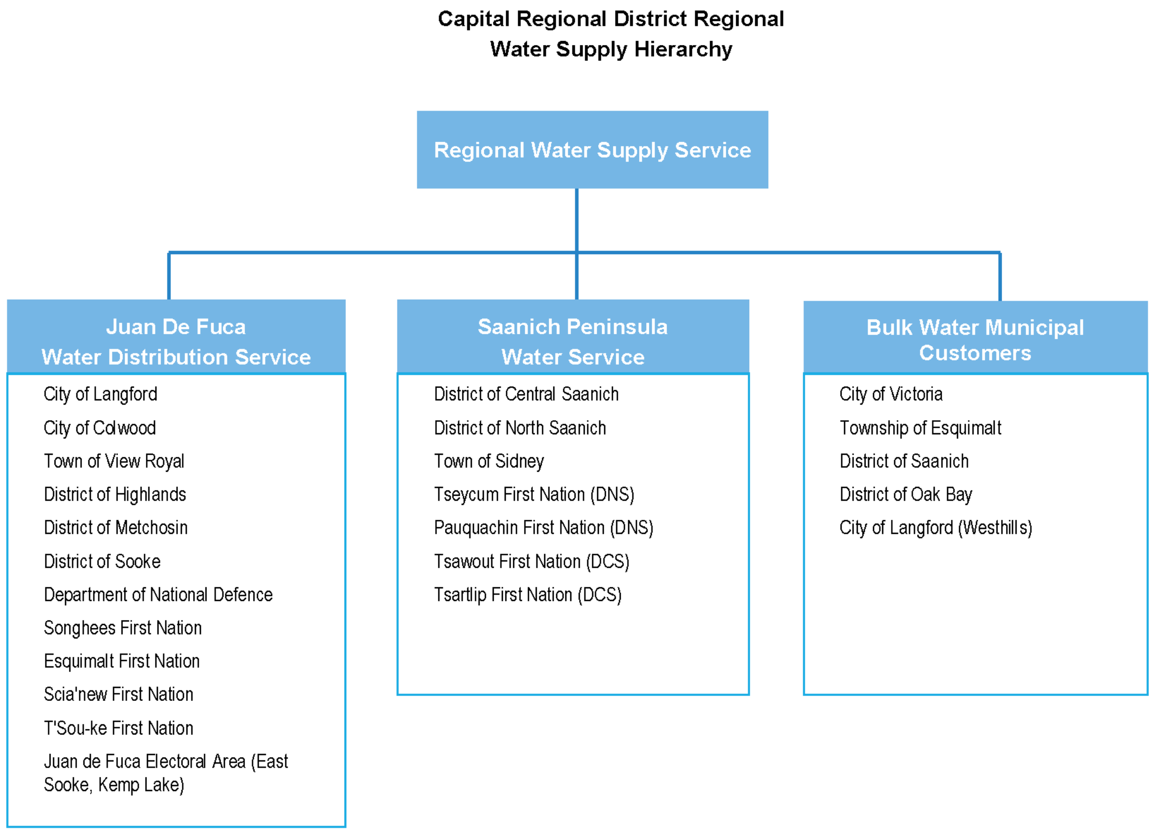


Figure E.1: Regional Water Supply Hierarchy

The primary water supply source for the RWS is the Sooke Lake Reservoir (SLR). The Sooke watershed supply is a high-quality, low turbidity source which enables the RWS to currently operate as an unfiltered source. Advanced disinfection facilities consisting of UV, chlorine and ammonia are used for treatment. The water produced by the RWS meets all Provincial and Canadian guidelines for drinking water quality. **Figure E.2** illustrates the components and service area of the RWS.

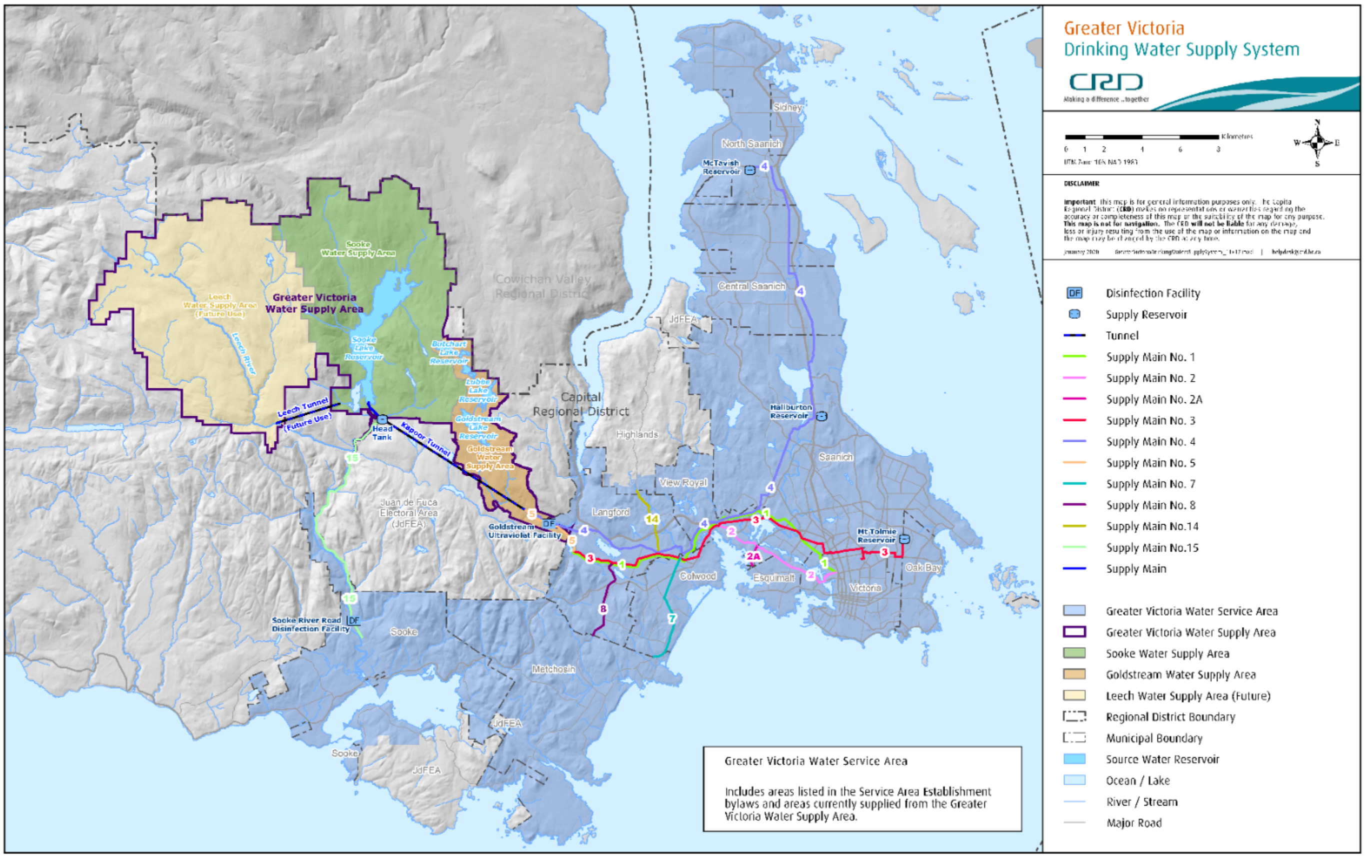


Figure E.2: RWS Water Service Area

The last Long Term Water Supply Plan for the Regional Water Service was completed in 1994 by Montgomery Watson and Dayton & Knight Ltd.(1994 Plan). The 1994 Plan outlined recommended improvements to increase the capacity and resiliency of the water supply and treatment facilities. Many of the critical improvements such as raising of the Sooke Lake Reservoir Dam, replacement of critical transmission mains, and installation of UV disinfection facilities to improve treatment were completed. This Master Plan for the Regional Water Service has been completed to update the 1994 Long Term Water Supply Plan, address key objectives identified in the 2017 Strategic Plan for the Regional Water Supply Service and sets out requirements for service upgrades based on a 2050 planning horizon.

2017 Strategic Plan

The CRD's 2017 Strategic Plan for Regional Water Service identified three primary commitments as follows:

1. To provide high quality, safe drinking water
2. To provide an adequate, long-term supply of drinking water
3. To provide a reliable and efficient drinking water transmission system

The Strategic Plan also identified Areas of Focus, strategic priorities, and actions including:

- CRD Board Priorities – Sustainable and Livable Region
- Climate Change Impacts – Mitigation and Adaptation
- Preparation for Emergencies and Post-Disaster Water Supply
- Supply System Infrastructure Investment – Renewing Existing and Preparing for New Infrastructure
- Planning for the Future Use of the Leech Water Supply Area
- Demand Management – Addressing Changing Trends in Water Demand

This 2022 Master Plan has been prepared to address the primary objectives and strategic priorities outlined in the 2017 Strategic Plan.

Concurrent Studies Informing the Master Plan

As part of this RWS 2022 Master Plan, three concurrent studies were completed by Stantec to inform this report. Key findings from these studies have been considered in this 2022 Master Plan. The studies and their content are summarized as follows and have been published by Stantec as stand-alone documents for use by the CRD.

Study 1 – Deep Northern Intake, Transmission and Treatment Study

This study investigated the option of installing a second intake to access deeper water in the north basin of the Sooke Lake Reservoir. The deeper intake would improve overall system resiliency and provide a more robust system in the event that the watershed is impacted by natural occurrences such as wildfires. Even though the proposed Deep Northern Intake would improve overall water quality, the deep intake would not enable the SLR to be drawn down below elevation 177m during a 1:50 year drought conditions without diversion of the Leech River to the SLR. Future diversion of Leech River water to SLR would assist in filling of the Sooke Lake Reservoir and reducing potential for water supply shortages during drought conditions. Excessive drawdown of SLR would also likely lead to water quality issues. The study also investigates transmission facilities necessary to connect the second intake to the existing RWS transmission system and outlines water treatment requirements.

Study 2 – Supply System Risk and Resiliency Study

Using the AWWA J100 methodology, the RWS has been assessed to determine potential vulnerabilities, risks, and threats to the water supply system associated with natural disasters, climate change, failure of equipment and other considerations such as damage to water supply infrastructure from seismic events.

Study 3 – Seismic Assessment of Critical Facilities (Phase 1)

A Phase 1 seismic assessment was completed for critical CRD water supply facilities. This study was a high-level screening assessment to evaluate the vulnerability of a limited number of priority CRD water supply facilities consistent with screening level assessment. The Phase 1 seismic assessment identified facilities that will require further Phase 2 detailed seismic evaluations and likely future seismic improvements pending the outcome of the Phase 2 evaluations.

Population Growth, Projected Water Demands, and Demand Management

Future population, within the CRD, has been projected using annual growth rates ranging from a low 1% annual growth to a high of 1.5% annual growth from the current population. The projections to 2050 planning horizon are outlined in **Table E.1**. A mid-range 1.25% annual population growth rate was selected for the purposes of planning future water supply facilities.

Table E.1: Projected Population of Regional Water Supply Service Area for Three Population Growth Scenarios

Year	Low (1.00%)	Med (1.25%)	High (1.50%)
2030	432,000	444,000	456,000
2050	527,000	569,000	615,000

The CRD has a very successful water demand management program. RWS water demands are amongst the lowest in British Columbia for a major metropolitan area. Per capita demands have declined from 559 L/c/d in 1998 to the current per capita demand of 337 L/c/d (combined residential, ICI and agricultural). **Figure E.3** illustrates the benefit of targeting even lower demand rates. With a modest reduction to 300 L/c/d, the Sooke watershed could supply enough water to meet demand until 2060. The red dashed line in **Figure E.3** depicts an estimate of the safe 1:50 year drought yield (67Mm^{3}Y) of SLR and illustrates the impact of different consumption levels on extending the life of the SLR. If demand continues at the current rate (no decline curve), the SLR source will be at its capacity limit by 2045. The CRD should continue to promote water conservation throughout the region and strive to lower per capita demands from current levels. Given the finite capacity of the Sooke watershed, planning for the future diversion of Leech River to SLR should commence within the next 10 years.

Recommendations arising out of this Master Plan include continued demand management and conservation programs on a regional basis with all RWS member municipalities including ICI and agricultural customers served by RWS.

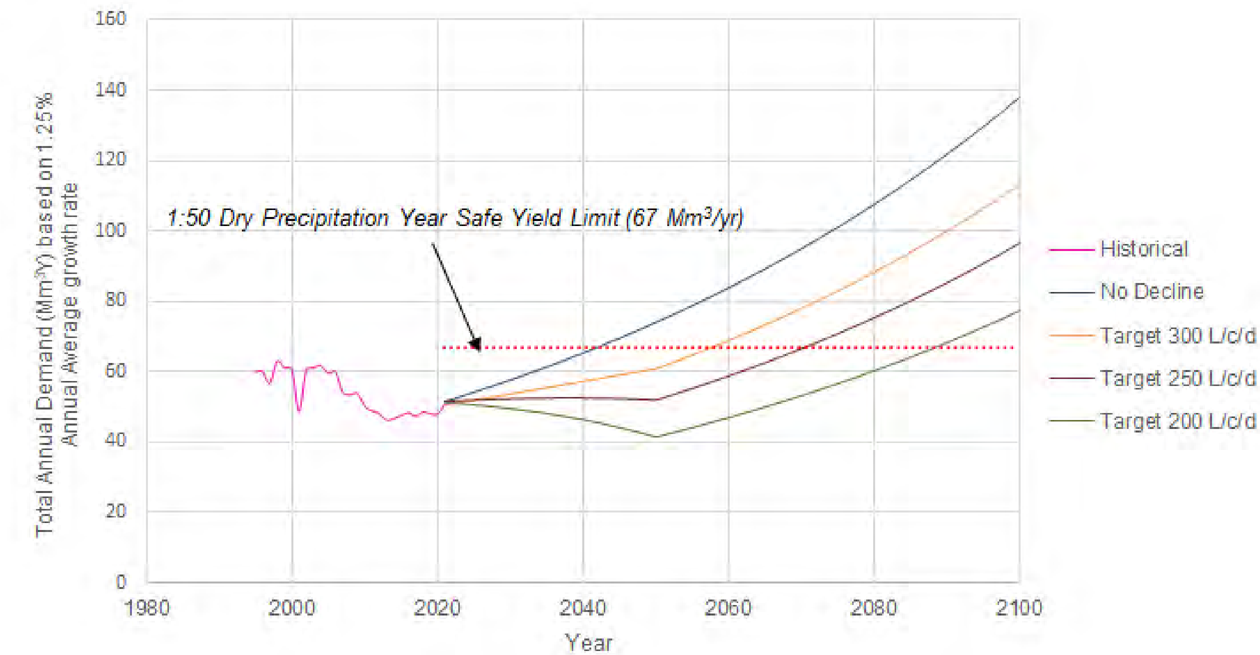


Figure E.3: Water Demand Projections

Water Quantity

A hydrological assessment has been completed for the Sooke and Leech watersheds. It is estimated that the Sooke watershed has the capability to supply an additional 40% increase in annual demand (up to 67 Mm^3 Y) over the current demand of 48 Mm^3Y. Projecting from the current annual demand level using a population growth rate of 1.25%, the Sooke watershed safe yield capacity will be reached before the 2050 planning design horizon in the year 2045. **Figure E.4** illustrates the Sooke Lake Reservoir water level response to varying increases in annual demand ranging from a 10 to 50% increase over current annual demand levels for a 1:50 year drought precipitation year followed by a year of normal precipitation.

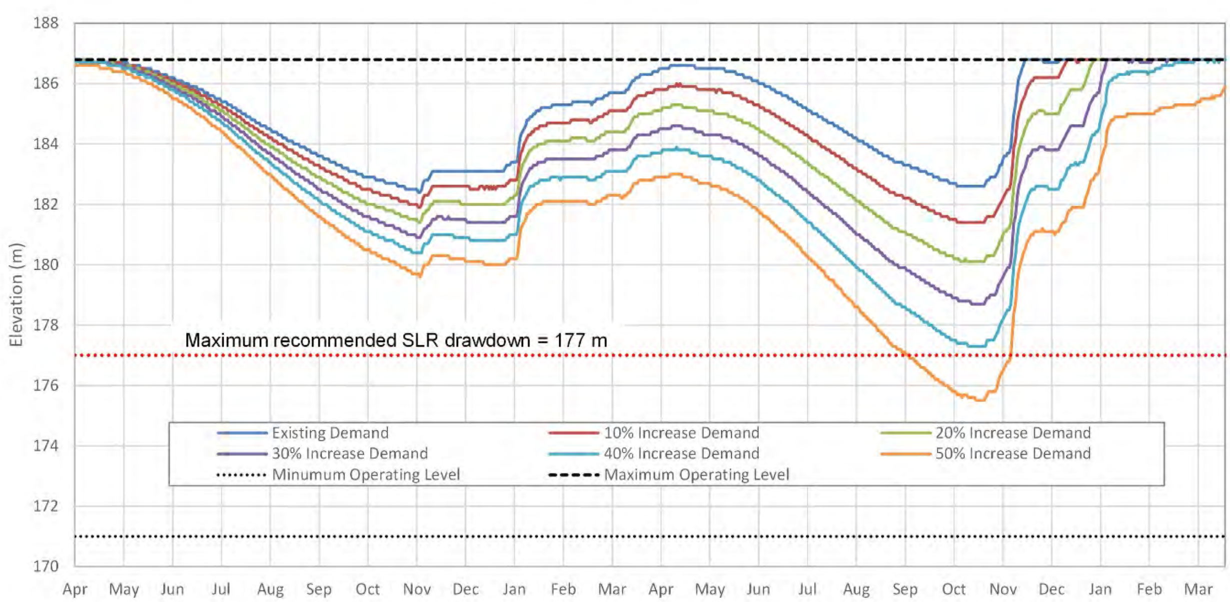


Figure E.4: Simulated Water Level in Sooke Lake Reservoir for a 1:50 Dry Precipitation Year

The SLR response assumes there is no multi-year drought condition experienced, which is consistent with historical records for this source. This figure indicates that an increase of 40% over current annual demand is the maximum that can be sustained without impacting the ability of the SLR to fill during a normal precipitation year following a 1:50 drought year.

Leech Watershed

The Leech watershed has been identified as a possible long-term additional supply for the RWS. The Leech watershed has a large catchment area of 9,600 hectares in comparison to Sooke watershed with 8,862 hectares. The Leech watershed has the capability of producing significant flows in the winter months. However, during the summer months the Leech River inflows are negligible. Development of storage on the Leech River or direct diversion will be required to augment flows to SLR. The amount of water that can be diverted to Sooke Lake will depend on the outcome of a further detailed hydrology and water balance model as well as discussions with the Province on the Environmental Flow Needs Policy requirements under the Water Sustainability Act. In lieu of construction of a dam, another possibility is a direct intake into Leech River and diverting flows to SLR via the Leech tunnel during periods of higher flow in the shoulder seasons depending on SLR water levels. Direct diversion would also improve SLR resiliency during drought conditions and assist in refilling of the SLR to protect against multi-year drought conditions impacting SLR water levels. This would require development of a reservoir water balance and operating model to determine the optimal operation of the combined SLR and Leech River diversions. This model would also assist in managing water levels in SLR for dam safety. The Deception Gulch Reservoir could be used to transfer flows to SLR, but upgrades to Deception Gulch Dam and spillway would be required as well as improvements to the Sooke Lake Reservoir Saddle Dam.

As population grows in the CRD water demands will also increase to a threshold limit and ultimately the finite capacity of the Sooke watershed will be reached and the Leech watershed will have to be brought into service. At a mid-range demand growth of 1.25% annually it is projected that the Leech water supply would have to be in service by the year 2045. This is the approximate year when demands will reach the 1:50 year safe drought yield of the Sooke watershed.

Planning for diversion of the Leech River should commence by 2032 as it can take some time to conduct the required planning, environmental studies, permitting, design, and construction of works necessary to develop this source. The Leech River source should be in service no later than 2042 several years ahead of time when the safe yield of the Sooke watershed is reached.

Goldstream Watershed

The Goldstream watershed and the series of upland lakes serve as a valuable secondary source with an available storage of 10 Mm^3. This storage is suitable for suppling RWS when the Kapoor Tunnel must be taken out of service for inspection and maintenance. Potential landslides in the Goldstream Canyon limit the use of this source during wet weather but if an intake to Goldstream Lake and a transmission main are constructed to Japan Gulch then this source could serve as a year-round supply and provide up to 20% of the current annual demand. Detailed hydrology was not completed for the Goldstream watershed as it primarily serves as a secondary supply for RWS.

Deep Northern Intake and Transmission

The possibility of installing an intake to extract water from the deeper basin of the SLR has been investigated and is discussed in detail in the *Deep Northern Intake, Transmission and Treatment Study* (Stantec 2021). Major findings of the study indicate that a deeper intake would be useful to provide a second redundant intake into the SLR which would improve system resilience and enable extraction of water below the existing intake tower low port elevation of 169 m. While the Deep Northern Intake provides improved water quality and resiliency during drought conditions, reservoir operation below levels of 177 m would make it more difficult to replenish the reservoir during average winter precipitation periods following a 1:50 year drought condition unless water from Leech is diverted to the SLR. In addition, drawing the SLR below 177 m could also lead to water quality issues from low water levels in some areas of the reservoir and siltation associated with shore erosion. The deeper intake does provide added benefits of better water quality, more stable temperature, and less likelihood of algae related water quality concerns. It would also serve as a redundant supply if the existing intake tower were to fail during a seismic event or if an extended multi-year drought condition is experienced.

A preliminary location has been identified for the deep northern intake approximately 2 km north of the boat launch. This intake location will be confirmed by further investigations including geotechnical, and further water quality sampling.

Connection of a proposed Deep Northern Intake could be made in a staged approach by connecting to the existing Head Tank downstream of Sooke Lake Dam. This would enable the CRD to draw from deeper sections of the SLR to better manage water quality as well as provide improved resiliency during emergency conditions or drought periods. Ultimately, the intake could be connected to a second transmission system (1994 Jack Lake alignment) connecting to Japan Gulch Reservoir to provide redundancy to the Kapoor Tunnel.

A variety of options have been investigated for connection of the proposed Deep Northern Intake to a secondary transmission system for Kapoor Tunnel. These include a second intake and gravity conveyance tunnel, pumped overland transmission mains along different alignments, a floating pump station and submerged marine pipeline, or a hybrid tunnel and pumped transmission system. The final selection of the preferred option can be made at the preliminary design phase, but all options are feasible. A lower level of service suitable to supply the year 2100 ADD would be suitable for sizing of this transmission main and reducing the overall pumping power required to deliver water via a transmission main corridor which was referenced in the 1994 Plan as the Jack Lake alignment. The intake, pump station, and transmission main for delivery of flows to the Head Tank would be sized for the year 2100 MDD so the pump station can serve as a complete redundant intake serving the Head Tank and Kapoor Tunnel. The second phase of the project would involve construction of additional booster pumping stations and the transmission main following the Jack Lake alignment.

A floating pump station is an option that could be considered for the Deep Northern Intake. A similar size facility was constructed for Seattle Public Utilities Chester Morse Lake pump station and large capacity facilities have been built overseas. The decision on which option to pursue, a fixed land-based pump station and micro tunneled intake or a floating pump station can be made at the preliminary design phase.

The Kapoor Tunnel has sufficient hydraulic capacity to convey demands to the year 2100. IWS has been effective in managing this critical asset through regular inspections and maintenance repairs.

One of the recommendations of this 2022 Master Plan is to complete a seismic assessment of the tunnel to assess its vulnerability to seismic events.

Water Quality and Treatment

The RWS currently operates as an unfiltered system with advanced disinfection. Water quality from SLR with UV, chlorine and chloramine disinfection meets current provincial *Drinking Water Treatment Objectives for Surface Water Supplies* and Health Canada's *Guidelines for Canadian Drinking Water Quality.* The current practice of advanced disinfection using Ultraviolet light, chlorine, and ammonia provides an acceptable level of protection for RWS water customers. However, the disinfection systems can become compromised if turbidity, colour, and organic levels increase due to wildfires in the watershed or other environmental factors including climate change.

Many previously unfiltered sources serving large populations across North America are now considering or have installed filtration. These include the Portland Bull Run source and the New York Croton source. The Comox Valley Regional District also recently commissioned a new water filtration facility in July 2021. The long-term plan for Metro Vancouver's unfiltered Coquitlam source is to install filtration. With the trend to more stringent water quality requirements, it is likely just a matter of time before provincial or federal health authorities will be requiring filtration on all surface waters serving major population centres. Filtration has other benefits including improving overall water quality consistency, improvements in transmission system water quality and providing operational resiliency during periods of changing raw water quality. Filtration will also be required once Leech River water is brought online. A recommendation of this 2022 Master Plan is to plan for construction of filtration by the year 2037.

Several feasible multi-barrier filtration and disinfection process options have been identified and evaluated including direct filtration, DAF plus filtration and membranes. Based on the existing SLR raw water quality and life cycle cost evaluation direct filtration is a viable option for filtration of Sooke Lake Reservoir water. Further evaluation including filtration pilot studies is required to confirm the process selection. If Leech River water is used in the future it may require the addition of a sedimentation, flotation, or other clarification process to treat elevated turbidity, organics, and colour. A recommendation is that a filtration piloting program be completed for Sooke Lake and blended Leech River and Sooke Lake Reservoir water.

Three sites were evaluated for future filtration facilities. A potential water filtration site has been identified adjacent to the Japan Gulch Reservoir. This site offers advantages as it is central to CRD operations, readily accessible, and the plant can easily be connected to Kapoor Tunnel and the RWS transmission system. Further refinement of the final filtration plant location will depend on a variety of factors including geotechnical investigations and preliminary design details. The final site can be determined once further investigations are completed. Under the current configuration of the water transmission system, the Japan Gulch location would be unable to provide filtered water for the District of Sooke. Providing filtered water for the District of Sooke would require the construction of a new east – west transmission main, or a second filtration plant could be constructed at the Sooke River Road Disinfection Facility.

Planning for filtration and pilot investigations should commence in the next several years with a goal to having new filtration plant online by 2037. This timeline will provide sufficient time for the CRD to complete the necessary studies, investigations, and preliminary designs for the proposed facilities.

Water Storage Tanks

Water storage is required in a regional transmission system to balance peak hour demands and to provide for discretionary emergency storage. Currently there are only three in-service storage tanks (Head Tank, McTavish and Mount Tolmie) in the RWS system and most of the system operates as an on-demand system providing flows for peak hour balancing and fire protection via the RWS transmission system from Sooke Lake Reservoir. This operational approach places significant hydraulic capacity demands on the CRD transmission system and consumes residual hydraulic capacity for future growth. Balancing storage for the transmission system combined with distribution system balancing and fire storage is the recommended approach to reduce hydraulic demands on the RWS transmission system and defer future capacity improvements in the transmission system. The Mount Tolmie storage tank does not have sufficient capacity to meet the peak hour balancing demands of the service areas. It is recommended that an additional peak hour balancing tank and pump station be constructed at Smith Hill to serve major demand areas including the City of Victoria, District of Oak Bay, and District of Saanich. This tank will conserve the RWS transmission system capacity and enable the system to operate at the same or higher HGL with pumping and defer future capital investments in transmission mains as well as water filtration plant capacity expansion. A second clearwell equalization storage tank is also recommended immediately downstream of a proposed future water filtration plant at Japan Gulch. This clearwell will balance flows through the filtration plant so the plant is only sized to provide maximum day demand rather than peak hour demand. Elevated balancing storage or service pumping at the proposed Japan Gulch Filtration Plant site could be constructed at an HGL of 169 m (same as Head Tank) so filtered water could be pumped to this TWL so the transmission system hydraulic operation would be the same as current operations.

The provision of transmission system balancing storage has mutual benefits for treatment. The filtration plant can be “downsized” to supply the maximum day demand rather than the peak hour demand. The future water filtration facilities would have to be built with an additional 35% capacity without the installation of balancing storage on the transmission system.

Options Screening and Alternatives Evaluation

The development of Alternatives for this 2022 Master Plan used a similar methodology to the 1994 Plan, but the methodology employed was more complex. The principal considerations for this 2022 Master Plan are:

1. Security of supply (i.e., redundancy)
2. Conveyance of water between SLR and Japan Gulch
3. Siting of the Filtration Treatment Plant

Eighteen (18) options were identified for infrastructure improvements (see **Table E.2)** that support the principal considerations shown above. These options were evaluated with advantages and disadvantages summarized for each option and a numerical scoring was applied to each option to result in an initial screening of the preferred alternatives for further evaluation including cost considerations.

Table E.2: Master Plan Options Evaluation

Category	Component	Option	Description
Supply	Sooke Lake Reservoir (Intake)	S1	Deep Northern Intake
		S2	Lake Bottom Marine Intake
		S3	Floating Pump Station Intake
	Leech River (Intake)	S4	Leech River Diversion Intake to Leech Tunnel
		S5	Leech River Dam
Raw Water Transmission	Leech River to Sooke Lake Reservoir	RWT1	Leech Tunnel to Deception Gulch Reservoir
		RWT2	Leech Tunnel to Sooke Lake Reservoir deep basin
	Sooke Lake Reservoir to Japan Gulch	RWT3	Sooke Lake Reservoir to Japan Gulch tunnel
		RWT4	Hybrid pumping/tunnel alternative
		RWT5	Overland route through Leechtown and Jack Lake – 3 PS (DNI PS + 2 PS)
		RWT6	Overland Council Lake Alignment – 3 PS (DNI PS + 2 PS)
		RWT7	Overland Malahat Alignment - 3 PS (DNI PS + 2 PS)
Filtration	Filtration Plant Sites	T1	Sooke Lake Reservoir site
		T2	Japan Gulch site
		T3	Japan Gulch site + Sooke River Road site
	Filtration Technology	T4	Direct Filtration with granular media filtration
		T5	Dissolved Air Flotation (DAF) with granular media filtration
		T6	Membrane Filtration

The 18 options were evaluated and scored for alignment with the 2017 Strategic Plan Commitments and Areas of Focus. Each option was evaluated and then scored based on meeting the three primary objectives outlined in the 2017 Strategic Plan, including:

1. Level of Service Maintenance/Improvement
2. Resolving a RWS infrastructure improvement needs gap
3. Redundancy and security of supply

The results of the options scoring evaluations are shown in **Table E.3.**

Table E.3: Options Scoring Evaluation

Option	Description	Raw Score	Weighted
S1	Deep Northern Intake	37	80
S2	Lake Bottom Marine Intake	33	73
S3	Floating Pump Station Intake	33	69
S4	Leech River Diversion Intake to Leech Tunnel	27	57
S5	Leech River Dam / Storage	32	67
RWT1	Leech Tunnel to Deception Gulch Reservoir	29	60
RWT2	Leech Tunnel to Sooke Lake Reservoir deep basin	31	66
RWT3	Sooke Lake Reservoir to Japan Gulch tunnel	36	75
RWT4	Hybrid pumping/tunnel	31	64
RWT5	Overland route through Leechtown and Jack Lake – 3 PS	30	62
RWT6	Overland Council Lake Alignment – 3 &1 PS	30	62
RWT7	Overland Malahat Alignment - 3 &1 PS	28	56
T1	Sooke Lake Reservoir site	31	68
T2	Japan Gulch site	36	78
T3	Japan Gulch site + Sooke River Road site	30	66
T4	Direct Filtration	32	68
T5	Dissolved Air Flotation (DAF) with granular media filtration	32	68
T6	Membrane Filtration	33	70

This assessment resulted in a recommended priority capital improvement program which is outlined in **Table E.4.** The major capital works included in recommendation include a proposed Deep Northern Intake and pump station on the SLR, a transmission main sized for ADD to supply water from SLR to Japan Gulch in the event of an outage of Kapoor Tunnel and a direct filtration water filtration plant at Japan Gulch. Transmission mains to improve the hydraulic level of service as recommended in the 2018 GeoAdvice report and a new balancing storage tank and pump station at Smith Hill are also included in the recommended capital works plan. **Figure E.5** illustrates the recommended plan of improvements.

Table E.4: Capital Works Recommendations

	Option	2022$	Mid-Point of Construction	Inflated $
Supply				
Deep Northern Intake/Floating Pump Station	S3	$72,505,000	12/31/2031	$87,929,000
Leech River Diversion	S4/RWT1	$16,700,000	12/31/2044	$26,204,000
Sooke Lake Saddle Dam Hydraulic Improvements	M1	$10,000,000	12/31/2044	$15,691,000
Water Treatment				
Japan Gulch Dam Decommissioning	T2/T4	$10,256,000	12/31/2033	$12,940,000
Direct Filtration	T2/T4	$736,155,000	12/31/2035	$966,353,000
Clearwell	T2/T4	$23,999,000	12/31/2036	$32,134,000
Treated Water Pump Station	T2/T4	$29,780,000	12/31/2036	$39,873,000
Japan Gulch Water Filtration Plant Stage 2 Balancing Tank	M2	$15,384,000	12/31/2036	$20,599,000
Raw Water Transmission Mains				
DNI Transmission Main to Head Tank	M3	$38,768,000	06/30/2032	$47,483,000
3rd Main - Sooke Lake Dam to Head Tank	M4	$7,384,000	12/31/2032	$9,134,000
Jack Lake - Head Tank to Japan Gulch + 2 PS @ 2100 ADD	RWT5*	$208,649,000	12/31/2037	$284,959,000
Goldstream Reservoir Connector				
Goldstream Dam to Japan Gulch	M5	$67,075,000	12/31/2030	$82,971,000
Stage 1 Balancing Tank	M6	$5,538,000	12/31/2030	$6,850,000
Treated Water Transmission Mains				
Phase 1 Upgrades	M7	$7,499,000	6/30/2024	$7,838,000
Phase 2 Upgrades	M8	$38,204,000	6/30/2029	$44,085,000
Phase 3 Upgrades	M9	$55,293,000	6/30/2039	$77,792,000
Phase 4.1 Upgrades	M10	$47,670,000	6/30/2049	$81,771,000
Phase 4.2 Upgrades	M11	$48,928,000	6/30/2049	$83,930,000
East-West Connector				
Option 2 Transmission Main	M12	$58,562,000	6/30/2036	$77,639,000
Storage Tank				
Smith Hill Tank	M13	$12,820,000	12/31/2038	$17,859,000
Smith Hill Tank Pump Station	M14	$17,148,000	12/31/2038	$23,887,800
Total Estimated Cost		**$1,528,000,000**		**$2,048,000,000**

*Jack Lake alignment with Pump Stations and transmission main sized for 2100 ADD Level of Service flow ~375 MLD

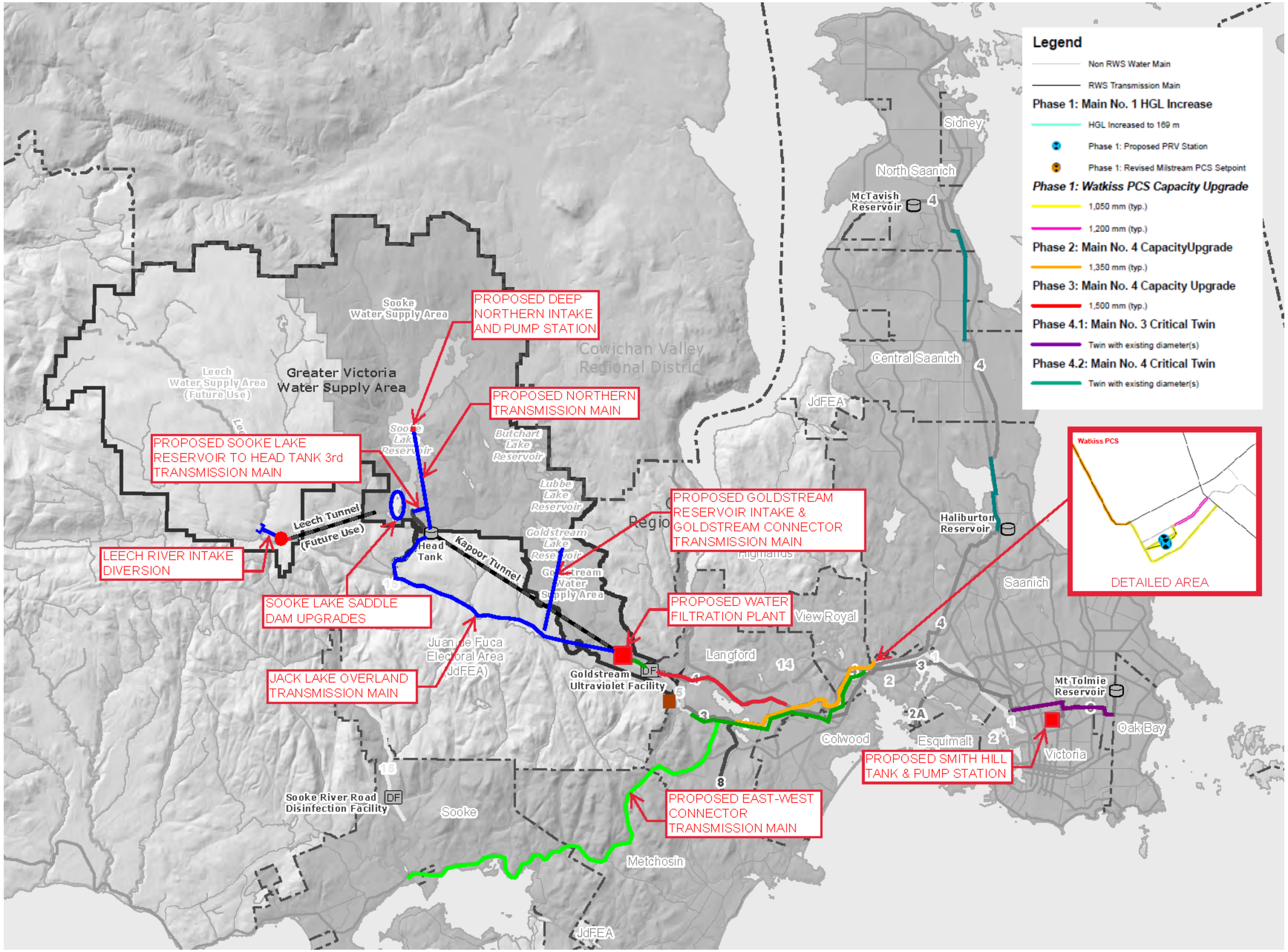


Figure E.5: Recommended RWS Capital Improvement Program

1.0 INTRODUCTION

1.1 Background

In October 2020 the CRD Integrated Water Services invited consultants to respond to a RFP to complete a Master Plan Update for the Regional Water Supply Service. The previous Long Term Water Supply Plan (1994 Plan) was completed in 1994 *(Montgomery Watson and Dayton & Knight Ltd*). Based on the 1994 Plan, "Alternative A" was adopted by the Greater Victoria Water Commission. Since that time a number of the recommended Alternative A projects have been completed which have improved the resilience and reliability of the water supply system as well as provided a higher degree of treatment by the incorporation of UV disinfection to protect against *Giardia* and *Cryptosporidum* pathogen.

The RWS was established under the RWS Establishment Bylaw No. 3322. The RWS supplies bulk drinking water for residential, commercial, institutional, and agricultural uses to approximately 400,000 people throughout the Greater Victoria area by the Regional Water Supply Service. The RWS operates the watersheds, dams, reservoirs, treatment (disinfection) and transmission systems which supply municipal water systems at transfer points to each municipality. The RWS raw water supply is one of the few remaining unfiltered sources in British Columbia serving a large population. The RWS also manages sub-regional water services, including the Saanich Peninsula Water Service and the Juan de Fuca Water Distribution Services, 8 First Nation communities, and Bulk Water Municipal Customers. The customers supplied by each system forming part of the RWS are shown in **Figure 1.1** below.

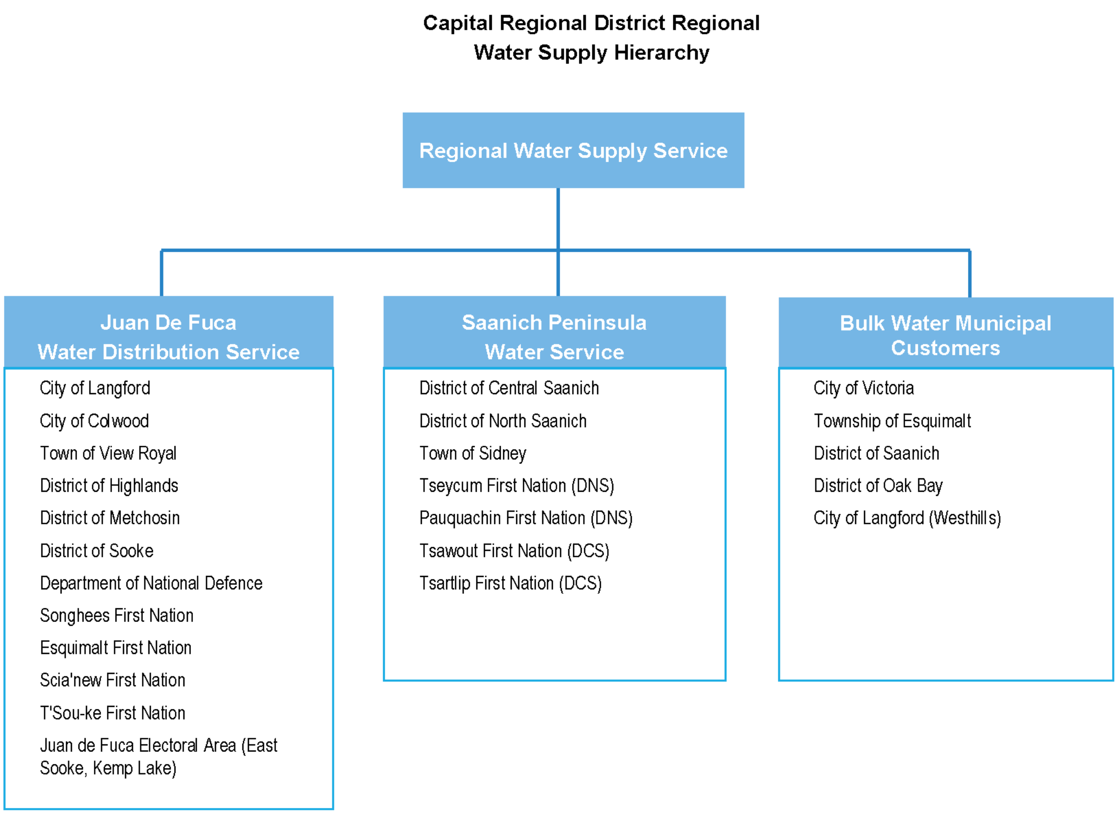


Figure 1.1: Regional Water Supply Hierarchy

An overall layout of the Regional Water Service Area is provided in **Figure 1.2**.

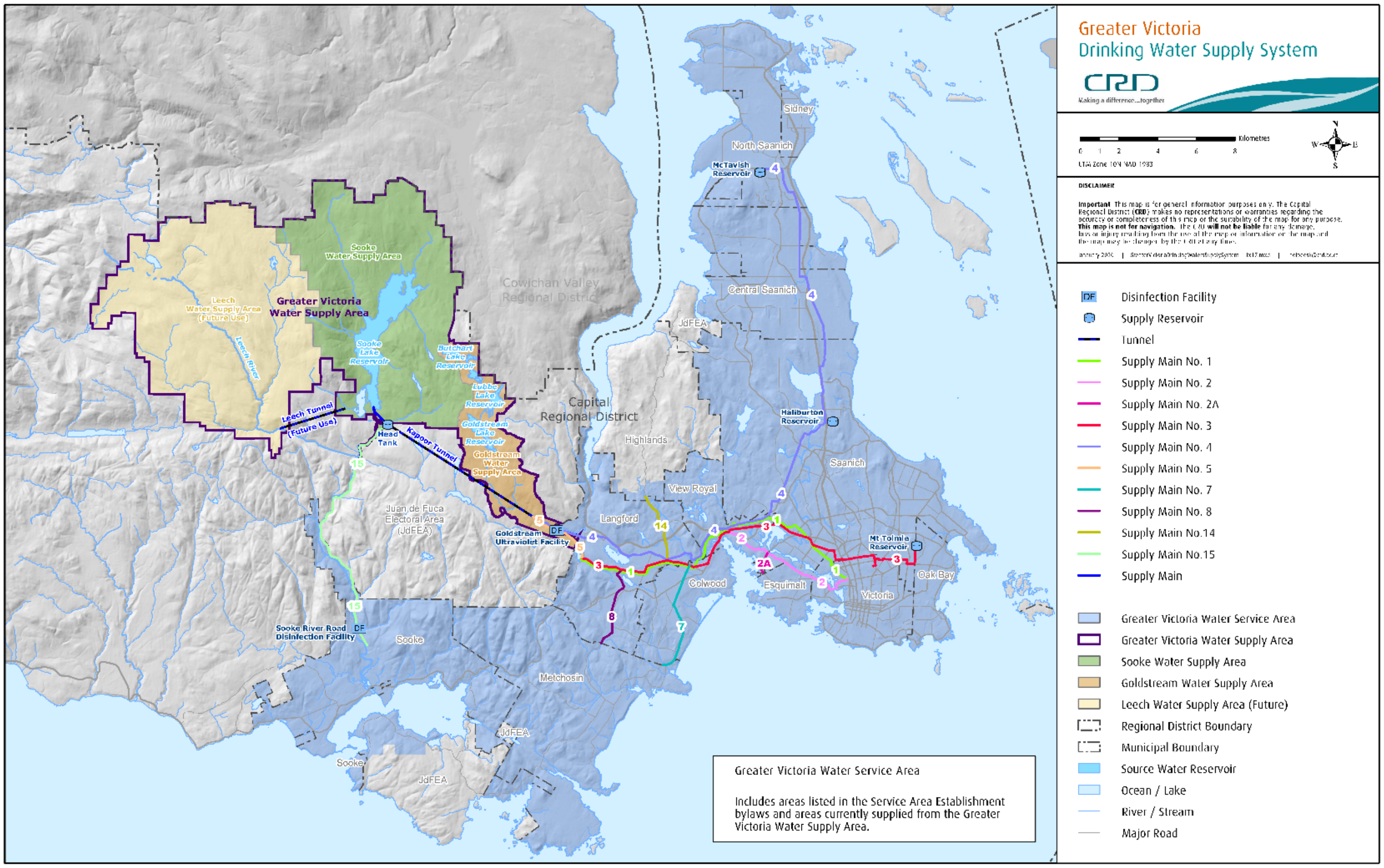


Figure 1.2: Overall Layout of Water Service Area

The major components of the RWS service include:

- Three watersheds including Sooke (primary), Goldstream (secondary) and Leech (planned for future use)
- 15 dams with 3 in Sooke watershed, 11 in Goldstream watershed, 1 off catchment, and 1 out of service.
- The 8.8 km Kapoor Tunnel to convey water from Sooke Lake Reservoir and the Leech watershed (future) to the transmission system
- 3.5 km Leech Tunnel (not in service, future use for diversion of Leech Watershed water)
- Two disinfection facilities using UV, chlorine and ammonia located at Goldstream Treatment Facility and Sooke River Road Disinfection Facility
- Approximately 120 km of transmission mains with varying materials and diameters ranging from 300 mm to 1530 mm
- Four storage tanks; a head tank downstream of Sooke Lake Dam to maintain system head; McTavish and Mount Tolmie balancing tanks; and Haliburton tank which is not in service
- Five major pressure control stations and numerous water meters

The RWS has historically provided cost effective service to customers which meets all Provincial and Federal drinking water quality objectives.

1.2 Assumptions and Limitations

This 2022 Master Plan has a defined scope of work and therefore some assumptions and limitations have been established. More significant assumptions and limitations are summarized as follows:

1.2.1 Master Planning

Best management practices for a water utility include the preparation and implementation of many types of plans including Strategic Plan, Master Plan, Capital Plan, Business Plan, Business Continuity Plan, Asset Management Plan and Emergency Management Plan. Each type of plan has a specific scope or focus and ultimately the plans should be integrated to result in a comprehensive management plan.

This assignment is specifically a Master Plan, which has been defined by AWWA as follows:

> *"…a utility a master plan usually documents medium-term and long-term plans for major projects, provides a comprehensive description of significant capital improvements, the concepts that justify their inclusion, and their relation to urban design, infrastructure, service delivery, and regulatory requirements. It consists of images, texts, diagrams, statistics, reports, maps, and aerial photos that describe how specific projects will be developed. Ideally, it provides a structured approach and creates a clear framework for planning and decision making."* (Water Utility Management, Manual of Water Supply Practices M5, 3rd Ed., AWWA)

The preparation of a Master Plan utilizes a process whereby the level of service expectations is identified (i.e., legislated obligations) and the existing system is weighed against a variety of expectations resulting in deficiencies for which mitigation is identified. These deficiencies tend to be related to engineered assets (e.g., enhanced water treatment process) that are required to supplement the existing assets. Although there is some relationship between an asset management plan and a master plan, an asset management plan is generally focused on the management of existing assets (e.g., asset capacity, condition, renewal/replacement, etc.) and improvements related to existing assets that are in-service.

1.2.2 Water Sources

The 1994 Plan identified many options for water supply within lands owned at the time by the CRD and other sources beyond the limits of ownership. Although those sources of water may be considered in the future, this 2022 Master Plan was limited toward optimizing the existing sources of water from the three existing watersheds (Sooke, Goldstream, and Leech) before sourcing water beyond these limits. Further, other long-term opportunities for water supply include the following, but detailed assessments of these sources were not included in this 2022 Master Plan:

- Desalination
- Groundwater
- "Off-catchment" land/watersheds

1.2.3 Financial

This Master Plan established a list of system deficiencies and high-level cost estimates for many options that have been identified. Identification of funding sources and potential senior level government grant opportunities are beyond the scope of this assignment. Opinions of Probable Cost should be updated as additional investigations and detailed engineering are completed.

1.2.4 Ongoing Master Planning

Best management practices for a water utility include routine and ongoing reassessment of earlier plans. In preparation of this 2022 Master Plan, many assumptions have been made and it is recommended that the Master Plan be updated on a regular schedule. Examples of issues that may influence or change the outcomes of this 2022 Master Plan include serviced population and the rate of growth, demand for water, changes in water use, land use policies, and drinking water standards and the results of more detailed modelling and analyses. A recommendation of this 2022 Master Plan is to conduct a review of the plan on a not more than 10-year schedule to monitor the progress of recommended improvements.

1.2.5 Regional Water Supply Service Area

This 2022 Master Plan was developed based on the existing service area of the Regional Water Supply Commission as established by Bylaw No. 2539/3371, a Bylaw for the Establishment and Operation of a Regional Water Supply Commission. Should the service area be increased in the future, then the Master Plan should be revised for implications such as increase in service population, water demand, conveyance, etc.

1.2.6 Legislation and Regulation, and Sector Guidelines and Standards.

The 2022 Master Plan was developed based on the existing legislation and regulation specifically related to drinking water (e.g., BC Drinking Water Protection Act, BC Drinking Water Regulation). Although there are many legislative obligations for water suppliers (e.g., worker safety, etc.) they will be identified and addressed in subsequent plans (e.g., preliminary, and detailed design phases). Many technical resources exist for drinking water guidance and standards. These resources are prepared by a variety of provincial, national, and international organizations such as Health Canada and the USEPA; while they are not necessarily required to be applied, they do provide good guidance on standard practice.

1.2.7 Existing Water System and Land Ownership/Rights

This 2022 Master Plan was developed based on the existing water system assets being located on lands owned by the CRD or lands for which the CRD has rights to occupy. Any land ownership or rights issues including negotiations and compensation have not been included in this 2022 Master Plan. If there is need to purchase land for construction of any recommended works, these costs are not included in the estimates.

1.2.8 Detailed Dam Assessments

The 2022 Master Plan did not include conducting detailed water supply dam assessments. The CRD diligently manages the dam assets related to the RWS system. The CRD has undertaken a variety of studies including dam safety reviews, capital improvements, preliminary failure mode analysis, etc., and the conclusions and recommendations have been added to the Master Plan by CRD to ensure that it is comprehensive.

1.2.9 Capital Cost Estimates

This 2022 Master Plan provides planning level evaluations and cost estimates for various options assessed during the study consistent with industry standards for similar work. This report is to be used by the CRD to provide an overall plan for improving the reliability and resiliency of the water supply system. Specific conclusions and recommendations are provided in later sections of the report along with recommendations for further investigations and preliminary engineering to refine concepts and costs.

1.3 Regional Water Supply 2017 Strategic Plan

The CRD completed a Strategic Plan for the Regional Water Supply in 2017. The Strategic Plan identified three primary commitments as follows:

1. To provide high quality, safe drinking water
2. To provide an adequate, long-term supply of drinking water
3. To provide a reliable and efficient drinking water transmission system

The Strategic Plan has identified Strategic Areas of Focus including :

- CRD Board Priorities – Sustainable and Livable Region
- Climate Change Impacts – Mitigation and Adaptation
- Preparation for Emergencies and Post-Disaster Water Supply
- Supply System Infrastructure Investment – Renewing Existing and Preparing for New Infrastructure
- Planning for the Future Use of the Leech Water Supply Area
- Demand Management – Addressing Changing Trends in Water Demand

The Strategic Plan identified the planning horizon to the year 2050.

1.4 Master Plan Objectives and Planning Horizon

The 2017 Strategic Plan identified commitments and Areas of Focus and an update to the previous planning studies and the 1994 Plan. The CRD has made significant improvements to the system since completion of the 1994 Plan and this 2022 Master Plan will update the findings of the previous plan and include other priorities that have developed in the Regional Water Supply since 1994.

The 2022 Master Plan includes the following major topics of study:

- Water Sources and Supply
- Water Quantity
- Water Quality and Treatment
- Water Transmission and Storage

Relevant and related topics include the potential effect of climate change on the RWS system and potential mitigations. The CRD has also undertaken a number of relevant studies related to dam safety reviews and this information is not considered as part of the 2022 Master Plan. However, the CRD has provided relevant background information on the dams for inclusion in this report for context and completeness. This 2022 Master Plan also provides relevant or future topics of study for the purposes of outlining the requirements for future work to refine the recommendations in this study.

The planning horizon for the 2022 Master Plan is to the year 2050. This horizon is considered a reasonable horizon for planning of water supply facilities. Some of the facility components, such as the proposed deep northern intake into Sooke Lake Reservoir and transmission main upgrades, would be better served by a longer planning horizon because the incremental costs to install a larger intake pipe are not significant and the design service life for intake pipes and transmission mains is typically 75 to 80 years. For the intake, a planning horizon to the year 2100 has been selected. It is good practice to look beyond the planning horizon of 2050 when assessing the long-term adequacy of water sources so the CRD can plan for additional sources and related infrastructure. A similar long term horizon was also considered when the Kapoor Tunnel was planned.

1.5 Concurrent Studies Informing the 2022 Master Plan

Three concurrent studies were completed to inform the 2022 Master Plan. The studies and their content are summarized as follows and have been released as stand-alone documents for use by the CRD.

Study 1 – Deep Northern Intake, Transmission and Treatment Study (IWS Report No. 1187)

This study investigated the option of installing a second intake to access deeper water in the north end of the Sooke Lake Reservoir. The study also investigates transmission facilities necessary to connect the second intake and water treatment requirements for Sooke Lake Reservoir and Goldstream watershed. A second intake is considered as an option to increase supply resiliency and access better water quality in the deeper northern basin of the Sooke Lake Reservoir. It also provides a second seismic resilient intake should there be an issue with the existing intake tower or failure of the Sooke Lake Dam.

Study 2 – Supply System Risk and Resiliency Study (IWS Report No. 1188)

Using the AWWA J100 methodology, the RWS has been assessed to determine potential risks, vulnerabilities and threats to the system associated with natural disasters, failure of equipment, and other considerations. This report helps inform the Master Plan in terms of identifying additional measures necessary to improve the reliability and resiliency for the water system, consistent with the 2017 Strategic Plan.

Study 3 – Seismic Assessment of Critical Facilities Study (Phase 1) (IWS Report No. 1189)

A phase 1 seismic assessment was completed for critical RWS facilities. This study was a high-level screening assessment to evaluate the vulnerability of primary RWS facilities consistent with a screening level assessment. It is noted that this study was a Phase 1 assessment which identified facilities that will require further Phase 2 detailed seismic evaluations.

1.6 Reference Information Provided by CRD IWS

CRD IWS provided the study team with significant background data including reports, water demand information and drawings. This information was uploaded to a dedicated project Sharepoint site for use by the study team. The list of information was voluminous; therefore, only a partial listing of previous significant work referenced is provided below.

- IWS Regional Water Supply – 2017 Strategic Plan, CRD
- 2012 Strategic Plan for Greater Victoria Water Supply System, April 2012, CRD
- 2004 Review of Strategic Plan for Water Management, CRD
- Greater Victoria Water District – Long Term Water Supply Plan, Montgomery Watson and Dayton and Knight Ltd., January 1994
- RWS Transmission Mains Hydraulic Capacity Analyses – Final Report, GeoAdvice Engineering Ltd., December 2020
- Various CRD Staff Reports including:
  - 2001-108: Use of Leech River to Supplement Sooke Lake Reservoir
  - 2001-40: History of Leech Tunnel
  - 2002-12: Deception Gulch Reservoir Change of Designated Use
  - 2003-72: Seismicity Hazard , Leech River Fault
  - 20-09:2021: Operating and Capital Budget
  - 2017-21: Post Disaster Emergency Water Supply and Distribution
  - 2019-05: Fisheries Water Release Program
  - 21-155: Demand Management Program Update
  - 2016-18: Limitation and Implications of Additional Raising of Sooke Lake Dam
- Historical Water Consumption Data, CRD
- Historical Sooke Lake Reservoir Water Levels, Precipitation Data, CRD
- CRD Water Quality Division Data
- CRD Watershed Mapping
- Archive drawings of existing major CRD water supply facilities

1.7 Work Arising Out of Recommendations from 1994 Long Term Water Supply Plan (1994 Plan)

1.7.1 Major Recommendations (Alternative A)

The 1994 Long Term Water Supply Plan investigated a number of "Alternatives" for improving the Regional Water Supply. "Alternative A" (see **Figure 1.3**) was selected as the recommended option for implementation.

"Alternative A" included the following capital works recommendations as listed in **Table 1.1**. Table 1.1 also provides a summary of the capital work completed since 1994 arising out of the recommendations from the 1994 Plan. Several of the key recommended projects were modified pending further engineering study and these include :

- The Goldstream UV Disinfection Facility was constructed instead of ozonation at Sooke Lake Reservoir. Advances in UV disinfection made it more practical and cost effective to install UV instead of ozonation.
- Main No. 15 and the Sooke River Road Disinfection Facility were constructed before the City of Langford to District of Sooke watermain..
- The transmission main from Leech Tunnel outlet to Sooke Lake Reservoir was not constructed as further detailed water sampling of Leech River was required and SLR is able to supply water for at least another 25 years. Diversion of Leech River water to SLR is discussed further in this 2022 Master Plan.
- Table 1.1 provides further information on the 1994 Plan projects status under the comments column including recommendations on whether specific projects should be completed in future years.

The CRD has completed most of the recommended projects outlined in the 1994 Plan. Major works include raising of Sooke Lake Dam, installation of enhanced disinfection (UV), and improving the capacity and the reliability of the regional transmission system. Other major works, including connection of the Leech Watershed, a second transmission system from Sooke Lake Reservoir to Japan Gulch, and filtration are yet to be completed and are investigated further in this 2022 Master Plan.

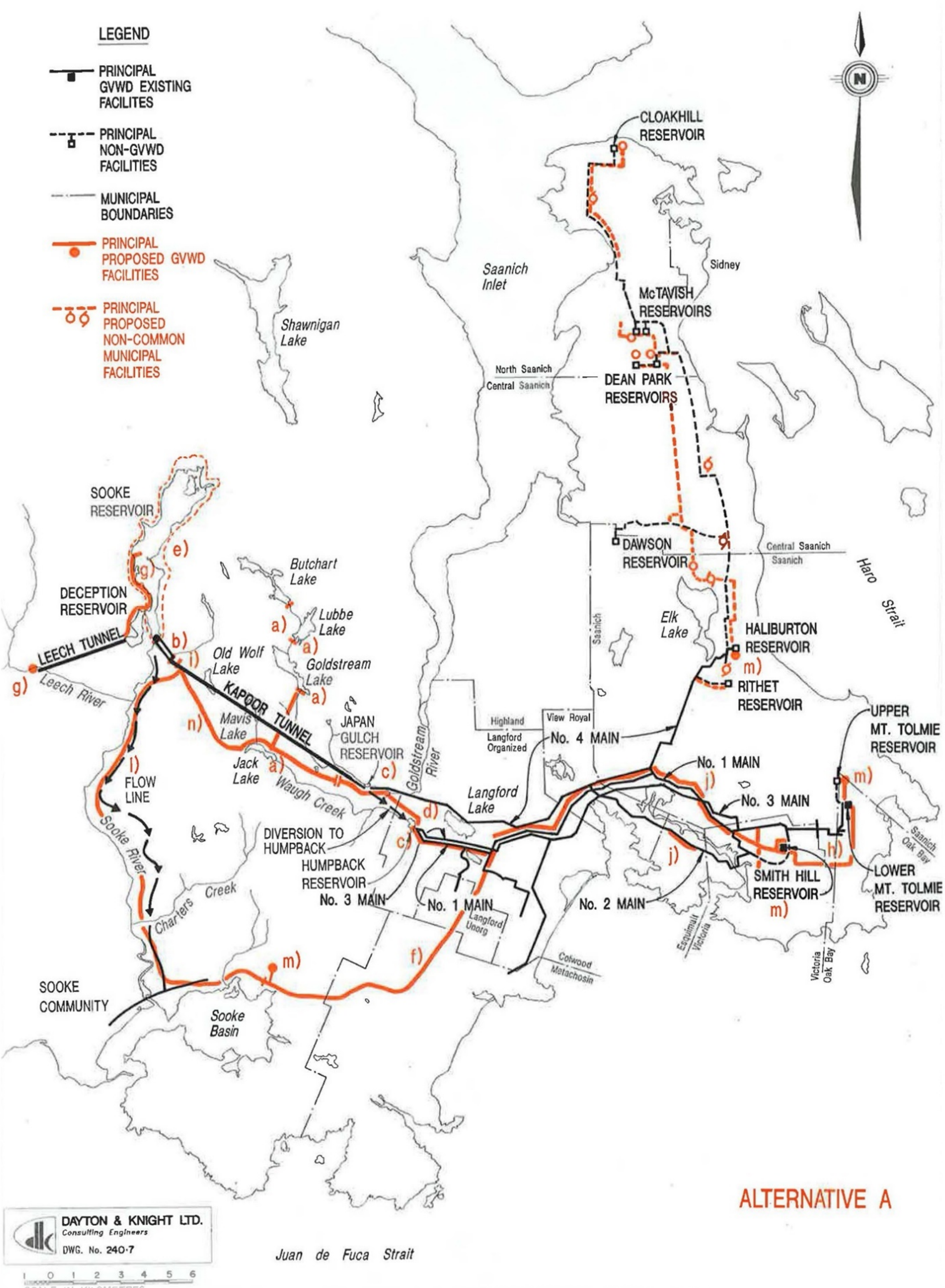


Figure 1.3: Diagram of 'Alternative A' – 1994 Long Term Water Supply Plan (Montgomery Watson / Dayton & Knight Ltd.)

Table 1.1: 1994 Long Term Water Supply Plan (Montgomery Watson / Dayton & Knight Ltd.) "Alternative A" Capital Works Recommendations

Item	Recommendation	Capital Project Name	Year Constructed	Status	Comments	2022 Master Plan Commentary
a1)	Rehabilitate three Upper Goldstream Reservoirs (Butchart, Lubbe and Goldstream Reservoirs)	Goldstream Dams Rehabilitation	1995	Completed	Capital project included Butchart Dam #1, 2 & 5, Lubbe Dams #1-4, Goldstream Dam and Japan Gulch Dam (not included in report recommendation)	Work was completed to improve reliability of this critical secondary source.
a2)	Connect Goldstream Reservoirs with a 600-750 mm transmission main to Kapoor Tunnel outlet for use during emergencies and tunnel maintenance	NA	Not completed	No action	No action since 1994. This pipeline is still an option and should be evaluated further to provide a secondary supply to RWS when Kapoor Tunnel is taken offline for inspection.	This is included as a recommendation of the 2022 Master Plan with connection to Japan Gulch.
a3)	Pilot test water filtration for Leech River/Sooke Lake Reservoir water integration	Leech River-Sooke Lake Reservoir Mixing Experiment	2008	Started (not completed)	Preliminary PowerPoint was completed by UVic but not in sufficient detail for planning of water treatment facilities. Further piloting is recommended as part of this Master Plan.	Recommendation of 2022 Master Plan. Blending will be assessed during the pilot program.
b)	Ozonation	UV Disinfection System Installed instead of ozonation	2004	Completed	Ultraviolet facility (alternative to ozonation) was constructed at Goldstream Disinfection Facility location, downstream of tunnel outlet adjacent to Japan Gulch Reservoir.	UV is a more cost-effective treatment for unfiltered source water than ozone. Once the final filtration process is selected the requirement for UV will be assessed.
c1)	Replacement of Humpback Reservoir with a smaller flood control facility	Deactivation of Humpback Dam	1999	Completed	Works included Humpback Dam stabilization berm and Humpback Reservoir overflow structure and channel along Kapoor Main (Humpback Dam and reservoir out of service)	NA
c2)	Decommission/remove Japan Gulch Dam	NA	Not completed	No action	Japan Gulch Dam rehabilitated in 1995 (refer to Item a1 above). Used to accept Goldstream River water during inspections and maintenance of Kapoor Tunnel.	Japan Gulch is critical reservoir for transfer of Goldstream water to RWS until Goldstream transmission main is constructed.

Item	Recommendation	Capital Project Name	Year Constructed	Status	Comments	2022 Master Plan Commentary
d)	Connect Kapoor Tunnel to No. 1 and No. 3 Mains	Kapoor/Humpback Watermain	1996	Completed	Main No. 5 installed from Kapoor Tunnel outlet to Humpback Reservoir (included Humpback PCS)	NA
e)	Raise Sooke Lake Reservoir	Raising Sooke Lake Reservoir	2002	Completed	Dam raised to provide additional storage.	Raising of SLR has provided source reliability consistent with 2017 Strategic Plan.
f)	Langford to Sooke Community water main	New Supply Pipeline to Sooke (3 Phases)	2007-2009	Completed	Alternative alignment (Main No. 15) installed from Sooke Head Tank to the District of Sooke (includes SRRDF).	Recommendation to install this main included in 2022 Master Plan (subsequent to Filtration Plant construction)
g1)	Leech River diversion Stage 1 to north end of Sooke Lake Reservoir	NA	Not completed	No action	No action since 1994. Further investigation required to determine best method for diversion of Leech River water to Sooke Lake Reservoir.	Diversion will be reviewed further as part of hydrology study and reservoir operating rules for combined Leech /SLR supply. It may be possible to transfer Leech water through DGR to SLR.
g2)	Leech River diversion Stage 2 - Pressurize Leech Tunnel to increase hydraulic capacity	NA	Not completed	No action	No action since 1994. This will require further investigation pending investigation of direct diversion of Leech River or construction of dam on Leech River.	This will be explored in hydrology study see g1) commentary above. Leech River not required for 20 years.
h)	Plan phase 3 work in Victoria to increase supply to south Victoria, Oak Bay, and southeast Saanich	NA	Modeling completed	No action	No action since 1994.	Hydraulic modeling has been completed and upgrades to Main No. 3 are recommendation of 2022 Master Plan. See Section 6.1.3.
i)	Water filtration plant at Kapoor Tunnel inlet	NA	Not completed	No action	Refer to CRD IWS Report No. 279 -Compliance with Surface Water Treatment Rule for Filtration Avoidance. Installation of UV enables compliance with SWTR Filtration Avoidance for most criteria as well as IHA requirements.	Future water filtration recommended to improve resiliency and a potential site recommended as part of this 2022 Master Plan.

Item	Recommendation	Capital Project Name	Year Constructed	Status	Comments	2022 Master Plan Commentary
j)	Progressively replace No. 1 Main with larger diameter steel system	Main No. 1 Replacement program	1994-2006	Completed	Entire Main No. 1 replaced in 12 phases	
k)	Deep Intake at northern basin of Sooke Lake Reservoir	NA	Not completed	No action	No action since 1994. Stantec report in 2021 studied this further.	Study completed to assess options.
l)	Second major transmission system from Sooke Lake Reservoir	NA	Not completed	No action	Alignment assumed to follow Sooke River to District of Sooke and loop back to the City of Langford. Partially completed (Main No. 15 installed)	An east west Juan De Fuca Water Services supply main is proposed to supply filtered water to Sooke after new plant is constructed. Overland “Jack Lake” alignment recommended in this Plan
m1)	Increase system storage volume - Sooke Community Tank	Sooke Community Water System Improvements	1998	Completed	JDFWD service improvements completed.	NA
m2)	Increase system storage volume - New Upper Mount Tolmie Tank	NA	Not completed	No action	No action since 1994. Not required.	Not required
m3)	Increase system storage volume - Haliburton Tank Expansion	NA	Not completed	No action	Haliburton Tank out of service since 2017	Not required.
m4)	Increase system storage volume - Smith Hill "Reservoir"	NA	Not completed	No action	No action since 1994.	Tank recommended at Smith Hill as part of this Master Plan.
n)	Diversion of Upper Goldstream Reservoirs to Sooke Lake Reservoir	NA	Not completed	No action	No action since 1994. Not necessary if pipeline from Goldstream to Japan Gulch is constructed. Diversion to Japan Gulch rather than Sooke Lake.	Goldstream Reservoirs will be diverted to recommended filtration plant site at Japan Gulch; transmission main included in 2022 Master Plan.

2.0 EXISTING WATER SYSTEM

2.1 Description of Existing Regional Water Supply System

2.1.1 Water Sources

Figure 2.1 illustrates the three contiguous watersheds that collectively form the CRD's Greater Victoria Water Supply Area (GVWSA). The GVWSA has an area of 20,611 hectares of protected, forested land largely owned and managed by the CRD. This area is the supply for the current and potential future water needs of the CRD's Regional Water Supply. The Sooke watershed is the primary water source, with the Goldstream watershed serving as a secondary or emergency backup source when the Kapoor Tunnel is out of service for inspection and maintenance. The Leech River Watershed is intended to provide additional water to meet future needs. A storage dam on the Leech River has not been constructed but the Leech tunnel has been constructed to enable future use of this source. Additional infrastructure will be required to enable effective capture of this water for use in the RWS system. Collectively, the GVWSA extends over an area of 20,611 hectares of protected, forested land largely owned and managed by the CRD.

There are also several off catchment sources including Jack Lake, Mavis Lake, Cabin Pond and Charters River which have been used for water supply in the past but are no longer used.

The watersheds are shown in Figure 2.1. **Table 2.1** provides the net watershed areas and other information for each of the contributing watersheds.

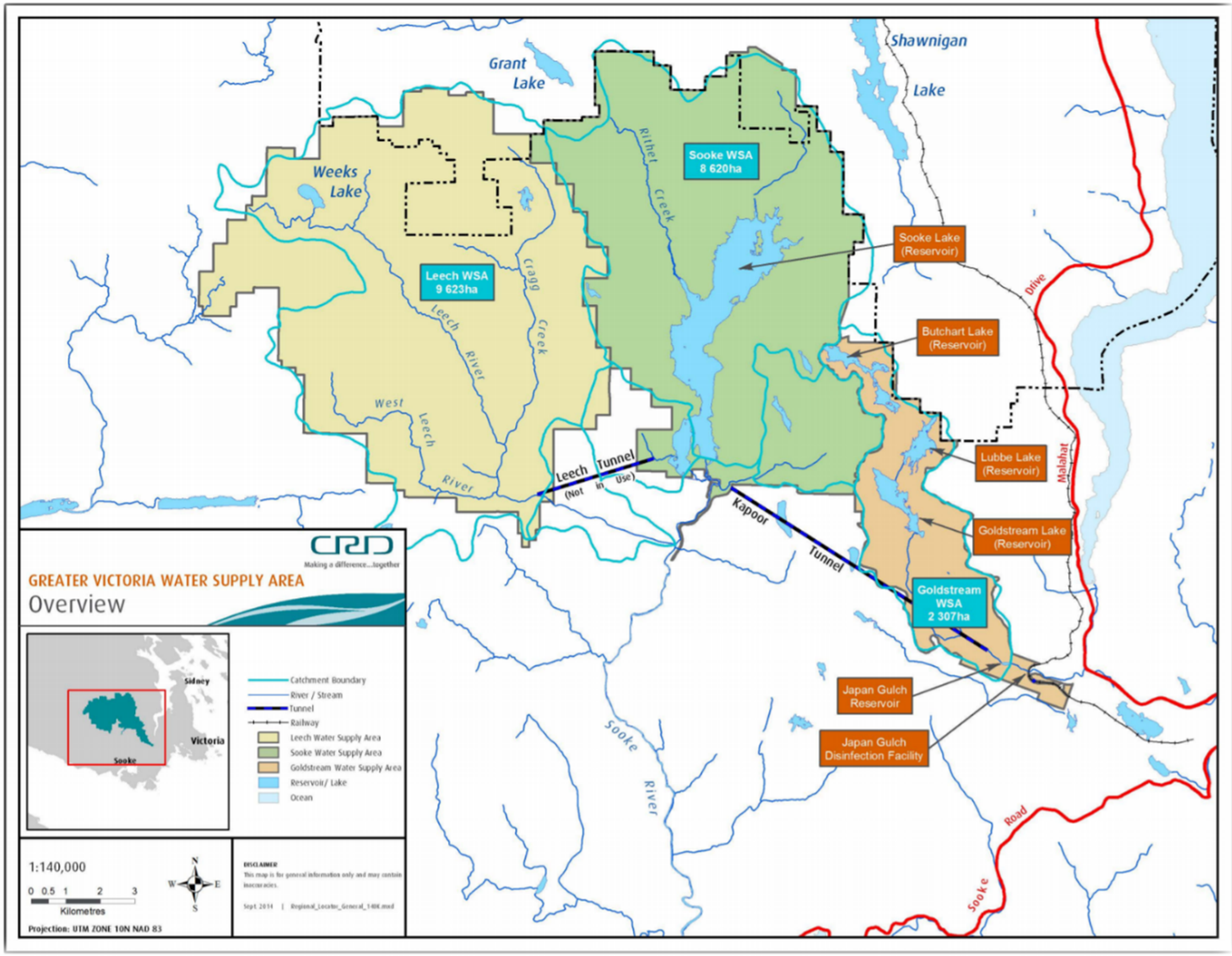


Figure 2.1: Greater Victoria Water Supply Area

Table 2.1: Watershed Information

Watershed	Catchment Area (ha)	Reservoir	Available Storage Volume (Mm3)	Comment	
				Quality	Quantity
Sooke	8,682	Sooke Lake	92.7	High quality, especially in hypolimnion. Extensively monitored.	Accessible volume limited by existing intake elevation and finite watershed basin yield.
Goldstream	2,300	Butchart Lake	3.3	High quality. Monitored monthly (Goldstream) and quarterly (Butchart).	Can supply sufficient water during maintenance of Kapoor Tunnel, but storage is limited. Has up to 10 Mm^3 available for use. Not currently available for use in JDFWD Service and District of Sooke.
		Lubbe Lake	3.0		
		Goldstream Lake	3.6		
		Japan Gulch	0.08	High quality except if slides encountered on Goldstream River or algae due to shallow reservoir depth.	Minimal storage in Japan Gulch but storage reservoir is supplied from Goldstream River and releases from higher level Goldstream dams. Japan Gulch Reservoir HGL 132 m provides driving head to RWS when Head Tank HGL 169 m out of service.
Leech (Future)	9,600	Possible future reservoir or direct diversion from Leech River via Leech Tunnel	None	Generally good quality but has higher colour levels. Long-term watershed restoration and rehabilitation in progress.	Use of this source during summer requires development of a new impoundment dam and reservoir. Transferable flows to Sooke Lake Reservoir are possible by direct diversion during higher flow seasons. Potential to divert to Deception Gulch Reservoir and then SLR.
Council Creek	1,068	Council Lake (No dam)	No firm reservoir volume available	High quality	Has been used as a Sooke Lake Reservoir augmentation supply via Council Creek diversion structure and pipe (Main No. 12). The watershed area of 1068 hectares is included in the Sooke Lake Reservoir total catchment area. Potential for reservoir storage development to be investigated.
Deception	650	Deception Gulch	4.0 Mm^3 to 6 Mm^3 at full supply level of 186.75 m	Currently not tested	Watershed not currently owned by CRD so unknown as to future use, but reservoir could be used as it is currently operated by CRD.

Sooke Watershed

Sooke Lake Dam and Sooke Lake Saddle Dam impound the Sooke Lake Reservoir. The Sooke watershed is the primary water source serving the RWS and consists of approximately 8,682 hectares (1,068 hectares Council Creek included) of forested land. Approximately 98% of the watershed is owned and managed by the CRD. Sooke Lake Reservoir was initially impounded in 1915, with the original dam replaced by larger ones, first in 1970 and a second time in 2002 to provide increased storage. Two long ridges on either side of the reservoir define the watershed. The main tributary to the Sooke Lake Reservoir is Rithet Creek. It supplies about 25% of the water entering the reservoir from a drainage area of about 1,740 hectares. A portion of water from the Council Lake releases to Sooke Lake Reservoir via a diversion pipeline (Main No.12) and a channel.

Figure 2.2 is a photograph of the Sooke Lake Reservoir which shows the significant surface area of the reservoir. The deep northern basin is approximately the middle left of the photo.

Figure 2.2: Sooke Lake Reservoir and Watershed (Looking East, Sooke Lake Dam on Right)

Figure 2.3 is a plan and section of the Sooke Lake Reservoir. The intake tower is located on the south end of the reservoir near the Sooke Lake Dam. The spillway crest maintains the full supply level of the reservoir at elevation 186.75 m +/-. The reservoir is normally drawn down up to 5 m over the summer demand period at existing consumption levels. The deeper sections of the SLR northern basin are not accessible because the lowest intake tower gate inverts are at elevation 169 m.

Sooke Lake Reservoir tributary creeks cease significant inflow into the reservoir during the dry season from late spring until substantial rains return in late fall and winter. Consequently, during the period from approximately May to October the level of Sooke Lake Reservoir experiences a net decrease because of higher summer demands, fisheries releases, and evaporative losses. Replenishment of this volume depends on the resumption of winter rains.

A 2021 study completed by Stantec, *Deep Northern Intake, Transmission and Treatment Study* assessed the viability of installing a deep northern intake to access deeper sections of the reservoir. This intake would increase reliability during drought conditions or post wildfire event and provide additional resiliency in the event of failure of the existing intake tower from a severe seismic event. The study concluded that while the deep northern intake would increase reliability and access cooler higher quality water, additional withdrawals should be limited to an increase of 40% above the current annual demand to enable replenishment of the reservoir on an annual basis during a 1:50 year drought event. Section 4.2 of this report provides the results of a hydrological assessment of the Sooke watershed and recommendations on safe drought yield and minimum reservoir operating levels.

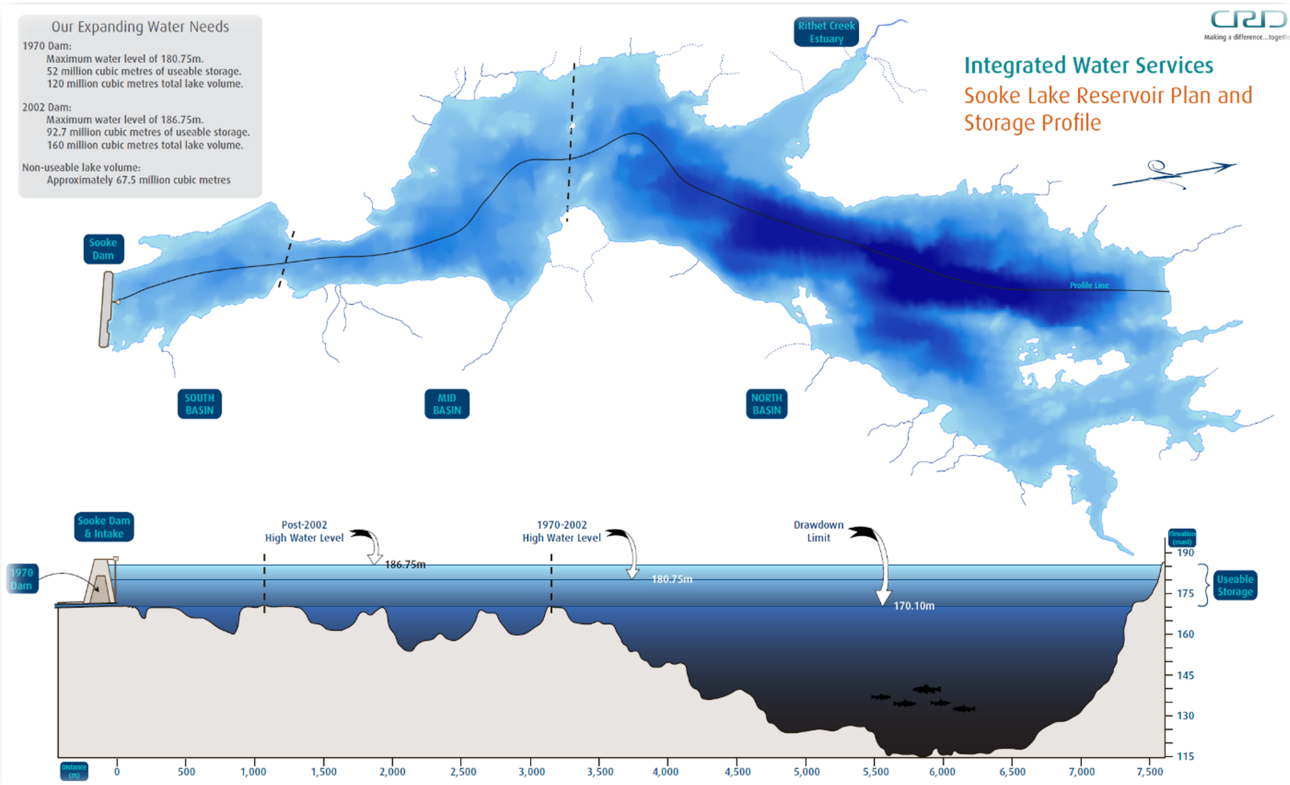


Figure 2.3: Sooke Lake Reservoir Plan and Profile (Provided by CRD)

Goldstream Watershed

The Goldstream watershed is approximately 2,300 hectares in size and is used as a secondary or emergency source of water when the Sooke Lake Reservoir Watershed is out of service for Kapoor Tunnel maintenance. The Goldstream source is unable to supply water to the District of Sooke, but water can be supplied directly from SLR via main No. 15 when Kapoor Tunnel is out of service. Approximately 98% of the watershed is owned and managed by the CRD. A series of four reservoir impoundments store water from the Goldstream Watershed, consisting of the Butchart, Lubbe, Goldstream and Japan Gulch Reservoirs. Flows from the upper impoundments are released into Goldstream River and diverted through Japan Gulch Reservoir where the water is extracted, screened (coarse), and disinfected prior to delivery to the transmission system. An intake facility in Japan Gulch Reservoir can supply the Goldstream Disinfection Facility when activated. Typically, this system is reserved for emergency use or as a temporary source during brief shutdowns of the Sooke Lake Reservoir system for inspection and maintenance of the Kapoor Tunnel and related facilities.

The Goldstream system provides an additional storage capacity of up to 9.9 Mm^3 (see Table 2.1). A portion of the water from the Goldstream watershed is allocated for downstream fisheries and amounts to 4.8 Mm^3 per year, potentially reducing the volume available for emergency and backup use.

Council Creek Watershed

The Council Creek watershed is 1068 ha in size with a small natural lake. Water from this small sub watershed can be diverted to Sooke Lake Reservoir from Main No. 12 and diversion structure to provide replenishment flows. Management of the timing of the diversion should be considered to optimize the replenishment of SLR. Ideally the water should be diverted during periods established by the Sooke Lake Reservoir water balance and operating rules.

Leech Watershed as a Potential Future Supply

A land area of just over 9,600 hectares was purchased from private forest landholders in 2007 and 2010 for use as a future source of water to the CRD's Regional Water Supply. As most of the original forest in the area has been harvested and an extensive road system developed, a long-term rehabilitation program is in progress to prepare the watershed for future use for water supply. Such activities include the reforestation, slope stability and soil erosion control, wildfire protection and forest fuel management, road deactivation, and fencing to reduce unauthorized access. Previous studies have indicated that portions of the watershed have unstable slopes which could have negative impacts on water quality in the Leech River. The photo below shows the Leech Watershed prior to rehabilitation activities.

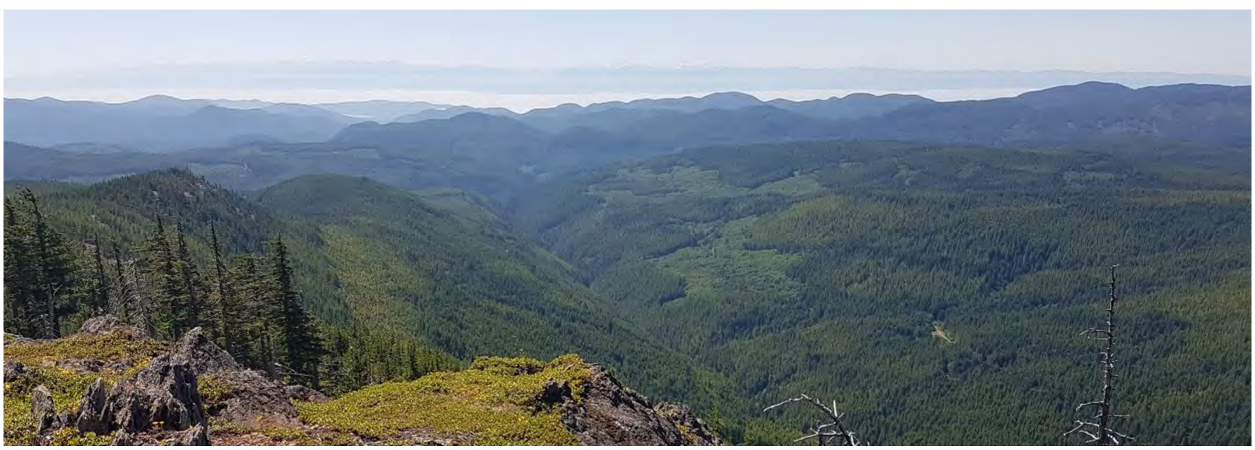


Photo 2.1: Leech Watershed

Water quality data collected by the CRD as part of the October 2021 *Leech River Watershed Water Quality Analyses* report indicates that water in the Leech River generally has low turbidity but does have elevated colour and turbidity levels during higher intensity first flush rainfall events. Further continued long-term water quality sampling of this source is recommended.

The northern portion of the watershed consists of a high elevation plateau with three small lakes and numerous wetlands. These areas drain south along deeply incised river valleys with slope stability issues, posing significant risk of erosion and increased turbidity and colour during periods of saturated soils and extreme precipitation. Restoring the watershed ecology and stabilizing slopes may assist in improving water quality but the outcome of these activities is uncertain and may not provide significant benefit for the capital expenditure.

While the precipitation captured by the Leech watershed is estimated to be greater than that of the Sooke and Goldstream watersheds combined, low summer flows require the development of storage impoundment dams or Leech River diversion works to incorporate this source into the Regional Water Supply System. The Leech River watershed also has similar hydrology to the Sooke Lake Reservoir watershed in that inflows into the river are negligible between May and October so without storage this source cannot provide any flow in the critical summer demand period. However, with a river diversion structure water from the Leech River could be used directly to augment SLR during drought periods and to provide additional supply to DGR and replenish SLR for emergency water use.

The Leech tunnel was constructed in the 1980s to divert water from Leech River to Deception Gulch Reservoir and ultimately Sooke Lake Reservoir. It is a 3.5 km - 2.5 m diameter concrete lined tunnel and was used once to supply water to SLR during a severe drought condition prior to raising of the Sooke Lake Dam.

The 1994 Plan considered several storage options. A low dam at the inlet of the Leech tunnel was estimated to impound 1 Mm^3 of storage, as well as provide adequate surcharge of the Leech tunnel to increase the capacity of the tunnel to convey water to Sooke Lake Reservoir. In addition, the 1994 Plan proposed a high dam at the confluence of the Sooke and Leech River to provide a reservoir with 7 Mm^3. Also considered was the impoundment of Weeks Lake in the upper portion of the Leech Watershed using a drawdown channel and dam combination to provide an additional 10 Mm^3 of storage. The primary advantage of using Leech will be as a replenishment supply to Sooke Lake Reservoir. Section 4 of this 2022 Master Plan discusses the hydrology of the Leech Watershed.

Deception Gulch Watershed as a Potential Future Supply

The Deception Creek watershed is a relatively small watershed with an area of 650 hectares. Deception Gulch Reservoir is immediately adjacent to Sooke Lake Reservoir and is separated by a saddle dam. It is not currently used for drinking water supply and there is no significant water quality information available and there is lack of understanding of seasonal water quality variations. The reservoir storage is 4 Mm^3 at low water level and 6Mm^3 at full supply level. If it is to be utilized as a potential source in the future, water quality information remains a gap and further sampling should be completed in the future.

2.1.2 Tunnels

2.1.2.1 Kapoor Tunnel

The Kapoor Tunnel is the major conveyance system for transmission of raw water from the Sooke Lake Reservoir to the transmission system. The tunnel inlet is adjacent to the Head Tank south of the Sooke Lake Dam. Construction on this tunnel commenced in the 1960s and was completed in 1969. The construction method for most of the alignment was drill and blast and a short section was completed using a tunnel boring machine (TBM). The tunnel is a circular concrete lined tunnel with a short section of horseshoe shaped cross section and is approximately 2.3 m diameter and 8.8 km long. The tunnel originally operated as a gravity open channel and in 1995 it was pressurized to a head of approximately 18 metres (169m HGL). Regular routine inspections have indicated that the tunnel is in good condition.

The Kapoor Tunnel is a critical single conveyance asset in the water supply system and failure would render the Regional Water Supply without water once the Goldstream reservoirs are depleted. Water supply to Sooke River Road Disinfection Facility is provided via Main No. 15 upstream of Kapoor Tunnel. Water supply to the District of Sooke is maintained when Kapoor Tunnel is taken out of service for inspection. The 2021 *Supply System Risk and Resiliency Study* completed by Stantec identified the Kapoor Tunnel as critical infrastructure with no redundancy and ideally, redundancy from a second pipeline or tunnel from Sooke Lake Reservoir would be desirable to increase resiliency. Failure of the Kapoor Tunnel (seismic event) would result in loss of water supply to the Regional Water Service from Sooke Lake Reservoir. Redundancy would be desirable, but constructing a second tunnel or transmission main would involve significant capital expenditure. Investigating the seismic resiliency and, if necessary, seismic strengthening of Kapoor Tunnel may be a more cost-effective, long-term measure to improve resiliency. The hydraulic capacity of the Kapoor Tunnel is sufficient to supply projected maximum day water demands to the year 2100.

2.1.2.2 Leech Tunnel

Leech Tunnel was constructed in the 1980s as a conduit for the future diversion of water from Leech Watershed to Sooke Lake Reservoir via Deception Gulch Reservoir. The tunnel is a concrete lined tunnel with an approximate length of 3.5 km and a diameter of 2.5 metres. Other than being used one time for emergency use prior to raising of the Sooke Lake Dam, the tunnel has not been used because the SLR has had adequate water to supply RWS demand. Flows from the tunnel can be diverted through Deception Gulch Reservoir, a relatively shallow impoundment adjacent to Sooke Lake Reservoir. It may be possible to increase the storage volume of Deception Gulch Reservoir by excavating the reservoir area deeper. However, this would be at considerable expense along with the issue of disposing of waste soil in the watershed or elsewhere.

2.1.3 Goldstream UV Disinfection Facility

The 1994 Plan recommended ozonation be installed at the inlet to Kapoor Tunnel to improve disinfection and provide protection against protozoa. The ozonation facility was not constructed as subsequent research on the use of UV light would provide good inactivation of *Giardia and Cryptosporidium*. CRD decided to use UV technology instead of ozone and the Goldstream UV Disinfection Facility (GDF) was constructed in 2004. This facility includes installation of 15 UV trains with 600 mm diameter UV reactors and associated equipment as shown in **Figure 2.4**. The Goldstream UV Disinfection Facility is located downstream of Japan Gulch Reservoir.

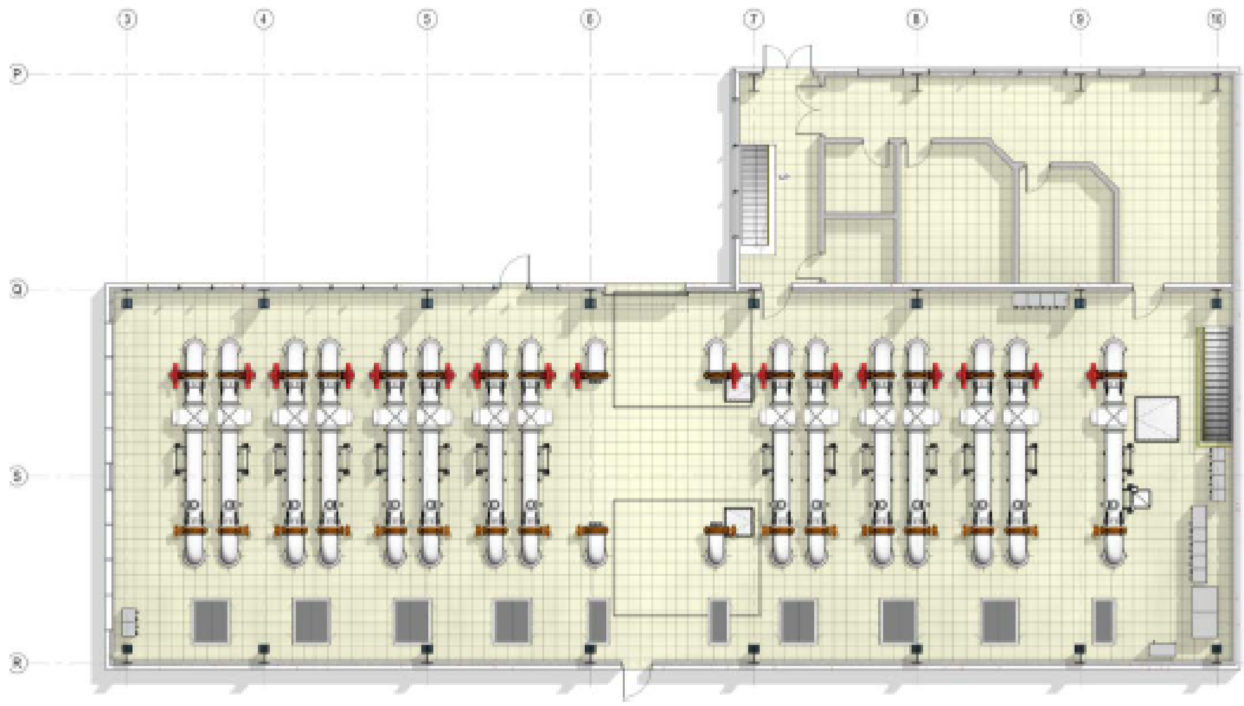


Figure 2.4: Goldstream UV Disinfection Facility

The facility operates as an on-demand UV disinfection system and is subject to peak hour flows. The CRD has recently completed a study *Goldstream UV Facility Upgrade* (Stantec 2021) and is planning to upgrade the UV equipment and capacity of the facility as the UV equipment is nearing the end of its useful life. The design criteria for the upgraded facility are outlined in **Table 2.2.**

Table 2.2: Design Parameters for Goldstream UV Upgrade

Design Parameter	Design Requirement
Design Flow	532 Megalitre per day (MLD)
UV Disinfection Level	Minimum of 3-log inactivation of Giardia cyst and Cryptosporidium oocyst always
Raw Water UV Transmittance	85%/cm
UV Reactor (UVR)Redundancy	n duty + 1 standby
UVR Number and Configuration	Symmetrical configuration including an even number of UVR, with 50% of the UVRs installed on each side of the facility (stream 1 and stream 2).
UV Transmittance Sensor Redundancy	2 UVT sensors per reactor
UV Facility Modularity	Able to operate half of the facility and isolate the other half for installation/maintenance purposes, using the existing piping by-pass configuration.
Controllers	Each UVR unit should have its own controller. The facility control system architecture should ensure that reactors can operate independent of each other.

The Goldstream UV facility provides primary disinfection in combination with chlorine for the majority of the CRD water supply. Primary virus inactivation is accomplished using sodium hypochlorite and a chloramine transmission system residual is maintained by the addition of aqua ammonia. This system currently meets IHA requirements for inactivation of protozoa. The existing UV system could easily be incorporated into a water filtration process in the future but depending on the process ultimately selected it may not be required.

2.1.4 Sooke River Road Disinfection Facility

The Sooke River Road Disinfection Facility (SRRDF) is supplied from Main No. 15 and serves CRD Juan De Fuca Water Distribution Service. This facility has a capacity of 20 MLD and is similar to the Goldstream Disinfection facility but at a much smaller scale. The facility has 2 duty and 1 standby medium pressure UV reactors. The facility also uses chlorine for virus inactivation. The secondary disinfection residual is maintained by producing a chloramine residual after the addition of ammonia. This system currently meets IHA requirements for inactivation of protozoa and viruses.

2.1.5 Major Transmission Mains and Pressure Control Stations

There are a number of major transmission mains in the Regional Water Supply. The transmission system is largely comprised of steel pipe with some pressure concrete lined steel cylinder pipe (PCCP). Pressure reducing valves (also referenced as pressure control stations) are located throughout the transmission system. The system is generally a branch lateral system which is gravity fed from the Sooke Lake Head Tank (HGL 169m). The major transmission system components are summarized in **Table 2.3**.

Table 2.3: Regional Water Supply Transmission Mains

Raw Water Supply Mains	
Kapoor Tunnel	8.8-kilometre, 2.3 m diameter concrete-lined tunnel that carries raw water from Sooke Lake Reservoir (via Head Tank) to upstream of the Goldstream Disinfection Facility
RW Main No.10	1.2 kilometre, 1219 mm diameter steel pipe (Sooke Lake Reservoir to Head Tank.
RW Main No. 11	1.2 kilometre, 1219 mm diameter concrete pipe (Sooke Lake Reservoir to Head Tank)
RW Main No. 12	1.15 kilometre , 1,200 mm diameter main used to replenish SLR from Council Lake
RW Main No. 15	14.7 kilometre, 610 mm diameter PVC and ductile iron pipe that carries raw water from Sooke Lake Reservoir (upstream of the Head Tank from Main No. 10 and Main No.11) to the SRRDF. Supplies water to the Sooke River Road Disinfection Facility. Unable to convey water from Goldstream watershed.
Leech Tunnel (out of service)	3.5 kilometre, 2.5 m diameter lined concrete tunnel for future diversion of Leech River Water to Sooke Lake Reservoir
Treated Water Transmission Mains	
Main No. 1	17.5-kilometre, 1524 mm, and 1067 mm diameter steel pipe (Humpback Reservoir Dam to Gorge Road E and David Street valve chamber in City of Victoria)
Main No. 2	7.6-kilometre 813 mm and 762 mm diameter steel and ductile iron pipe (Island Highway at Thetis overpass and Craigflower Road. Terminates at Main No. 1)
Main No. 2a	1.2-kilometre ductile iron pipe (Admirals Road from Craigflower Road to Esquimalt boundary)
Main No. 3	21.8-kilometre 1219 mm and 991 mm diameter steel pipe (Humpback PCS to Mount Tolmie Tank)
Main No. 4	34.7-kilometre 1321 mm, 1219 mm, 762 mm diameter steel and PCCP pipe, (Kapoor Tunnel outlet to McTavish Tank located in District of North Saanich)
Main No. 5	3.8-kilometre 1524 mm diameter steel pipe running (Kapoor Tunnel outlet to the Humpback PCS via GDF)
Main No. 7	6.2-kilometre 610 mm diameter steel and ductile iron pipe (Goldstream Avenue to Metchosin Road / District of Metchosin)
Main No. 8	6.1-kilometre 450 mm diameter steel and AC pipe (Belmont School to Happy Valley Road /District of Metchosin)
Main No. 14	3.5-kilometre 500 mm and 400 mm diameter ductile iron pipe (Goldstream Avenue and Veterans Memorial Parkway to District of Highlands border on Millstream Road)

Pressure Control Stations (PCS)	
Humpback PCS	Pressure control station located adjacent to the old Humpback Dam. Reduces pressure to main No. 1 and main No.3, fed from main No. 5. Hydraulically operated using pressure reducing valves (3 valves total).
Alderley PCS	Pressure control station located off Alderley Road north of Sayward Road. Reduces pressure to main No. 4 downstream of the PCS (pre-stressed concrete cylinder pipe section).
Millstream PCS	Feeds Main No.3 from Main No.4 (HGL setpoint of 114.0 m)
Burnside PCS	Feeds Main No.1 from Main No.4 (HGL setpoint of 104.0 m)
Watkiss PCS	Feeds Main No.1 from Main No.4 (HGL setpoint of 109.0 m)
Sooke River Road PCS	Maintains a HGL of 91 to 98 m, connection upstream of Head Tank.

Figure 2.5 provides a hydraulic schematic of the overall system operation. The schematic depicts the RWS starting with the Sooke Lake Reservoir (TWL 186.75m), a variable level intake tower at Sooke Lake Dam, and the Head Tank downstream of Sooke Lake Dam. The Head Tank provides a driving head HGL of between 170.2 to 169 m at the top end of the transmission system adjacent to the entrance to Kapoor Tunnel. A connection upstream of the Head Tank supplies the Sooke River Road Disinfection facility via Main No. 15. The secondary system is from the Goldstream reservoirs provides water to Japan Gulch Reservoir (TWL 132 m) and is used when the Kapoor Tunnel is out of service for maintenance and inspection.

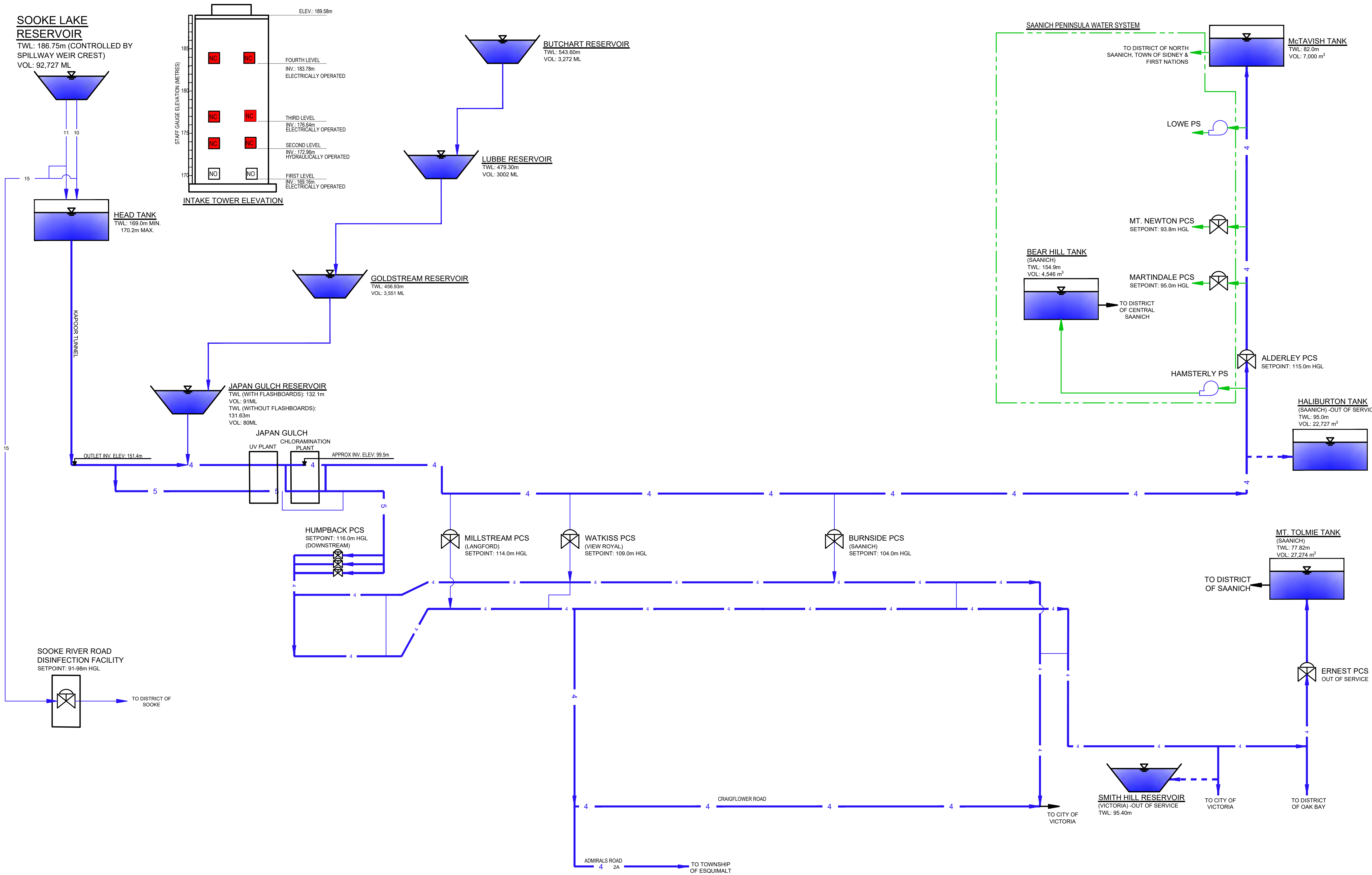


Figure 2.5: RWS Transmission System Hydraulic Schematic

2.1.6 Transmission System Storage Tanks

The RWS transmission system does not contain a significant volume of tank storage. The RWS system was developed as a gravity fed, on-demand system where instantaneous peak flows, peak hour flows and emergency fire flows are supplied from Sooke Lake Reservoir via the RWS transmission system. This approach requires the transmission system to have sufficient hydraulic capacity to convey the peak and fire flows and consumes residual hydraulic capacity which should be reserved for population and demand growth. This will become a significantly greater issue once a water filtration plant is constructed. Ideally, peak balancing storage should be constructed within the transmission system and the municipal distribution systems should provide fire and emergency storage for so that the hydraulic capacity of the RWS system is not stressed from requirement to provide instantaneous peak, peak hour, and fire flows. One location that has been identified as a potential site for balancing storage tank for the transmission system is the former Smith Hill Reservoir site which has been decommissioned. This site is ideally situated as it is located on a higher ground elevation on Smith Hill, land is owned by the CRD, and transmission mains are easily accessed. A pump station will be required to boost the HGL in the service area served by a proposed Smith Hill Tank.

The RWS does have in service and out of service storage tanks in their transmission system and these are summarized below in **Table 2.4**.

Table 2.4: Storage Tanks

Storage Tanks	
In Service	
Head Tank	TWL 170.2 m, LWL 169 m (raw water)
McTavish Tank	TWL 82.0 m – Volume 7,000 m^3
Mount Tolmie Tank	TWL 77.82 m – Volume 27,274 m^3
Out of Service	
Haliburton Tank	TWL 95.0 m – Volume 22,727 m^3
Smith Hill Reservoir	TWL 95.4 m – open decommissioned reservoir

2.1.7 Water System Governance, History and Background

This 2022 Master Plan is meant to be a technical and operational themed plan and it is important to consider the legislative framework and context as it guides and influences the mandate of the utility. This section identifies the authority of the Capital Regional District and the Regional Water Supply Commission and the mandate for the delivery of water to the regional as well as providing a brief history of the water system and related planning of the utility.

The history of the Regional Water Supply Service is well documented but for the context of the Master Plan it is important to identify some key milestones in the history related to the water system's ownership, performance, and planning. These historical milestones influenced the governance, ownership, improvements, and performance of the water system of today. These milestones include:

1. The Greater Victoria Water District (GVWD) was a statutory body created in 1948 by provincial legislation (Greater Victoria Water District Act) originally servicing Victoria, Saanich, Esquimalt, and Oak Bay.

2. By the late 1980's there were significant issues related to water quality and security of water supply which resulted in great controversy in the communities being serviced by the GVWD.

3. By 1994 the Greater Victoria Water District Long Term Water Supply Plan was completed which recommended comprehensive water system improvements.

4. By 1996 the Province of BC established a Special Commission to review the Conservation and Protection of the Greater Victoria Water Supply which addressed a broad range of issues (refer to Section 2.1.13).

5. By 1997 the Capital Region Water Supply and Sooke Hills Protection Act was adopted and in essence resulted in the conversion of ownership of the water system from the GVWD to the Capital Regional District and created the Regional Water Supply Commission (refer to Section 2.1.14).

6. By 1998 the Review of Capital Regional District Water Supply was prepared to address operations, financial expenditures and revenue and historical issues.

7. By 1999 the Strategic Plan for Water Management report, Volumes 1, 2, 3 and 4, by Reid Crowther, Aqualta, and Context, March 1999, was completed.

8. By 2004 the Review of the Strategic Plan for Water Management, by the CRD, November 2004, was completed.

9. By 2012 the CRD had completed the 2012 Strategic Plan for the Greater Victoria Water Supply System.

10. In 2017, the Regional Water Supply 2017 Strategic Plan was issued and approved. By 2020, the RWSC was updated on process (refer to Staff Report of October 21, 2020).

In addition, the progression and development of the water system is well documented in a variety of sources, including The Greater Victoria Water District - Water Supply Area Background Information Report, the CRD's library of studies and reports, Capital Expenditure Plans, Staff Reports for the GVWD and CRD, public archives and other sources.

2.1.8 Local Government Act of British Columbia and the Capital Regional District

The Local Government Act (LGA) of British Columbia provides the legislative framework for local governments including Regional Districts. The Capital Regional District is subject to the LGA and has established local service areas whereby a service is defined including the area or participants for the service (refer to Figure 1.1, Section 1.1).

With the conversion of the water system ownership from the GVWD to the CRD in 1997 pursuant to the *Capital Region Water Supply and Sooke Hills Protection Act,* several bylaws were created and since updated (refer to Section 2.1.10).

2.1.9 Capital Region Water Supply and Sooke Hills Protection Act

In 1997 the *Capital Region Water Supply and Sooke Hills Protection Act* was adopted by the Province of BC. This Act required the conversion of the Greater Victoria Water District to the Capital Regional District and stipulated the governance and mandate of the water service.

In summary the Act included:

- The establishment of a “water supply local service area” of the Regional District and identified participating areas (municipalities and an electoral area)
- The Act also established the “water distribution local service”, otherwise known as the Juan de Fuca Water Distribution Service
- Establishment of the Regional Water Supply Commission
- Establishment of the Sooke Hills Wilderness Regional Park
- Power to make regulations
- Transfer of assets, liabilities, and authority to the CRD and transfer of bylaws

2.1.10 Water Service Related Bylaws of the Capital Regional District and Regional Water Supply Service

Pursuant to the authority of the Capital Regional District by the *Capital Region Water Supply and Sooke Hills Protection Act*, several bylaws have been created related to service establishment, commission representation, water advisory committee, establishment of a regional park, power to make regulation and transfer of assets. A summary of the more relevant bylaws is as follows:

- **Bylaw 2539/3371** – *A Bylaw for the Establishment and Operation of a Regional Water Supply Commission* defines the water supply local service participating areas, establishes the Regional Water Supply Commission and general business, identifies obligations for ongoing strategic planning, encourages conservation and water demand management practices, and annual operating and capital budgeting requirements.
- **Bylaw 2541** – *Water Advisory Committee Bylaw No. 1, 1997,* (A Bylaw for the Establishment and Operation of a Regional Water Supply Protection and Conservation Advisory Committee) and to directly quote the Bylaw, the role of the Committee is “to provide advice to the RWSC on water supply, water quality, the stewardship of the lands held by the Regional District for water supply purposes and water conservation purposes”.
- **Bylaw 3061** – *Capital Regional District Water Conservation Bylaw No. 1, 2003,* which was a result of the service establishment bylaw that addressed water demand and conservation issues.

- **Bylaw 3516** – *Capital Regional District Cross Connection Control Bylaw No. 1, 2008* (as amended by Bylaw 4037). This Bylaw resulted from an Order by the Chief Medical Health Officer for Vancouver Island Health Authority pursuant to the Drinking Water Protection Act since it was determined that a significant risk existed to the drinking water in the absence of devices to control contamination.
- **Bylaw 2804/4050** – *Capital Regional District Water Supply Area Regulations Bylaw No. 1, 2000, Amendment Bylaw No. 1, 2016*, which restricts access to the water supply area and regulates activities within the watershed.
- **Bylaw 2739** – *Capital Regional District Water Management Strategic Plan Bylaw No. 1, 1999*, this resulted in the obligation of the service establishment bylaw and in essence adopted the Strategic Plan for Water Management as prepared by Reid Crowther, Aqualta and Context in March of 1999.

Many additional bylaws exist that specifically related to financial and loan authorization.

2.1.11 Summary of Prior Reports, Studies, Inquiries, and Reviews

There have been many studies and reports commissioned for a variety of scopes and reasons over the decades of operation of the Regional Water Supply Service. The following Sections 2.12 to 2.17 are a summary of the more significant long term or master planning, strategic planning, special and other studies of note that have influence on this 2022 Master Plan.

2.1.12 Greater Victoria Water District, Long Term Water Supply Plan, Montgomery Watson/Dayton & Knight Ltd., 1994

In 1992 the GVWD initiated a planning process and hired a consultant to assess the water service and provide recommendations for improvements. By 1994 the *Greater Victoria Water District Long Term Water Supply Plan (Montgomery Watson and Dayton and Knight Ltd.).* was completed which recommended comprehensive water system improvements and included a schedule with a significant capital expenditure plan.

At the time, the context of the recommended improvements was all encompassing, including renewal and rehabilitation of existing assets, new assets to address a higher level-of-service and to address future water demand. Some of the improvements included dam rehabilitation, water treatment study and enhancement, raising of Sooke Lake Dam, replacement of Main No. 1, and a Deep Northern Intake from Sooke Lake Reservoir. Many of the recommended improvements have been completed, some were revised in scope and detail, and some were deemed no longer necessary. A summary of the recommendations and status is provided in Section 1.1. This plan and other subsequent studies formed the basis of the current 2022 Master Plan.

2.1.13 Special Commission on the Conservation and Protection of the Greater Victoria Water Supply

Subsequent to the delivery of the 1994 Plan there was great concern arising from the customers which resulted in the Province of BC establishing in 1996 a “Special Commission on the Conservation and Protection of the Greater Victoria Water Supply” which addressed a broad range of issues including governance, operation, public participation, retail water systems, land use, water conservation and ownership transition. The commission was led by Mr. David Perry and the recommendations resulted in the conversion of the water system from the GVWD to the CRD (*Capital Region Water Supply and Sooke Hills Protection Act*). The recommendations are summarized by number and title only for general context as follows:

- Recommendation #1 Compensation
- Recommendation #2 Governance Model
- Recommendation #3 Public Participation Group on Regional Water Issues
- Recommendation #4 Retail Water System
- Recommendation #5 Kapoor Land Limited Exchange
- Recommendation #6 Disposition of Crown Land Lot #87
- Recommendation #7 No Status Quo for Council Creek Basin
- Recommendation #8 No Land Exchange for Council Creek Basin
- Recommendation #9 Purchase of Council Creek Basin
- Recommendation #10 Cease the Council Creek Diversion
- Recommendation #11 Highway 117 Closure
- Recommendation #12 Alternate Galloping Goose Right-of-Way
- Recommendation #13 Land Use in Non-Catchment Areas
- Recommendation #14 Tenure and Management of Non-Catchment Lands
- Recommendation #15 Supply-Side and Demand-Side Water Management
- Recommendation #16 Regional Demand-Side Management Measures
- Recommendation #17 Provisional Demand-Side Management Measures

2.1.14 Review of Capital Regional District Water Supply, D.L. Mackay, P.Eng., April 1998

Subsequent to the Special Commission of 1996, the *Capital Region Water Supply and Sooke Hills Protection Act* was adopted in 1997 and by 1998 another review was commissioned, *Review of Capital Regional Water Supply*, by D.L. Mackay, P.Eng., April 1998. This review addressed operating and infrastructure, cost sharing development cost charges, historical issues that were technical and operational in nature, operational and organizational issues, and other issues. There were five general recommendations, and they are summarized by number and title only for general context as follows:

- Recommendation #1 - Identification of the Regional Water Supply System
- Recommendation #2 - Operating and Maintenance Costs
- Recommendation #3 - Existing Debt
- Recommendation #4 - Future Debt
- Recommendation #5 - Review of the Water Quality Testing and Reporting

2.1.15 Strategic Pan for Water Management, 1999

In 1997 the Province of BC enacted a regulation requiring the CRD to prepare a Strategic Plan looking forward 20 years and addressing the water supply, water conservation and the management of the catchment lands and the regulation included a requirement that the plan be regularly updated. In 1998 the CRD hired a consulting consortium to prepare the Strategic Plan for Water Management, March 1999. The plan was comprehensive and included public consultation, water quality issues, demand and reliability, demand-side management, supply-side management, water management options and included a decision process and results. Generally, the conclusions and recommendations were adopted, and they set the goals for the CRD for the next period.

2.1.16 2012 Strategic Plan

The *2012 Strategic Plan for the Greater Victoria Water Supply System* was prepared by the CRD, and it was another comprehensive plan that identified strengths, challenges, and opportunities. The plan resulted in numerous strategies and actions as well as key recommendations: adapting to climate change, addressing changing trends in water use, and workforce planning. Further recommendations included:

1. Increase the minimum usable storage volume for Sooke Lake Reservoir used to calculate water system reliability to better highlight the importance of maintaining source water quality,
2. Continue to adapt demand management initiatives to match changing trends in water use with an ongoing target of deferring expansion of the water supply system for 50 years,
3. Incorporate climate change projects and a broader range of water use projections in the next analysis to determine when an expansion of water supply will be required,
4. Update the hydraulic model to the water transmission system,
5. Develop level of service policy and formal agreements with bulk water customers to clarify the requirements for the supply of bulk water to distribution systems,
6. Assess the value of non-owned catchment and buffer lands for the protection of the Greater Victoria Water Supply Area and work with other CRD departments to develop a coordinated corporate strategy and process for land purchases and exchanges,
7. Review and update the Capital Regional District Water Supply Area Regulations Bylaw to incorporate the security requirements of the Leech Water Supply Area,
8. Update the watershed assessment and risk assessment framework to the Greater Victoria Water Supply Area to include the Leech Water Supply Area, and
9. Develop a State of the Water Supply Area report prior to the next review of the Strategic Plan.

It is not the intent of the 2022 Master Plan to review and evaluate each of the foregoing. The recommendations have been provided for context and linkage to the current Master Plan.

2.1.17 Regional Water Supply 2017 Strategic Plan

In 2017, the CRD had prepared another Strategic Plan that was adopted by the Regional Water Supply Commission and the CRD Board of Directors. This Strategic Plan included the following statement:

> *"This Strategic Plan for Regional Water Supply sets Commitments and identifies Strategic Priorities and Action, with a planning horizon to the year 2050, that will guide the future direction for the Regional Water Supply Service. The Strategic Plan will also support CRD Board priorities, provide context for water serving policy, and align with other CRD strategies and plans."*

The Strategic Plan is broadly based on three Commitments and six Areas of Focus, summarized as follows:

Commitments

1. Provide high quality, safe drinking water
2. Provide an adequate, long-term supply of drinking water
3. Provide a reliable and efficient drinking water transmission system

Areas of Focus

1. CRD Board Priorities – Sustainable and Livable Region
2. Climate Change Impacts – Mitigation and Adaptation
3. Preparing for Emergencies and Post-Disaster Water Supply
4. Supply System Infrastructure Investment – Renewing Existing and Preparing for New Infrastructure
5. Planning for the Future Use of the Leech Water Supply Area
6. Demand Management – Addressing Changing Trends in Water Demand

This strategic direction is important for the Master Plan as it sets the framework and criteria for which to evaluate the existing system to determine gaps or deficiencies in the existing assets, management of the service to meet anticipated future demands, adapt to potential changes, and prepare and mitigate emergencies.

As noted in Section 2.1.7, a Master Plan is one of many plans that are scope and objective focused such as Business Continuity Plans, Asset Management Plans, Emergency Plans, Financial Plan, Strategic Plan, etc. [refer to AWWA definition] and ultimately the suite of plans is aligned and complementary.

2.1.18 Planning by Participating Areas / Municipal Customers

Beyond the internal planning conducted by the CRD, it is imperative that the various plans of each of the participating areas or municipalities (see Section 2.1.7) be integrated. Ultimately the Master Plan addresses the expectations of the municipal distribution services, but more detailed coordination of water system performance is achieved via a variety of other aspects including coordination of Official Community Plans, Development Cost Charge programs, asset management planning, Level-of-Service agreements (existing and pending), and asset ownership agreements.

2.2 Historical Supply Reliability

The reliability of the CRD water system has historically been good and the raising of the Sooke Lake Dam in 2002 provided additional resiliency. The RWS has provided an acceptable level of service for the major municipal customer base. Reliability on the supply, transmission, and treatment side has been good; there has been no loss of service or significant complaints from the customer base. Taste and odour complaints have occasionally occurred from the customer base as a result of algae in Sooke Lake Reservoir, but normally algae concentrations are not high enough to cause major issues with water quality.

Section 5.0 of this report discusses the historical water quality data from Sooke Lake Reservoir. The raw water quality from this primary source is considered very good and meets provincial and federal guidelines without filtration. Turbidity levels have typically been below 0.4 NTU on average with other parameters also falling within current Health Canada Guidelines for Canadian Drinking Water Quality.

The Goldstream reservoirs have been used as a secondary water supply during inspections of Kapoor Tunnel. The Goldstream reservoirs water quality is generally a good quality source but is sometimes impacted by landslides along the Goldstream River canyon which conveys water to Japan Gulch Reservoir. These slides have typically occurred during wet weather high flow periods.

The CRD has recently completed the *Leech River Watershed Water Quality Analysis Report* (October 2021) to obtain additional information related to Leech River water quality. In general, the water quality is quite good with a mean turbidity of 1.3 NTU but with peak turbidity up to 157 NTU. Of significance from a water quality perspective is elevated levels of colour exceeding the BC Safe Drinking Objective of 15 TCU for more than 58% of samples. High turbidity events were associated with wet weather during first flush rainfall events. The high turbidity combined with elevated colour would require use of a conventional treatment process for treatment. The Leech River water has low pH and alkalinity, similar to Sooke Lake Reservoir.

The Deception Gulch Reservoir is adjacent to Sooke Lake Reservoir. This reservoir has a volume of 1.5 Mm^3 due to its shallow depth. The reservoir primarily serves as a source for downstream fisheries flow release. It could also serve as a receiving reservoir for flows from Leech Watershed and eventual transfer into Sooke Lake Reservoir via a control structure in Sooke Lake Saddle Dam. Further water quality testing of this reservoir is warranted.

2.3 Historical Water Quantity

In 2020 the CRD used 48 Mm^3 of water from the Sooke Lake Reservoir. In an average year, the Sooke Watershed has been able to supply water demands and Sooke Lake Reservoir is replenished by precipitation to full supply level over the winter months. In 1987, prior to raising of the Sooke Lake Dam in 2002, the CRD did experience water shortages from the Sooke watershed due to high water use and limited storage. In conjunction with raising of the Sooke Lake Dam, the CRD implemented a water conservation program and has been able to reduce their demands significantly, and water shortages have not been an issue even during dry years. In 2009, the

CRD experienced an approximate 1:50 year drought condition and due to hot weather and lack of precipitation, the Sooke Lake Reservoir did not fill until the 2010 winter season. Since the raising of the dam in 2002, the 2009 drought year (an approximate 1:50 year event) has been the only year that Sooke Lake Reservoir did not fill. A hydrological assessment of the Sooke watershed has been completed as part of this study and is discussed in Section 4.2 of this report.

2.4 Water Supply System Redundancy

The RWS has several infrastructure components where redundancy is a concern. The main concerns include the lack of redundancy for the Kapoor Tunnel, a single Main No. 15 serving the Sooke River Road Disinfection Facility, single pipes for Main No 3 and Main No.4 serving the Saanich Peninsula and a single intake tower in Sooke Lake Reservoir. Failure of any of these components during a seismic event could result in termination of water service to all or parts of the RWS service area. In addition, Main No. 4 and Main No. 15 have sections with bridge crossings of waterways which could be vulnerable during seismic events. RWS dams are also a concern and the CRD has been upgrading the dams in the past 20 years to meet Provincial Dam safety requirements.

A *Supply System Risk and Resiliency Study – Phase 1* (Stantec 2021) and a S*eismic Assessment of Critical Facilities Study* (Stantec 2021) provided an assessment of critical facilities and a plan for future upgrades to reduce the overall vulnerability of critical components of the RWS. The *Deep Northern Intake, Treatment and Transmission Study* (Stantec 2021) provides alternatives for a second intake and redundancy options for the Kapoor Tunnel.

2.5 Level of Service

Level of Service (LoS) is a commonly used concept to define the expected or required performance criteria of a system or asset. In the context of this Master Plan, the LoS concept was considered throughout its preparation and development. Several cited LoS definitions include the following:

> *"The defined service quality for a particular activity (i.e., roadways) or service area (i.e., street lighting) against which service performance may be measured. Service levels usually relate to quality, quantity, reliability, responsiveness, environmental acceptability and cost."* (International Infrastructure Management Manual V.3.0)

and

> *"Level of Service should form the basis for determining appropriate practices, approaches and funding for capital renewal and maintenance activities. Utility managers must know what levels of service are required by regulations, what LoS customers desire and the related costs" and "Getting value from assets is about making sure they perform as desired at the right cost."* (Water Utility Management, Manual of Water Supply Practices M5, 3rd Ed., AWWA)

The LoS is important for many reasons as it establishes the performance expectations of assets such as those related to a water system. During the preparation of this Master Plan, it was recognized that the LoS concept should be applied in anticipation of the comprehensive conclusions and recommendations that would result in significant expenditures. Therefore, consideration will be given to a variety of LoS's for the proposed improvements. Defining the LoS for an existing and operational utility is an iterative process whereby the system is constantly being assessed for a variety of performance criteria.

For the context of the Master Plan, two general categories of LoS were considered and are discussed as follows:

- **Non-Discretionary LoS** – Non-Discretionary LoS refers to the absolute requirements for service such as legislated obligations. For this Master Plan the primary LoS obligations are set out in the BC Provincial Drinking Water Protection Act, Water Sustainability Act and Dam Safety Regulation. Although there are numerous other legislated obligations (e.g., worker safety) for the management of a water utility, they will be identified and addressed in future detailed plans where appropriate (e.g., preliminary, and detailed design).
- **Discretionary LoS** – Discretionary LoS refers to the LoS that may be decided by the utility owner and customers. Financial sustainability and affordability may be influencing factors in determining the performance of a system or assets. Quite often perceptions of LoS influence conclusions which may be unaffordable in both capital costs and life-cycle costs. It is premature at the Master Planning phase, but the process of value engineering can be applied in subsequent phases of project development to ensure good return on investments.

Specific examples of applying the LoS concept to various asset categories include the following:

- **Water Treatment** – Current drinking water legislation is outcome based with the expectation of meeting potability standards or guidelines (e.g., GCDWQ, USEPA, etc.) and the legislation does not prescribe particular types of treatment processes. The LoS concept can be applied when detailing a water treatment plant design criteria (e.g., materials selection, redundancy of process, power supply, etc.).
- **Water Conveyance Mains** – There is no specific legislation to define the LoS for conveyance mains. The utility has discretion in the selection of materials, means of construction, and capacity, etc. The LoS may be influenced by proven and routinely available materials and potentially the insurance sector (e.g., Seismic Guidelines for Water Pipelines, American Lifelines Alliance). For example, a main for the intent of providing redundancy to an existing main may be sized to replicate full capacity, partial capacity, or a limited capacity for emergencies.

Some general opportunities for applying the LoS concept include the following, but the implications of each should be carefully identified and assessed:

- Redundancy
- Materials selection and life expectancy
- Seismic performance
- Loss of service (planned maintenance or unplanned failure)
- Coupling policy with assets, such as Water Conservation Bylaw or use restrictions during loss of service
- Functionality or operational performance

The CRD has a process of determining the existing or available LoS through the Master Planning process, Asset Management Program, and consultation/coordination with municipal or bulk customers to determine expectations. Further, the CRD plans to prepare and establish formal Level of Service Agreements with each of the customers (existing Capital Project). Such agreements could include LoS related terms such as:

- General terms of water purchase, governance, and administration
- Quality of delivered water and responsibility for surveillance/monitoring
- Allocation and water supply
- Defined ranges of demands (e.g., peak, daily, maximum day, annual, etc.), hydraulic grade line limits and service areas
- Water conservation commitments
- Asset ownership and transfer points
- Define comprehensive transmission/supply and distribution systems criteria and collaborative systems development
- Asset management and risk mitigation investments and,
- Acceptable duration for interruptions to service, including major emergencies.

It is important to define these LoS issues as they set the criteria and framework for RWS utility planning. The existing RWS system has been well managed and has benefitted from capital and other investments in the system that resulted in many years of reliable and cost-effective service (e.g., raising of Sooke Lake Dam and Reservoir, replacement of Main No. 1, etc.). The CRD will need to continue to identify system limitations and improvement measures as water demand increases and the ultimate capacity thresholds are approached and surpassed.

3.0 WATER DEMANDS

Planning of the water supply requires the prediction of future water use, or demand forecasting, in order to anticipate and address limitations in capacity and plan for new infrastructure at the optimal time. Forecasting demands involves uncertainty due to the limited precision with which population growth rates can be predicted and inherent uncertainty of future water use patterns. Historical information provides a sound basis for prediction of demands, provided the future growth patterns and water use remain similar to what has been previously experienced. For this study the CRD has provided good historical consumption data which provides a basis for establishing trends in demands and historical water use patterns. However, any forecast results require regular periodic review and evaluation with corrections applied to future demands as new information becomes available and policies change. Subsequent long-term planning iterations may then adjust the schedule and sequence of required capacity related improvements accordingly. Demand forecasts will be developed to include several planning horizons. The planning horizon of 2050 has been established as requested by the CRD for treatment and transmission evaluations. A longer term planning horizon of 2100 for a deep intake on Sooke Lake Reservoir and associated conveyance of raw water is considered appropriate because the service life of these major assets is typically 75 years or more and future staged expansion of these facilities is difficult and costly.

The RWS customer demand is primarily residential (64%), other sector uses include: ICI (22%), agricultural (3%) and non-revenue water (approximately 11%). CRD demand management efforts have focused primarily on residential demands and to a lesser extent ICI and agricultural. The ICI component is a significant demand worth considering for future demand management initiatives.

3.1 Historical Population Growth

Key considerations in demand forecasting include historical patterns of population growth and associated water demand. Statistics Canada uses a Victoria metropolitan census area that corresponds closely with the Regional Water Supply Service Area boundaries. The CRD has developed historical population estimates for the Regional Water Supply service area for non-census years and corrections for the population not connected to the Regional Water Supply Service area. Estimates for the years 1995 to 2019 are outlined in **Table 3.1** with the corresponding annual growth rate. The average population growth rate from 1995 to 2019 was 1.1%. The average for 2010 to 2019 was 1.5%. As is common in British Columbia, many communities have seen periods of several years where growth has been above average but historically the growth rates in the CRD have been approximately 1.1% when a longer horizon is reviewed.

Table 3.1: Historical Population and Annual Growth Rates for the Regional Water Supply Service Area (1995 - 2019)

Year	Population	Growth Rate (%)
1995	300,400	-
1996	302,400	0.7
1997	306,400	1.3
1998	307,700	0.4
1999	308,900	0.4
2000	309,600	0.2
2001	310,400	0.3
2002	312,700	0.7
2003	315,400	0.9
2004	317,800	0.8
2005	322,400	1.4
2006	325,400	0.9
2007	327,500	0.6
2008	331,100	1.1
2009	334,100	0.9
2010	337,400	1.0
2011	339,227	0.5
2012	344,450	1.5
2013	349,638	1.5
2014	356,299	1.9
2015	365,112	2.5
2016	372,975	2.5
2017	377,865	1.3
2018	382,625	1.3
2019	387,400	1.2

The 1994 Plan predicted populations of 389,000 in 2012 compared to actual of 344,450 and 667,000 in 2044. Based on historical census data these estimates have been overly conservative. For this reason, it is appropriate to look at sensitivity of population impacts from different growth scenarios. Section 3.2 presents a sensitivity analysis of three different growth scenarios and provides recommendations for future population projections.

3.2 Projected Population Growth

The regional population growth has varied depending on factors such as birth rate, life expectancy, employment, and migration. Projections of future population are difficult to predict and net migration to the CRD area is anticipated to be the most significant factor (BC Stats 2019). Population projections developed by BC Stats for the CRD used an average annual population growth rate of just under 1% and predict a decrease in growth starting mid-century. A more conservative approach is justified for population projections and associated water demand forecasts used for long-term planning of high cost and long-life infrastructure. Three annual population growth scenarios were considered for projections: 1.0%, 1.25%, and 1.5%. While these population projections will be used to forecast future demands for planning purposes, it is important that they be reviewed and reassessed periodically at intervals of ten years or less or when CRD planning and Statistics Canada Census information is updated. The population projections for the three scenarios are displayed in **Table 3.2** for the planning horizons corresponding to years 2030, 2050, and 2100. The historical and projected population scenarios are plotted together in **Figure 3.1**.

Table 3.2: Projected Population of Service Area for Three Population Growth Scenarios

Year	Low (1.00% Annual Growth)	Med (1.25% Annual Growth)	High (1.50% Annual Growth)
2030	432,000	444,000	456,000
2050	527,000	569,000	615,000
2100	867,000	1,060,000	1,294,000

The choice of year as a planning horizon depends on the nature of the water supply facilities to be constructed. For medium range planning purposes, the year 2050 is appropriate and would include the potential staging of additional treatment works and related infrastructure. For the purposes of designing assets, such as deep intake structures drawing from the northern basin of the Sooke Lake Reservoir and any associated tunnels used for raw water conveyance, an extended planning horizon to 2100 is justified.

The intermediate growth rate scenario of 1.25% corresponding to a projected population of 569,000 for year 2050 is recommended for actual planning level use, with the high and low scenarios providing an indication of the magnitude of probable range of estimates expected.

It is important to note that when developing water demand forecasts based on a per-capita demand model, the projected population introduces the greatest source of uncertainty in the results compared to uncertainties in the actual demand assumptions (AWWA 2017). Furthermore, the uncertainty increases considerably with time. The impact of uncertainty in forecasted demands must be considered in planning and design efforts. Equally important is keeping good records of actual water use, which the CRD has done for many years.

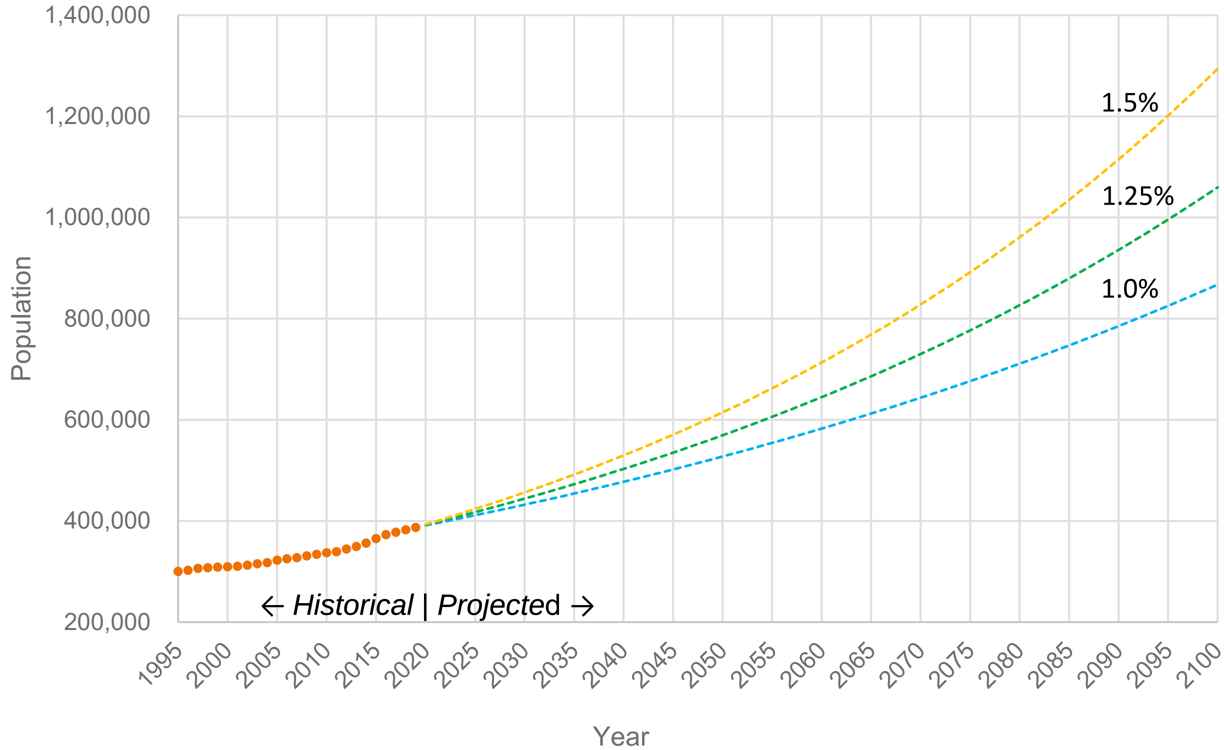


Figure 3.1: Population Projections to 2100 for Low (1.0%), Medium (1.25%), and High (1.5%) Annual Growth Scenarios

3.3 Water Use and Demand Projections

3.3.1 Historical Demand

Demand projections involve the prediction of future water demands based on historical water use. Key demand parameters will be defined and their historical trends considered. Demand data is based on production records and is not disaggregated by end-use, customer type, or municipality. There is an assumption that water use segregation between residential, ICI and agricultural consumption will remain consistent with population growth.

Average Day Demand (ADD)

The Average Day Demand (ADD) is the total volume of water delivered to the water system in one year divided by days in a year. The units are either million litres per day (MLD) for the system total demand or litres per capital per day(L/c/d)with normalizing by the population estimate. The ADD has generally decreased over the past two decades due to CRD water conservation efforts and use of low flow fixtures and appliances, from a peak of 172 MLD in 1998 to a low of 132 MLD in 2019. The average per capital day demand from 1998 to 2019 was 450 L/c/d. The average ADD from 2010 to 2019 was also 132 M. The per-capita ADD has also declined steadily over that period from 546 L/c/d in 1995 to 254 L/c/d in 2019. The per-capita ADD average has flattened out for the last 10 years so the average from 2010 to 2019 of 366 L/c/d was used to project future demands. These observations are consistent with the experience of water utilities across North America and partly due to improved appliance and plumbing fixture efficiency and conservation efforts.

Winter Day Demand (WDD)

The Winter Day Demand (WDD) is the average daily demand observed during the winter or off-peak period for a given year starting from the first day in November of that year and ending the last day of February of the following year (4 months). As with ADD, the units of WDD are either MLD or L/c/d for system total and per-capita demands, respectively. The WDD is assumed to strongly correlate with the year-round indoor residential demand and population served because there are negligible irrigation and tourism demands in the winter season.

During the winter, the daily demand fluctuates minimally within a given year as demands are largely based on indoor uses and are assumed to directly relate to population served. A slight downward trend corresponds to steady adoption and spread of high efficiency fixtures and appliances used within homes and businesses, such as low flow toilets, shower heads, dishwashers, and washing machines. For example, until the mid-1980s toilets used 20 L per flush. Building codes now require residential toilets that flush 4.8 L or less, and older existing toilets are slowly being replaced. Similar trends have occurred with washing machines and dishwashers. An increasing awareness among the public of the importance of water conservation has likely contributed to the trend.

Using the period of November 1st of a given year to the end of February of the following year, the average WDD has decreased from a peak of 129 MLD in 1998 to 98 MLD in 2019. The average WDD from 2010 to 2019 was 99 MLD. The per-capita WDD has decreased from 424 L/c/d in 1996 to 254 L/c/d in 2019. The average per-capita WDD over 2010 to 2019 was 274 L/c/d.

Table 3.3: Average Daily Demands for 2010-2019 for RWS (GDF and SRRDF)

Demand Parameter	Demand (MLD)	Demand (L/c/d)
ADD	132	336
WDD	99	274
MDD	242	-
M3DD	226	-
M5DD	218	-
PHD*	321	-

*2016-2020

Maximum Day and Peak Hour Demand (MDD and PHD)

The Maximum Day Demand (MDD) is the largest volume of water delivered to the system in a single day for a given year. The Peak Hour Demand (PHD) is the maximum volume delivered in one hour on the maximum demand day. Peak hour demands occur in any 24-hour period throughout the year, but the highest PHD usually occur in the summer months when irrigation demands are the greatest. Both MDD and PHD are expressed in units of mega litres per day (MLD). The water supply assets collectively must be capable of providing the MDD. The PHD is typically used for sizing of storage, pumping, and distribution facilities.

The RWS maximum day demand (MDD), usually occurring in July or August, has significantly decreased over the past three decades, consistent with North America-wide trends. The decrease is generally due to ongoing conservation efforts, greater efficiency, enforcement of watering restrictions, public education, as well as metering and billing based on volumetric usage.

The MDD has declined to 224 MLD in 2019 from a high value of 369 MLD in 1985. During the extreme hot heat dome in June and July 2021, a single day demand of 274 MLD was experienced. This was the highest maximum day demand since the 2009 drought when a demand of 293 MLD was experienced. The average MDD during 2010 to 2019 period was 242 MLD. The per-capita MDD has declined from approximately 1100 L/c/d in 1995 to 578 L/c/d in 2019. The average per-capita MDD over 2010 to 2019 was 673 L/c/d. The MDD is largely a function of outdoor irrigation and agriculture. Further decreases may occur due to increased densification and the greater proportion of multi-family over single-family dwellings. Changes to landscaping practices, plumbing fixtures and washers that require less water may also decrease MDD. However, increased agricultural activity within the service area or relaxation of bylaw watering restrictions could have the opposite effect and continued diligence on water conservation measures is important.

The PHD observed on the maximum day has been evaluated based on CRD combined flow data for water supplied from both the Goldstream and Sooke River Road disinfection facilities over the years 2016 to 2020. The PHD for the full system has ranged from 311 to 339 MLD, with an average of 321 MLD. This represents a PHD to MDD peak factor of 1.36 on average over this time.

The ratio of MDD:WDD has been relatively stable over both the 1995-2019 and 2010-2019 periods, averaging in both cases to 2.46. This supports the assumption that declines in both indoor and outdoor demands have been comparable and that the aggregate mixture of customer types has been similar. This assumption should be confirmed in future reviews of demands.

Maximum 3-Day and 5-Day Demand (M3DD / M5DD)

Additional parameters of potential importance are the maximum 3-day demand (M3DD) and maximum 5-day demand (M5DD), which averages the daily demands spanning one or two days on either side of the maximum day, respectively. These values both declined similarly to the MDD, from 369 and 338 MLD in 1985 to averages of 226 and 218 MLD over the period of 2010 to 2019, respectively. Interestingly, the ratios of MDD to both M3DD and M5DD have remained relatively constant over the past 10 and 25 years at 1.07 and 1.11, respectively. These multi-day demand parameters are valuable when considering capacity trade-offs in finished water production at the existing disinfection facilities and future filtration plant, clearwell and system storage. Increases in system storage capacity for peak demand flow balancing allow a smaller treatment plant and cost savings.

For the period of 2010 to 2019, the average total and per capita demands are summarized in **Table 3.3** and the average demand ratios are summarized in **Table 3.4.**

Table 3.4: Average Demand Ratios for 2010-2019 for Regional System (GDF and SRRDF)

Demand Parameter	Ratio
ADD:WDD	1.34
MDD:WDD	2.46
MDD:M3DD	1.07
MDD:M5DD	1.11
PHD:MDD*	1.36

*2016-2020

Long-term planning requires consideration of the total volume of water used by the regional system each year to assess aspects such as water license allowance and reliability of source yield. Total annual demand and total summer demand are two demand parameters are commonly used for long-term planning.

Total Annual Demand (TAD)

The total annual demand (TAD) represents the total volume of water used by the system in a year expressed in millions of cubic meters (Mm^3). The TAD for the Regional Water Supply Service, increased steadily since the 1940s to surpass 30 Mm^3 around 1970. The early 1980s saw a rapid increase, exceeding 40 Mm^3 around 1980. Between 1985 and 2010, TAD fluctuated between approximately 50 and 60 Mm^3, remaining below 50 Mm^3 from 2011 to the present. The average TAD from 2010 to 2019 has been 48 Mm^3 (excluding conservation demands) comparable to levels seen in the early 1980s when the population was approximately half of what it is today. Note that all demand values discussed in this report represent the total water supplied to the entire regional water system, including residential, industrial, commercial, institutional, and agricultural customers, as well as non-revenue water. The total annual demand is useful when assessing the adequacy of lake reservoir storage and the seasonal impacts on water levels in Sooke Lake Reservoir.

Total Summer Demand (TSD)

Of particular importance in managing Sooke Lake Reservoir levels is the portion of the annual demand occurring during the dry summer months and high demands due to outdoor use, particularly irrigation by residential, commercial, and agricultural customers. Daily demands fluctuate depending on temperature, precipitation, and regulated irrigation watering days. The Total Summer Demand (TSD) represents the total volume of water used by the system in a year between May 1st and October 1st (five months) expressed in Mm^3. During this period stream inflows to Sooke Lake Reservoir effectively cease and the level of the reservoir generally declines until the resumption of significant precipitation and cooler weather, typically in October. Water system demand fluctuates the greatest during the summer, depending on the daily temperature and precipitation. Over the past 25 years, the TSD has averaged 29 Mm^3, with a peak of 34 Mm^3 in 1998, followed shortly by the minimum of 22 Mm^3 during a drought in 2001 (involving Stage 3 watering restrictions). The average over the period of 2010 to 2019 was 27 Mm^3. The ratio of the TSD to TAD over the periods of 1995-2019 and 2010-2019 has been 0.55 in both cases.

Table 3.5: Average Annual Demand Volumes for 2010-2019 for RWS (GDF and SRRDF)

Parameter	Value
TAD	48 Mm^3
TSD (5 months)	27 Mm^3
TSD/TAD	0.56

3.3.2 Future Demand Forecasts

The development of future demand forecasts for the Regional Water Supply involves the following approach and assumptions:

1. Use a conservative approach to project from current per capita demand levels and assume no further decline in demand due to improved conservation and efficiency. This assumption should be reviewed every 5 years and particularly after new water conservation measures are implemented and their effectiveness analyzed. The impacts on summer demand of future climate change should also be considered and if necessary, a climate change factor should be included in future projections. The 2021 Heat Dome is a good example of how extreme hot weather due to climate change can impact MDD. Future adjustments to projections can be made if necessary.
2. Assume constant per-capita WDD, MDD:WDD, ADD:WDD, and TSD:TAD remain at average values for 2010 to 2019 until the year 2100.
3. Assume constant PHD:MDD at average value of 2016-2019 until 2100.
4. Calculate WDD for future years by the product of per-capita WDD and projected population.
5. Calculate ADD and MDD for future years as the product of WDD of future years and the constant ratios ADD:WDD and MDD:WDD, respectively.
6. Calculate PHD for future year by the product of MDD of that year and the constant ratio PHD:MDD.
7. Calculate the TAD of future years as the forecasted ADD of that year multiplied by number of days in that year.
8. Calculate the TSD of future years as the product of TAD of that year multiplied by the constant ratio TSD:TAD.
9. Conservations flows for ecology or fisheries will be in addition to domestic drinking water demands so these should be considered when assessing the yield capability of the source to supply total water demands.

This approach and its assumptions imply that the mixture of demand types and proportions remain effectively the same in aggregate into the future. Such assumptions require regular re-evaluation, assessment, and correction to the forecasted demands but are suitable for Master Planning level evaluations and planning when capacity expansion to RWS facilities is required.

The declining historical and future constant per-capita WDD are illustrated in **Figure 3.2**.

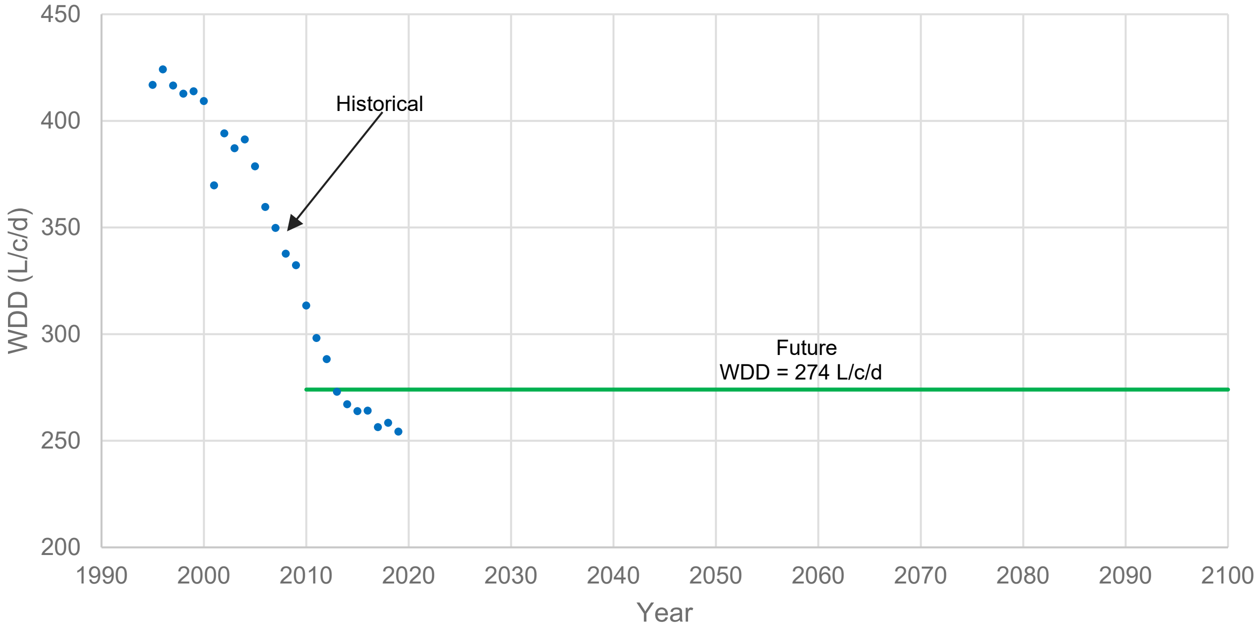


Figure 3.2: Historical and Future Per-Capita WDD

By applying the three population growth scenarios (1.0%, 1.25%, 1.5%), a constant per-capita WDD of 274 L/c/d based on the average over the past decade and applying the average MDD:WDD ratio corresponding to the same period, the following demand forecast is produced as shown in **Figure 3.3.**

These projections predict a flattening or reversal of the declines in demand observed over the past 15 years, returning to system demand levels of the early 1990s. Consequently, capital improvements for transmission system are anticipated to focus primarily on addressing existing deficiencies, improvements in resiliency, and needed rehabilitation and replacement efforts as well as population growth.

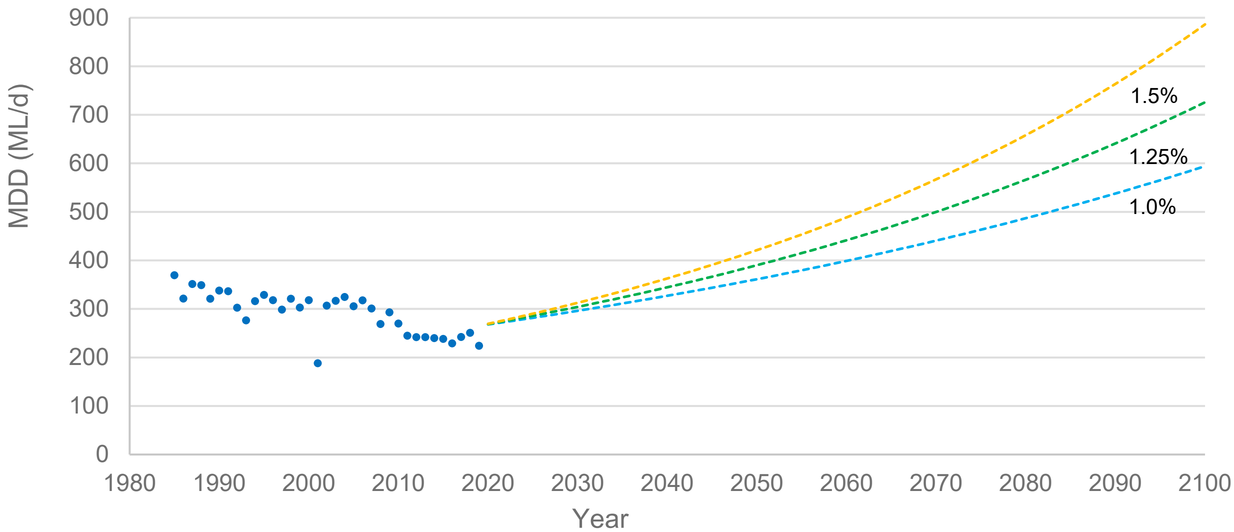


Figure 3.3: MDD Forecast for 2020 to 2100 for Annual Population Growth Scenarios

At the 2050 planning horizon, the MDD is expected to attain the peak levels seen in the mid-1980s mainly due to population growth. Subsequent growth beyond 2045 will require additional source development such as diversion of Leech River, new infrastructure, and increased capacity for the system, in addition to any ongoing replacement and rehabilitation. For the purposes of planning the proposed Deep Northern Intake and raw water conveyance investments from Sooke Lake Reservoir, the planning horizon of 2100 is considered assuming full redundancy, though the uncertainties in forecasted demands are greatest at this distant horizon. Numeric values for the various demand parameters are tabulated in **Table 3.6.**

Table 3.6: Forecasted Daily Demands (MLD)

Planning Horizon	Demand Type	Low (1.0%)	Med (1.25%)	High (1.5%)
2050	WDD	145	156	168
	ADD	188	203	219
	MDD	361	390	421
	M3DD	337	364	393
	M5DD	325	350	378
	PHD	491	530	572
2100	WDD	238	290	355
	ADD	309	377	461
	MDD	594	726	886
	M3DD	555	678	828
	M5DD	534	652	796
	PHD	807	986	1204

The TAD and TSD projections to 2100 are shown in the **Figure 3.4** for the three growth scenarios and summarized in **Table 3.7**. These forecasted demands should be considered when evaluating the adequacy of existing water licenses, the safe yield of current sources, and planning the possible development of other sources such as the Leech watershed. The projected range of TAD agree with estimates produced by CRD Environmental Services, using the same initial condition and similar growth scenarios.

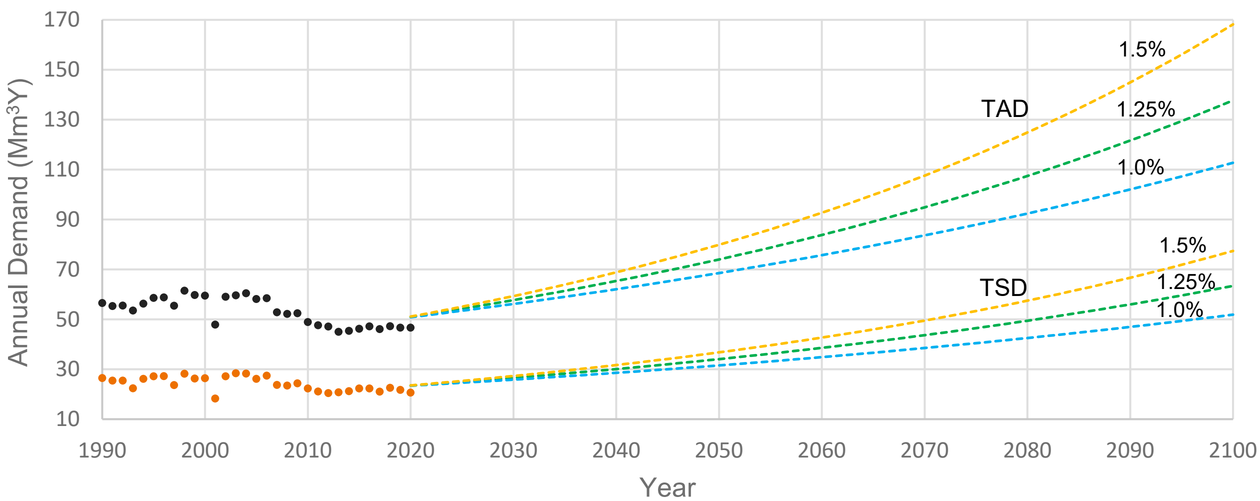


Figure 3.4: Total Annual and Summer Demands – 2020 to 2100 (growth rates indicated)

Table 3.7: Forecasted Total Annual and Total Summer Demand (Mm^3)

Planning Horizon	Demand	Low (1.0%)	Med (1.25%)	High (1.5%)
2050	TAD	69	74	80
	TSD	38	41	45
2100	TAD	113	138	168
	TSD	63	77	94

From the above analysis, the medium growth scenarios results are suggested for planning purposes, with the high and low scenario results providing an estimate of uncertainty. As the peak demand parameters are of greatest importance in system planning and design, the recommended values are summarized in **Table 3.8** using the medium growth (1.25%) scenario and rounded to the nearest 10 MLD. The corresponding projected values for the year 2030 are provided to guide subsequent revaluation and corrections, as the shorter-term predictions are anticipated to involve the least uncertainty. The current demand values, expressed by the average values observed over the period of 2010 to 2019. The historical peak values for these parameters are also included. In the case of daily demands, a peak was observed in 1985 at comparable levels to those forecast for 2050 in the medium growth scenario.

Table 3.8: Summary of Historical, Current, and Forecasted Maximum Day and Peak Hour Demands (MLD)

Demand	Past Peak	Current	Planning Horizons		
	1985	2010-2019	2030	2050	2100
MDD	370	240	300	390	730
M3DD	350	230	280	360	680
M5DD	340	220	270	350	650
PHD	530[a]	320[b]	410	530	990

a. 1994 - GVWD Long Term Water Supply Plan
b. 2016-2020 Average
c. Projections are rounded.

The TAD and TSD values are summarized in **Table 3.9**. In this case, TAD and TSD peaks occurred in 1998, coinciding with levels forecast to occur regularly between 2030 and 2050.

Table 3.9: Summary of Historical, Current, and Forecasted Total Demands (Mm^3)

Demand	Past Peak	Current	Planning Horizons		
	1998	2010-2019	2030	2050	2100
TAD	63	48	58	74	138
TSD	35	27	32	41	77

Several key observations can be made from the above analysis. Firstly, the next two decades provide an opportunity to address needed improvements to the reliability and resiliency of the existing system while simultaneously developing new source capacity before it is needed. Secondly, the total draws on the source are predicted to exceed their historical peaks during the period of 2030 to 2050 (approximate 2045) assuming no further reductions in demand due to additional efficiency and conservation measures. It is also noted that the total demands outlined in the tables above do not include the environmental flow needs flows which are constant at 5.4 Mm^3Y and are used to assess the adequacy of the water sources.

3.4 Demand Management

As the population served by the Regional Water Supply Services continues to grow, eventually a point will be reached when the demand will exceed the reliable safe yield of the source water, incurring a deficit and requiring capital expenditures to develop additional source capacity. The demand forecasts developed involve the conservative assumption that no further reductions in total per-capita demand are expected in the future below the average observed over the period of 2010 to 2019. However, for the past three decades a significant decline in demands has been observed consistent with trends experienced across North America. Not only have total per-capita demands decreased, total annual, average daily, and maximum daily demands have also declined despite population increases. Such declines are due to greater conservation, efficiency in plumbing fixtures and appliances and successful demand management initiatives by the CRD. The CRD should continue with their conservation and public education program for residential, agricultural and ICI users.

Future demands will depend on actual population growth, housing density, landscaping practices, weather, lifestyle changes, industrial and agricultural activity, legislative changes, technology enhancements, water pricing and other factors. In addressing the questions of future source capacity and reliability, it is rational to consider what additional impacts the current and future demand management activities may have on future demands and further deferral of capacity increases.

The AWWA defines demand management as "*the practice of systematically reducing water use for a broad spectrum of utility customers through efficiency measures and conservation, often as an alternative to purchasing new water or expanding water treatment facilities*." (M52 – Water Conservation: A Planning Manual).

3.4.1 Brief History of Key Demand Management Efforts in Greater Victoria

The overall demand management philosophy has been to continue deferral of supply expansion by achieving cost-effective and long-lasting reductions in water use using an adaptive approach that allocates resources based on trends relative to program goals. CRD's approach to demand management has been quite successful and should continue to optimize use of the water resources with the WSA.

A brief history of some of the key elements in the demand management efforts of the CRD and its predecessor is described below. Public outreach and education have been a major element and has assisted in fostering a cultural shift in consumers.

1993 Public education efforts regarding water conservation and encouragement of voluntary outdoor water use restrictions began following a dry period experienced across most of North America during the late 1980s and early 1990s.

1994 Development of a regional Demand Management Program a key recommendation of the 1994 *Long Term Water Supply Plan,* with focus to be directed at the residential sector comprising approximately 70% of total water use. First initiative was a rebate program to encourage adoption of low flush toilets.

1997 Enactment of the *Capital Regional Water Supply and Sooke Hills Protection Act* and Regulation established CRD authority over a Regional Water Supply, including the requirement to "encourage effective conservation of the water supply".

1999 The Strategic Plan for Water Management, Volume 1 – Supply Management and Demand Management was prepared for the CRD and included a reexamination of the recommendations of the *1994 Long Term Water Supply Plan*. Demand Management program options were developed for moderate and aggressive efforts, with a moderate level of effort selected.

2001 In 2001 the CRD experienced a drought condition and low Sooke Lake Reservoir water levels. In February of 2001 the CRD adopted the Water Conservation Bylaw 3061 establishing mandatory outdoor water use restrictions to be scheduled between June 1st and September 30th and enforceable throughout the service area to reduce peak day demand and manage water supply. Initial Stage 1 restrictions allowed watering of lawns twice per week, Stage 2 once per week, and Stage 3 no lawn watering permitted. Advancement to Stages 2 or 3 are determined by the CRD based on multiple considerations, particularly Sooke Lake Reservoir level. Stage 3 restrictions (no lawn watering) were imposed from April 2 to December 18, 2001, relaxing to Stage 2 until January 8, 2002.

2002 Rebate program extended to high efficiency front-loading washing machines.

2003 Water Conservation Bylaw amended to advance Stage 1 seasonal water restriction schedule starting May 1st to further reduce outdoor water use.

2004 Demand Management program expansion into the industrial, commercial, institutional (ICI) sector, to include water use audits, industry education, and infrastructure grants and rebates to promote and improve water efficiency. Rebates included encouraging replacement of 'once through' cooling systems using large amounts of water.

2005 Changes to the plumbing code result from the Water Conservation Plumbing Regulation under the Local Government Act. New toilets must be low flush type with a maximum flush volume of 6 L per flush, a significant reduction from older toilets with flush volumes from 13 L to more than 20 L per flush.

2017 Water system audit completed for the RWS and JDFWDS, SPW service areas using the AWWA M36 methodology for treated water from source meters to connection points with retail municipalities, regional subsystems, and westshore communities. Non-revenue water components estimated, including real and apparent losses for key locations or customer connections and associated lost value.

2021 The Regional Water Supply Commission approves the administration of a once-through cooling equipment replacement rebate program in the 2022-2026 budgets to continue promoting water efficiency in the industrial, commercial, institutional (ICI) sector.

3.4.2 Current CRD Demand Management Program

Ongoing demand management activities are described in a report submitted by the CRD's Environmental Protection as an update to the Regional Water Supply Commission on February 17, 2021. Key priorities and deliverables involve public outreach and education, research, and technical assistance to improve efficiency. Current demand management activities are described as follows:

- Research and Planning
  - Long-range water demand forecasting tool
  - Seasonal Demand Analysis
  - Agricultural Trend Analysis
  - Local Government Supply and Demand Analysis

- Residential Water Conservation
  - Go Golden Campaign promotes the reduction of non-essential outdoor watering of residential lawns
  - Strive for Five Campaign promotes behavioural change to reduce shower time among the young adult demographic for the second largest contribution to indoor water use
  - Development of educational water videos covering outdoor water use tips, irrigation system best practice, and the benefits of conservation
  - Irrigation Management involves promotion of irrigation best practices to reduce waste, promote healthier plants and encourage use of native plant species
  - Fix a Leak Program promotes awareness and proactive leak detection habits by homeowners to reduce an estimated 14% of residential indoor water use lost to leaks
- Industrial/Commercial/Institutional (ICI) Water Conservation
  - Water Use Assessments target high water users in the retail sector for voluntary participation in audit and promotion of water efficiency practices
  - Targeted Building Owner Outreach to address water efficiency practices by businesses that share a water bill based on square footage rather than usage
  - Landscape Water Calculator is a map-based tool to be customized for the Greater Victoria region to calculate the water budget of for a given property
  - Aerator Replacement Program to improve water efficiency of faucets at commercial facilities
  - Once-Through Cooling (OTC) videos being developed to continue educational approach of discouraging use of OTC equipment and promote replacement with alternative cooling systems

3.4.3 Potential for Further Demand Reductions

Forecasted demands have been projected from current day demands based on evaluation of historical consumption records. It is reasonable to expect improvements in conservation and efficiency to continue up to a certain limit. To what extent such improvements will have a meaningful impact on water demands is less certain. Any significant reductions will effectively offset anticipated demand increases and further defer source development and infrastructure capacity expansion requirements. Changes in local regional policy such as watering restrictions, move to xeriscape landscaping, rate structures and other initiatives have the potential to further reduce water demands.

The total (all in) per-capita demand can be calculated by taking the sum of all water uses including residential, ICI, agricultural and nonrevenue water and dividing by the population estimates for the given year. This allows comparison with other relevant jurisdictions and industry averages. The total per-capita demand of the Regional Water Supply has declined significantly from 546 L/c/d in 1995 to 337 L/c/d in 2020. The ten-year average over 2010 to 2019 was 366 L/c/d. The CRD estimates that the total demand may currently be disaggregated by sector as follows:

residential (64%), ICI (22%), agriculture (3%), and non-revenue water (11%). This implies that the residential only per-capita demand for 2020 was approximately 240 L/c/d. A 2016 study by the Water Research Foundation on residential end-uses of water reported a North America average of 220 L/c/d for residential per-capita demand. Using the USEPA WaterSense New Home Specification as the definition of a “high efficiency” home, it was also estimated that residential per-capita demand in high efficiency homes would be approximately 140 L/c/d. The most significant criteria for high efficiency homes are toilets that use less than 7.6 L per flush and clothes washers that use less than 114 L per load. Appliances that meet or exceed these specifications are currently common and many homes in the RWS have already converted to these appliances. Eventually, as older fixtures and appliances are replaced, the high efficiency home of today may be the standard home in the future.

Outdoor water use can be estimated from the ratio of ADD to WDD and has historically fluctuated between 30% and 40% of total water demand, with a minimum occurring at 17% for the year 2001 when Stage 3 restrictions were applied from April to December. The ratio of MDD to WDD has remained relatively constant around 2.5. Reductions in outdoor demand may result if the proportion of high-density housing grows and landscaping and behavioural practices favour increased conservation. Reducing irrigation water consumption during the summer months is of paramount importance because of little to no yield from any of the watersheds in the summer months.

The intermediate population growth scenario estimates for the 2050 MDD (used for sizing of filtration facilities) will be reduced from 390 MLD to 316 MLD and the TAD will decrease from 74 Mm^3 to 67 Mm^3 (the 1:50 year drought safe yield) if a modest 10% reduction in both the WDD and the peak factor MDD: WDD are applied to the demand forecast methodology. The universal spread of high efficiency fixtures and appliances and additional technological improvements could promote the continued trend in declining demand despite population increases.

Figure 3.5 shows the sensitivity and impact on the conservation of water in the Sooke Lake Reservoir for various demand management scenarios ranging from 200 to 300 L/c/d. As an example, reducing demand to 300 L/c/d results in extending the Sooke supply to 2060 while a target of 250 L/c/d could extend the source to 2070. The Sooke supply capability will reach its limit around 2045 with the current demand levels and an annual population growth of 1.25%. The red dashed line on Figure 3.5 shows the safe 1:50 year annual yield of the Sooke Lake Reservoir at 67 Mm^3. Using this graph, it is possible to project the life of the SLR using various demand scenarios. Modest and achievable reductions in demand, (e.g., 300 L/c/d from the current demand of 337 L/c/d) will go a long way to extending the life of the Sooke Lake Reservoir beyond the 2050 planning horizon.

Other areas for future demand management include outreach to ICI and agricultural water users and establishment of programs to conserve water for these users.

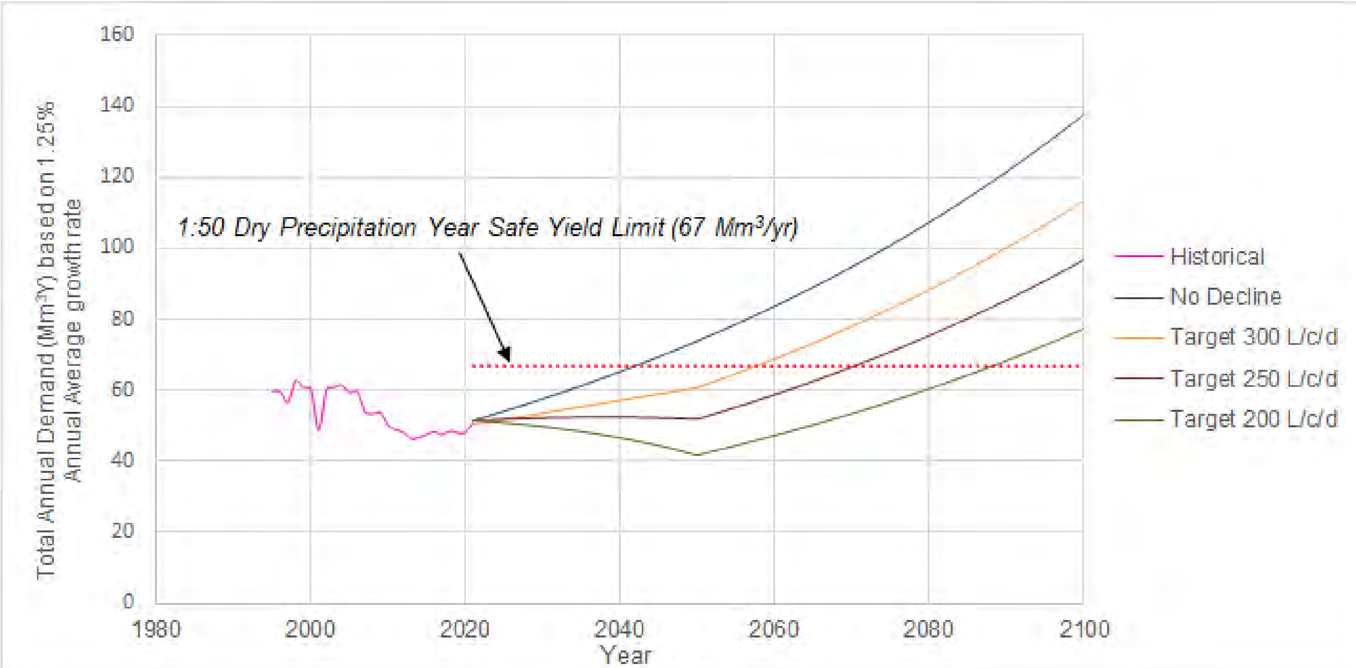


Figure 3.5: Total Annual Demand for Various Water Conservation Target Reductions

4.0 WATER SOURCES

4.1 Existing Sources of Water

The Regional Water Service has a number of surface water sources that are used for water supply. A description of the existing sources of water is provided below in **Table 4.1**.

Table 4.1: Watershed Information

Watershed	Catchment Area (ha)	Reservoir	Available Storage Volume (Mm^3)	Comment	
				Quality	Quantity
Sooke	8,682	Sooke Lake	92.7	High quality, especially in hypolimnion. Extensively monitored.	Accessible volume limited by existing intake elevation and finite watershed basin yield.
Goldstream	2,300	Butchart Lake	3.3	High quality. Monitored monthly (Goldstream) and quarterly (Butchart).	Can supply sufficient water during maintenance of Kapoor Tunnel, but storage is limited. Has up to 10 Mm^3 available for use. Not currently available for use in JDFWD Service and District of Sooke.
		Lubbe Lake	3.0		
		Goldstream Lake	3.6		
		Japan Gulch	0.08	High quality except if slides encountered on Goldstream River or algae due to shallow reservoir depth.	Minimal storage in Japan Gulch but storage reservoir is supplied from Goldstream River and releases from higher level Goldstream dams. Japan Gulch Reservoir HGL 132 m provides driving head to RWS when Head Tank HGL 169 m out of service.
Leech (Future)	9,600	Possible future reservoir or direct diversion from Leech River via Leech Tunnel	None	Generally good quality but has higher colour levels. Long-term watershed restoration and rehabilitation in progress.	Use of this source during summer requires development of a new impoundment dam and reservoir. Transferable flows to Sooke Lake Reservoir are possible by direct diversion during higher flow seasons. Potential to divert to Deception Gulch Reservoir and then SLR.
Council Creek	1,068	Council Lake (No dam)	No firm reservoir volume available	High quality	Has been used as a Sooke Lake Reservoir augmentation supply via Council Creek diversion structure and pipe (Main No. 12). The watershed

Watershed	Catchment Area (ha)	Reservoir	Available Storage Volume (Mm^3)	Comment	
				Quality	Quantity
					area of 1068 hectares is included in the Sooke Lake Reservoir total catchment area. Potential for reservoir storage development to be investigated.
Deception	650	Deception Gulch	4.0 Mm^3 to 6 Mm^3 at full supply level of 186.75 m	Currently not tested	Can be used to transfer future Leech River water to SLR.

The RWS previously included numerous smaller off catchment upland lakes including Mavis Lake and Jack Lake, Cabin Pond, Charters River, and Humpback Reservoir. These sources were decommissioned due to water quality concerns and a suspected cryptosporidium outbreak. Future use of these sources could be considered once a filtration plant is constructed or if required for additional water supply.

4.1.1 Sooke Watershed

The Sooke Lake Watershed consists of approximately 8,862 hectares net catchment area and is the primary source of water for the CRD's regional water supply. The Sooke Lake Reservoir created by the construction of the Sooke Lake Dam at the south end of the watershed enables impoundment of 92.7 Mm^3 of usable storage with the existing intake facilities. Approximately 98% of the watershed is owned and managed by the CRD. Sooke Lake Reservoir was initially impounded in 1915, with the original dam replaced by larger ones, first in 1970 and a second time in 2002. Two long ridges on either side of the reservoir define the watershed. The main tributary to the Sooke Lake Reservoir is Rithet Creek. It supplies about 25% of the water entering the reservoir from a drainage area of about 1,740 hectares. Water from approximately 546 hectares of the Council Lake watershed can be diverted into the reservoir through Main No. 12 and a channel.

Sooke Lake Reservoir tributary creeks cease significant inflow during the dry season from late spring until substantial rains return in late fall. Consequently, during the period from approximately May to October, the level of Sooke Lake Reservoir typically experiences a net decrease due to water demand, water released for downstream fisheries conservation and evaporative loss. Replenishment of this volume depends on the resumption of winter rains.

Sooke Lake Dam was raised in 2002 to create more storage. The full supply operating level is 186.75 m (spillway crest) and at this elevation there is 92.7 Mm^3 of storage available for use with the existing Sooke intake tower. Access to the intake tower and screen is via a bridge. Water is extracted from SLR using a multi-level intake port system which includes a fine 0.5 mm mesh travelling screen. Water can be extracted from SLR using a multi gate system at four different intake port elevations to enable extraction of water at lower levels as the reservoir level drops. The intake tower can draw water down to 170.4 m and provides head above the 169.16 m invert of the lowest intake tower port. During normal operations in non-drought periods, the CRD does not draw the SLR down to low levels to protect water quality. For much of the winter the reservoir level exceeds the spillway crest elevation of 186.75 m.

A *Deep Northern Intake, Treatment and Transmission Study (Stantec 2021)* was completed to investigate the feasibility of installing a deeper intake to access water in the deep northern basin of the SLR. A review of lake bathymetry was undertaken to determine stage storage elevations for the reservoir. With the proposed Deep Northern Intake located at elevation 150.0 m the available lake volume that can be accessed with a lower intake is 137.8 Mm^3. This would allow the CRD to access cooler and better quality deeper northern basin water and from a lower level than is currently available from the Sooke Lake Dam intake tower. It is noted that to ensure replenishment of supply on an annual basis in the future once the safe drought yield of 67.3 Mm^3 /YR (see Section 4.2) is reached, the Sooke Lake Reservoir should not be drawn down below 177 m. Drawing the SLR below 177 m once the annual demand reaches 67.3Mm^3Y could also lead to water quality issues from low water levels in some areas of the reservoir and siltation associated with shore erosion. Stage volume data for the SLR is provided **Table 4.2**. As part of RWS normal operations the SLR is not typically drawn down below 175m due to concerns regarding water quality. The SLR water level operating range is illustrated in Table 4.2 in green font. The deeper intake would not provide any additional water supply by lowering the intake without the future diversion of the Leech River into the Sooke Lake Reservoir. Table 4.2 clearly illustrates that there is not significant advantage to lowering the intake below elevation 150 m due to the steep lake bottom bathymetry.

Table 4.2: Existing Bathymetry of Sooke Lake Reservoir

Elevation (m)	Lake Volume (Mm^3)	Percentage of Lake Volume (%)
186.75	160.3	100
185	147.5	92.0
180	115.3	71.9
175	88.1	54.9
170	67.6	42.2
165	52.3	32.6
160	40.2	25.1
155	30.5	19.0
150	22.5	14.0
145	15.9	9.9
140	10.7	6.7
135	6.8	4.2
130	3.8	2.3
125	1.7	1.1
120	0.6	0.4
115	0.02	0.01
113.6	0	0

The Stantec study concluded that the proposed deep northern intake would provide redundancy for the existing intake tower, improve supply resiliency during drought conditions and can be used during normal operations to enable access to cooler high-quality water. However, hydrological investigation indicates that the reservoir would have difficulty filling during a 1:50 year drought if water levels were drawn below 177 m for future increased annual demands up to 40% greater than current demands. While the second intake does provide redundancy and access to high water quality in deeper sections of the reservoir, it will not provide additional water supply as the Sooke watershed has a finite safe yield which is limited to an increase of 40% over existing annual demands in a 1:50 year drought. Extraction of demands greater than 40% over current levels will make it difficult for the reservoir to fill following a 1:50 year drought condition without Leech River flows. Other issues such as environmental impacts and reduction of water quality from significant reservoir level drawdowns would have to be assessed prior to lowering the reservoir below historical low operating levels for an extended period of time.

The primary benefits of constructing a deep intake are access to more storage and stable water temperature, high quality raw water not subject to algae blooms, redundancy from a second intake, and increased resiliency in the event the water level must be drawn down below typical drawdowns in a severe drought condition. The City of Las Vegas recently installed a second intake into Lake Mead to access lower portions of the reservoir. The severe droughts in the US Southwest in 2021 required the Lake Mead reservoir to be drawn down significantly below normal operating levels. The advantage of having the deeper second intake significantly improved the resiliency of the water supply during an emergency extended multi year drought condition. Without a deep intake, the City of Las Vegas would have had difficulty meeting their water supply demands in the summer of 2021.

4.1.2 Deception Gulch Reservoir

Deception Gulch Reservoir (DGR) is a shallow reservoir located adjacent to Sooke Lake Reservoir. The reservoir has a catchment area of 6.5 km^2 and a volume of 1.5 Mm^3. The reservoir is shallow and is not used as part of the drinking water system. Limited water quality information is available for this reservoir so further water quality sampling is required to confirm the viability for use as a drinking water source. This reservoir does warrant further investigation as a potential receiving reservoir for diverted Leech River water. Improvements to the Deception Gulch Dam and spillway and Sook Lake Saddle Dam would be required. The Deception Gulch Reservoir could serve as a receiving reservoir for water diverted from Leech, which could then be transferred to Sooke Lake Reservoir. The existing gate system would have to be rebuilt and the hydraulics of transfers from Deception Gulch Reservoir to Sooke Lake Reservoir will have to be confirmed. Upgrading of the Sooke Lake Saddle Dam would be required to facilitate the water transfer to SLR.

4.1.3 Council Creek Watershed

Council Creek is a small watershed which has been used as an augmentation supply for Sooke Lake Reservoir. The catchment is relatively small, at 1068 hectares and there is no storage in this catchment but there is a small lake (Council Lake). It may be possible to construct a dam in this watershed to provide additional reservoir storage. Further investigation on the potential for storage development on this source may be warranted. Water is diverted to SLR via Main No. 12 and a channel.

4.1.4 Goldstream Watershed

The Goldstream Watershed is approximately 2,300 hectares in size and is used as a secondary or emergency source of water when the Sooke Lake Reservoir watershed is offline for the Kapoor Tunnel inspection and maintenance. A series of four reservoir impoundments store water from the Goldstream Watershed, consisting of the Butchart, Lubbe, Goldstream and Japan Gulch Reservoirs. The Goldstream reservoirs store about 10 Mm^3 of water. Approximately 98% of the watershed is owned and managed by the CRD. An intake facility from the Goldstream River to Japan Gulch Reservoir supplies screened water to the Goldstream Disinfection Facility when activated. One of the issues with this source is that it can be subject to turbidity fluctuations during high rainfall due to slides which occur in the Goldstream River Canyon upstream of Japan Gulch Reservoir. The Goldstream watershed serves a valuable function as a secondary or emergency supply and can supply water for 2 to 4 weeks depending on demand and water quality conditions.

Connecting the Goldstream source directly to the transmission system via a pipeline would improve the overall resiliency of supply as high-quality water could be extracted directly from Goldstream Lake rather than the Goldstream River which is prone to turbidity excursions during wet weather. A screened intake would be required in Goldstream Lake Reservoir for the piped transmission system and Japan Gulch would be removed from service.

4.1.5 Leech Watershed as a Potential Future Source

An area of nearly 9600 hectares within the Leech watershed was purchased in 2007 and 2010 from private forest land holders for use as a future source of water for the CRD’s regional water supply. As the area was harvested starting in the 1960s and continued to 2007. Much of the area has been replanted and a long-term rehabilitation program is in progress to prepare the watershed for future use. Such activities include the reforestation, slope stability and soil erosion control, wildfire protection and forest fuel management, road deactivation, and fencing to reduce unauthorized access.

The quality of water available from the Leech watershed is suitable for use as a drinking water source with treatment of elevated colour levels and turbidity. Both of these water quality parameters could easily be removed with a filtration plant. The northern portion of the watershed consists of a high elevation plateau with three small lakes and numerous wetlands. The lower canyons have steep slopes and the West Leech and Leech Rivers, and Cragg Creek can have sediment issues during slope failures and major flow events. Efforts to restore the watershed ecology are ongoing but these efforts will not reduce the potential threat to water quality from slope failures in these canyons.

The potential yield of the Leech watershed is estimated to be greater than that of the Sooke and Goldstream watersheds combined, seasonal flows require the development of storage impoundment dams for which options are limited and would involve significant capital investment for construction of a new high dam in the Leech watershed. The cost for construction of new or multiple dams on Leech River will be significant and require further evaluation, geotechnical and hydrological study to confirm feasibility. Another option for consideration is construction of an intake on the Leech River and diversion to DGR via Leech Tunnel. This option would involve diverting water to DGR and then to SLR. Further hydrology and a reservoir operating model are required to confirm the feasibility of concurrent Leech River / Sooke Lake Reservoir operations.

The 1994 Plan considered several storage options. A 12 m high dam at the inlet of the Leech tunnel would provide an estimated 1 Mm^3 of storage, as well as provide adequate surcharge of the tunnel to increase the capacity of the tunnel to convey water to Sooke Lake Reservoir. A 50 m dam at the same location was estimated to provide 7 Mm^3 of additional storage. Also considered was the impoundment of Weeks Lake in the upper portion of the Leech Watershed using a drawdown channel and dam combination to provide an additional 10 Mm^3 of storage. The cost for construction of new or multiple dams on Leech River will be significant and require further evaluation, geotechnical and hydrological study to confirm feasibility.

As part of this 2022 Master Plan, Stantec investigated construction of a dam at a conceptual level to determine the viability of increased water supply from the Leech watershed. Preliminary modeling indicates it would be feasible to develop an additional 13 Mm^3 from Leech watershed with a high dam. The requirement to meet downstream fisheries conservation allocations may limit the amount of water that can be developed for drinking water in this source, but the CRD already has an existing water license on this source so discussions should be held with the province to ensure that CRD will have access to full licensed annual withdrawal of 30.8 Mm^3. Another option is direct diversion from the Leech River via a weir and intake which would discharge directly to the Leech Tunnel. This type of a system could be easily implemented at low cost but would likely only be useful in the shoulder seasons as inflows into Leech watershed are limited during the summer months, like the Sooke watershed.

The alternative options developed by the 1994 Plan for system expansion and upgrading include augmenting the Sooke Lake Reservoir with water transferred from the Leech Watershed and involve bypassing of the Deception Gulch Reservoir due to perceived water quality concerns. The water quality in Deception Gulch Reservoir requires further assessment through a detailed water quality sampling program. Diverting water to SLR via DGR would be more cost effective than construction of a pipeline or diversion channel to SLR. The mixing of Leech and Sooke source waters would accelerate the replenishment of the Sooke Lake Reservoir upon resumption of winter rains, thus alleviating the duration of the critical dry period to some extent and mitigating against back-to-back drought years. However, transfer of Leech River water to the Sooke Lake Reservoir will likely increase the need and/or level of treatment and increase the risk of algal blooms, depending on the resulting blend and nutrient levels. Ideally this option would also require the development of storage in the Leech watershed to provide a source of water for use during the summer high demand period. Alternatively, a direct intake into the Leech River could be considered to divert water to Deception Gulch Reservoir and then Sooke Lake Reservoir during the shoulder seasons when water is available from the Leech River.

In October 2021, the CRD completed the *Leech River Watershed Water Quality Analysis Report*. This report indicated that Leech River water quality was generally good but did have elevated levels of colour exceeding the 15 TCU threshold objective. Turbidity levels are slightly higher than Sooke Lake Reservoir with a mean value of 1.3 NTU. Colour and turbidity could be removed with a conventional filtration process to meet Provincial and Federal drinking water guidelines.

At a mid-range demand growth of 1.25% annually it is projected that the Leech water supply would have to be in service by the year 2045. This is the approximate year when the safe 1:50 drought yield of the Sooke watershed will be reached. Planning for diversion of the Leech River should commence by 2032 as it can take some time to conduct the required planning, environmental studies, design, and construction of works necessary to develop this source.

4.1.6 Reservoir Operating Balance Procedures

The CRD recognizes the importance of the reservoir operating procedures to reduce the risk associated with operating reservoirs at high water levels in the winter and to optimize the capture and use of water in each of their watersheds. The CRD is planning preparation of a hydrological model and reservoir water budget and operating rules model to optimize use of the Sooke Lake Reservoir, Council Lake, and the Goldstream reservoirs. Such a model would enable the CRD to optimize water use for domestic and downstream environmental flow needs. This model could also be used to optimize Leech River diversions to Sooke Lake Reservoir as well as being used to optimize reservoir storage development on the Leech River.

4.1.7 Other Surface Water Sources

It is prudent to first confirm the feasibility of storage or diversion from the Leech River watershed and then explore other opportunities beyond the Leech supply if necessary.

The 1994 Plan investigated other potential sources outside of the existing WSAs. These included the Upper Jordan Watershed / Bear Creek Reservoir operated by BC Hydro and Koksilah River Watershed. Both of these watersheds are remote from the transmission system and would involve significant capital investment to develop. The Upper Jordan Watershed is currently operated by BC Hydro for power generation so the likelihood of developing this source for drinking water supply would be remote.

The likelihood of developing additional water sources which are not currently under the control or jurisdiction of the CRD is remote. For this reason, optimization of existing sources in the WSA is the preferred strategy for providing additional water during the planning horizon for this 2022 Master Plan. Once filtration is in place, previously used and now decommissioned off catchment sources such as Jack Lake, Mavis Lake and Cabin Pond could also be explored as possible additional sources. Furthermore, the development of the Leech River supply has significant potential to yield additional water supply beyond the 2050 planning horizon.

4.1.8 Groundwater

The 1994 Plan reviewed the potential for groundwater development within the CRD. Current wells within the CRD have limited capacity with yields that are considered to be too low for a large regional water supply system. Groundwater quality is unlikely to be as good as surface water sources in the CRD. Groundwater development is not considered a long-term viable water source within the CRD.

4.1.9 Desalination of Sea Water

Desalination is becoming more popular due to advancements in technology. In California several large facilities have been constructed and at least six (6) are in the planning or design phase. The main disadvantage of desalination is that the operational and maintenance costs are significantly higher than conventional treatment processes treating better quality surface waters. Brine disposal is also a concern with this technology. This technology would only be explored as a last resort once all other surface water sources are fully explored and used to their safe yield limit.

4.2 Source Watershed Hydrology

4.2.1 Hydrologic Climatic Conditions

The Leech, Sooke and Goldstream Watersheds are each designated as individual Water Supply Areas (WSAs). Cumulative assessments of the historical climate and hydrologic data available within the WSAs have not yet been completed; therefore, regional assessments and estimates have been used in the following sections to characterize existing climate and hydrologic conditions. The WSA watersheds are shown in **Figure 4.1**.

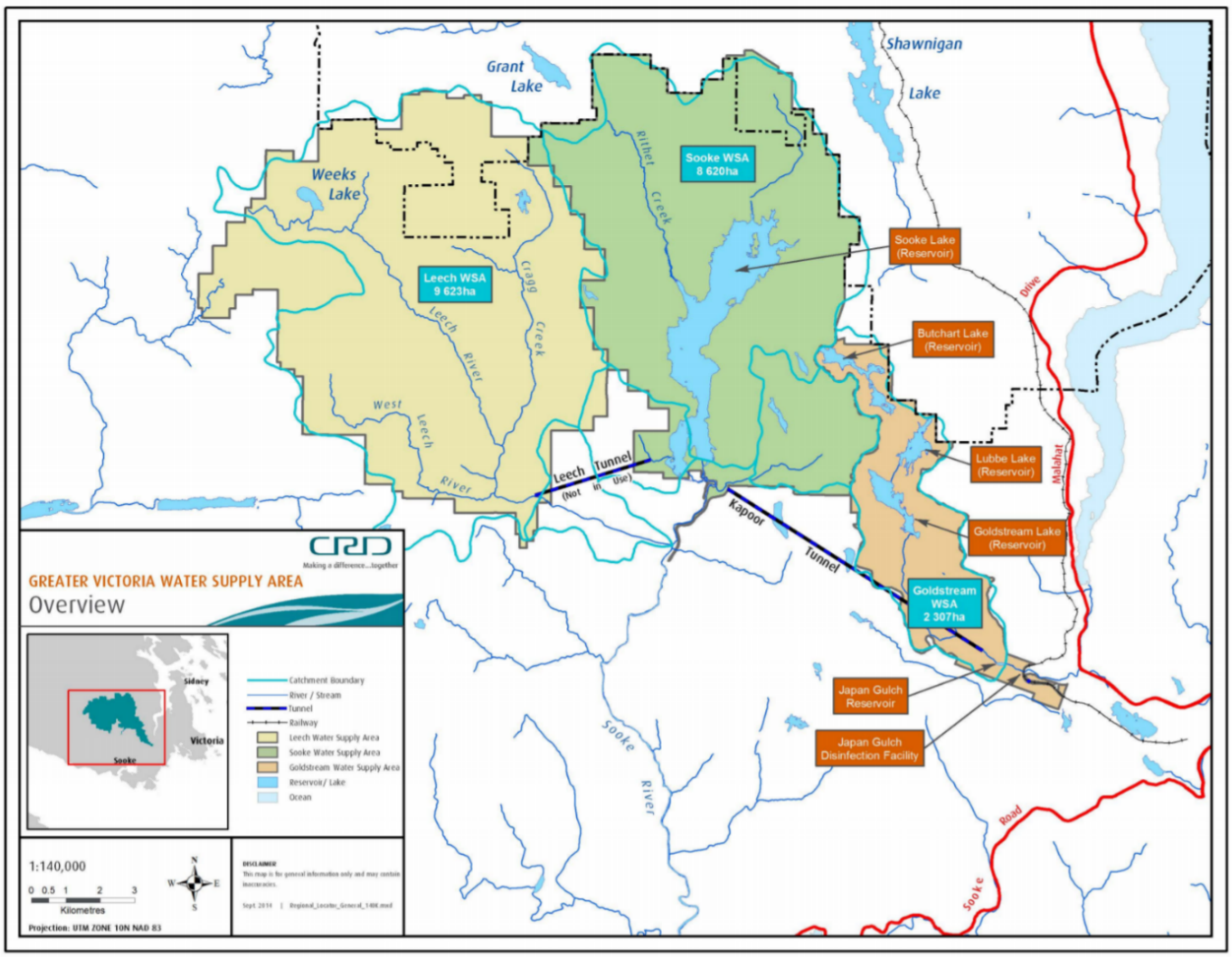


Figure 4.1: Existing Watersheds Water Supply Areas

4.2.1.1 Climate

The WSAs are located within the Eastern Vancouver Island Georgian Depression Ecoprovince Ecoregion of BC, bounded by the Vancouver Island Mountains and Olympic Mountains to the south, the southern Coast Mountains, and northern Cascade Ranges to the east (Demarchi 2011). The climate is characterized by moderate temperatures and heavy precipitation in the fall and winter seasons. Snowfall is not frequent and when it does occur, it typically accumulates at higher elevations only.

Climate parameters have been measured at several climate stations within the WSAs beginning as early as 1895. Climate stations currently in operation as well as historical stations that are no longer active are shown in **Table 4.3**.

Table 4.3: Historical Climate Stations within the Water Supply Areas

Station	Station ID	Elevation (m)	Period of Record
Leech River Watershed			
Chris Creek FWx[2]	FW009	561	2015 to present
Martin's Gulch FWx[2]	FW007	512	2009 to present
Survey Mountain FWx[2,3]	unknown	unknown	2019 to present
Sooke River Watershed			
4RW6 FWx[2,3]	FW004	675	1996 to present
North Basin FWx[1]	FW008	280	2013 to present
Judge Creek	unknown	200	1994 to present
Rithet Creek FWx[1]	unknown	223	1994 to present
Sooke Lake Dam FWx	FW006	180	1995 to present
Sooke Lake[2]	1017560	173	1903 to 1966
Sooke Lake North[2]	1017563	231	1966 to 2011
Goldstream River Watershed			
14G FWx (Goldstream Dam)[2]	FW001	493	1998 to present
31N FWx[1] (Butchart Reservoir)	FW003	606	1996 to present
Mt McDonald FWx[1]	FW005	436	1996 to present
Goldstream Lake Reservoir	1013240	459	1894 to 1953
Japan Gulch[1]	unknown	142	1999 to present

Notes:

[1] Precipitation not measured at this station

[2] Snow measured at this station

[3] Snow water equivalency measured at this station

FWx: Fire Weather Station

Source: station details were either provided by CRD or obtained from Environment and Climate Change Canada (ECCC) historical data (Canada 2021a)

Temperature

Temperature climate normals are available for two regional climate stations that are located within 14 km of the WSAs for the most recent period available (1981-2010). Shawnigan Lake (El. 159 m; ID 1017230) and Duncan Kelvin Creek (El. 103 m; ID 1012573) are located at elevations that are lower than the majority of the WSA watersheds (which range from approximately 135 m to 951 m). To generate temperature climate normals within the WSA watersheds and at a range of elevations more representative of the WSA watersheds, ClimateBC was used. ClimateBC provides point climate parameter estimates for historical and future data on a monthly or annual basis (Wang et al. 2016). Using ClimateBC, monthly temperatures were generated for the 1981-2010 climate normals period and are also shown in **Figure 4.2.** Survey Mountain (El. 951 m) and Japan Gulch Dam (135 m) were selected to represent the range of temperature climate normals. In comparison to the regional lower elevation climate normals, the ClimateBC generated estimates for the 1981-2010 period estimated lower average temperatures in May through September at all elevations and higher winter temperatures at lower elevations (December through February). Comparison of the two ClimateBC locations, highlights the strong effect that elevation has on temperature.

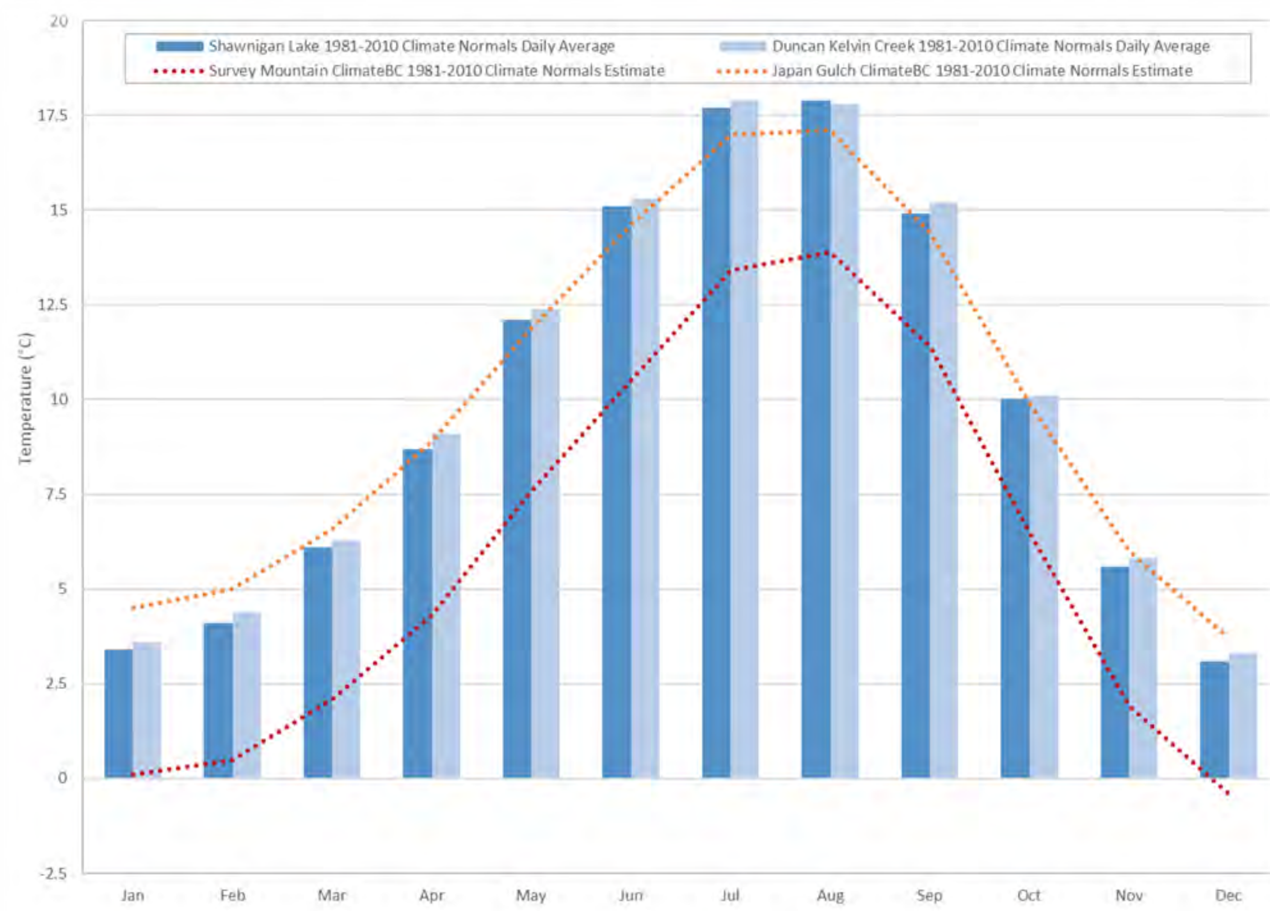


Figure 4.2: Regional 1981-2010 Temperature Climate Normals (ECCC) and ClimateBC Generated Estimates

Precipitation

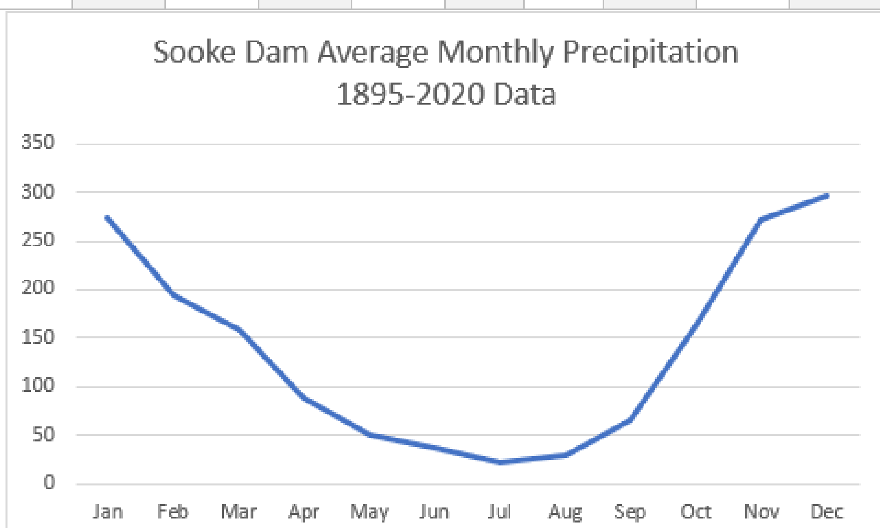
Precipitation within the WSAs is relatively higher in the late fall, winter, and early spring, and low in summer months **(Table 4.4)**. Precipitation is highest in the Leech River Watershed (CRD 2021) which contains higher elevations than the Sooke and Goldstream watersheds. Orographic effects on precipitation have been estimated to be approximately 2 mm per 100 m of elevation gain (CRD 2018) and records indicate a general trend of increase from southeast to northwest in the Goldstream and Sooke Watersheds (Niemann 1993).

Snow accumulations within the WSAs are variable year to year with snow typically being melted by April (CRD 2017). Snowpack is measured at a few stations within the WSA (FRW6 FWx, Chris Creek and Martin’s Gulch FWx; **Table 4.3**). However, snow water equivalent within the WSAs is not measured (CRD 2018). Regional snow survey stations collect data at elevations above (Jump Creek 3B23P at El. 1,160 m and Heather Mountain Upper 3B24P at El. 1,190 m) or below (North Rd Lab 3B25P at El. 48 m in Victoria) the elevation ranges most common within the WSAs (from El. 951 m at Survey Mountain to El. 135 m at Japan Gulch). ClimateBC 1981-2010 climate normal estimates within each of the WSAs estimated snow to be 3% to 5% of annual precipitation at elevations between 135 m and 211 m, 7% to 8% at elevations between 400 m and 460 m and 9% to 20% at elevations from 460 m to 951 m.

A local long-term daily precipitation record was estimated (Acres 1999) by combining station data collected from the Goldstream Lake, Sooke Lake, Sooke Lake North, and Sooke Lake Dam FWx climate stations (stations listed in **Table 4.3**). Average monthly and annual precipitation depths from this estimated dataset extended with recent Sooke Lake Dam FWx data are provided in **Table 4.4.** Annual wet and dry return periods were estimated using this combined data set and are provided in **Figure 4.3**. The two driest precipitation years in the last twenty years are estimated to have return periods of 32 years (2008) and 42 years (2000) based on this combined dataset.

Table 4.4: Estimated Sooke Lake Dam Average Monthly and Annual Precipitation (1895 to 2020 Data Provided by CRD)

Average Precipitation (mm)												
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
273.2	194.3	159.1	88.1	49.6	36.2	22.6	29.1	65.7	163.2	272.6	296.0	1,649.7



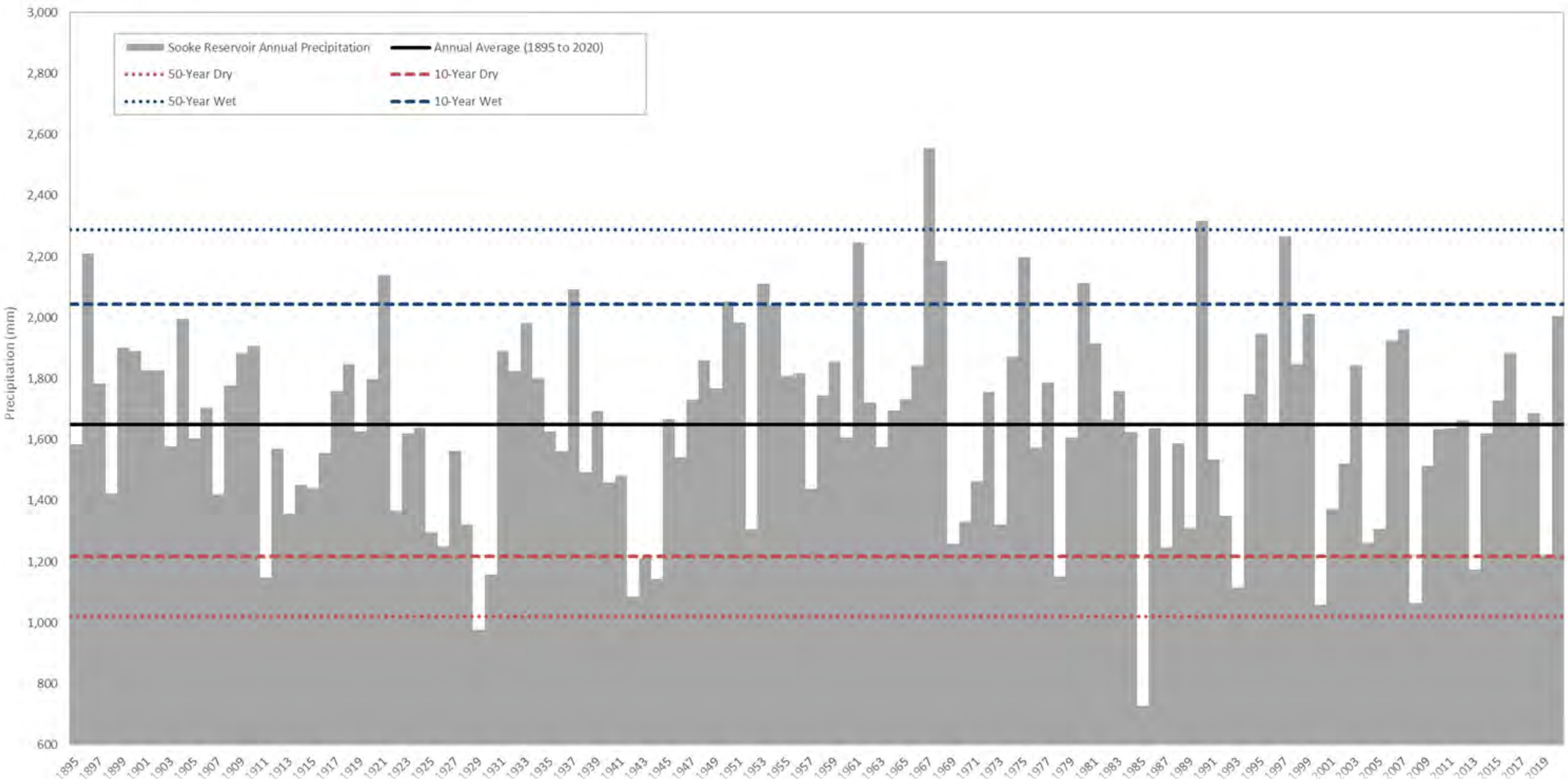


Figure 4.3: Estimated Historical Sooke Lake Dam Annual Precipitation (Data Provided by CRD) and Estimated Annual Return Periods

Evaporation and Evapotranspiration

Evaporation is the process of water changing phase from a liquid to a vapour causing it to be lost to the atmosphere (e.g., over a body of water). Evapotranspiration is the process where water vaporizes from plant tissue (transpiration) along with evaporation from liquid water forms (e.g., water losses from vegetation and soil to the atmosphere). Neither evaporation nor evapotranspiration are directly measured within the WSAs, however several regional and local estimates are available. The average annual historical evaporation from the Sooke Lake Reservoir was modelled to be 762 mm between 1996 and 2005 (Werner et al. 2015). The lowest modelled annual evaporation during this period was 679 mm in the 1996/1997 water year and the highest was 836 mm in 1997/1998 (Werner et al. 2015). The highest evaporation rate in 1998 also corresponded with the highest average annual air temperature between 1971 and 2000 (Werner et al. 2015). The mean annual Sooke Lake Reservoir evaporation is estimated to be in the range of 600 to 800 mm (Canada 1975). Evapotranspiration and groundwater losses combined have been estimated to be 480 mm (Acres International 1999). Annual Hargreaves reference evaporation estimates from ClimateBC ranged from 672 mm near the Sooke Lake Dam (El. 187 m) to 578 mm on Survey Mountain (El. 951 m) and monthly estimates were highest in July and lowest November through February (**Table 4.5**). Approximately 5 Mm^3 evaporates from the surface of Sooke Lake Reservoir on an annual basis.

Table 4.5: ClimateBC Estimated 1981-2010 Hargreaves Reference Evaporation Climate Normals (mm)

El. (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
187	12	20	39	61	91	106	118	102	66	33	15	10	672
951	11	18	34	53	78	91	104	91	57	29	13	0	578

4.2.1.2 Hydrology

The Leech, Sooke and Goldstream Watersheds are located within the West Coast Region of the Natural Resource Operation Regions for BC within Hydrologic Zone 28 (Eastern Vancouver Island; Ahmed 2017) and within the Coastal Western Hemlock Zone of the BC Biogeoclimatic Zones (FLNRORD 2018). The Leech watershed is the largest by area and has the highest elevation of the three watersheds. Runoff relationships in each of the watersheds vary due to the differences in tree cover, topography, elevation, and soil (CRD 2018).

Leech Watershed

The Leech Watershed drains generally northwest to southeast. The watershed contains several lakes, with Weeks Lake wetland and Jarvis Lake being the largest two (**Table 4.6).** Jarvis Lake flows into Cragg Creek which flows into the Leech River in the southeast portion of the catchment. Weeks Lake flows into the main arm of the Leech River. The West Leech River in the southwest portion of the watershed flows into the Leech River downstream of its confluence with Cragg Creek. The Leech Tunnel (currently not in use) diverts water from the Leech River downstream of the confluence with the West Leech River before it flows into the Sooke River and into Sooke Inlet.

Table 4.6: Surface Areas of Major Waterbodies within the Leech Watershed

Waterbody	Surface Area (ha)
Jarvis Lake	14.2
Worley Lake	3.5
Weeks Lake	27.6
Source: CRD 2015, Acres 1999	

The northern and eastern parts of the Leech Watershed are dominated by bed rock outcrops (CRD 2015). Elevations within the watershed range from approximately 950 m at Survey Mountain to 140 m at the mouth of the Leech River (CRD 2018). The Coastal Western Hemlock biogeoclimatic subzones located within the watershed are Submontane Moist Maritime (CWHmm1), Montane Moist Maritime (CWHmm2) and Western Very Dry Maritime (CWHxm2; FLNRORD 2018). Approximately 95% of the area within the Leech Water Supply Area (which covers a similar percentage of the watershed area footprint) has been harvested and 400 km of roads have been constructed (CRD 2021). A watershed restoration program has been funded since 2009 to facilitate forest recovery.

The hydrologic response time within the Leech watershed to precipitation events is short (peaks occur within hours and days, estimated Leech River lag times have ranged from 2 to 6 hours; CRD 2015) due to the in-progress forest restoration, extensive road network, shallow soil depths and steep gradient streams in the upper Leech River Watershed (CRD 2015).

Hydrometric stations where historical flow data has been collected within the Leech River Watershed are summarized in **Table 4.9**. Hydrometric data collected at the Leech River hydrology station (located downstream of the Leech Tunnel) provided by CRD are shown in **Figure 4.4** (note this data has not been reviewed for quality assurance and quality control). These records indicate the mean annual discharge at the station is approximately 5.75 m^3/s.

Data from **Figure 4.4** indicates that the Leech Watershed produces little flow from mid June to mid August when consumptive water demands are high. Impoundment would be required if the Leech River is to be used in the future for CRD water supply.

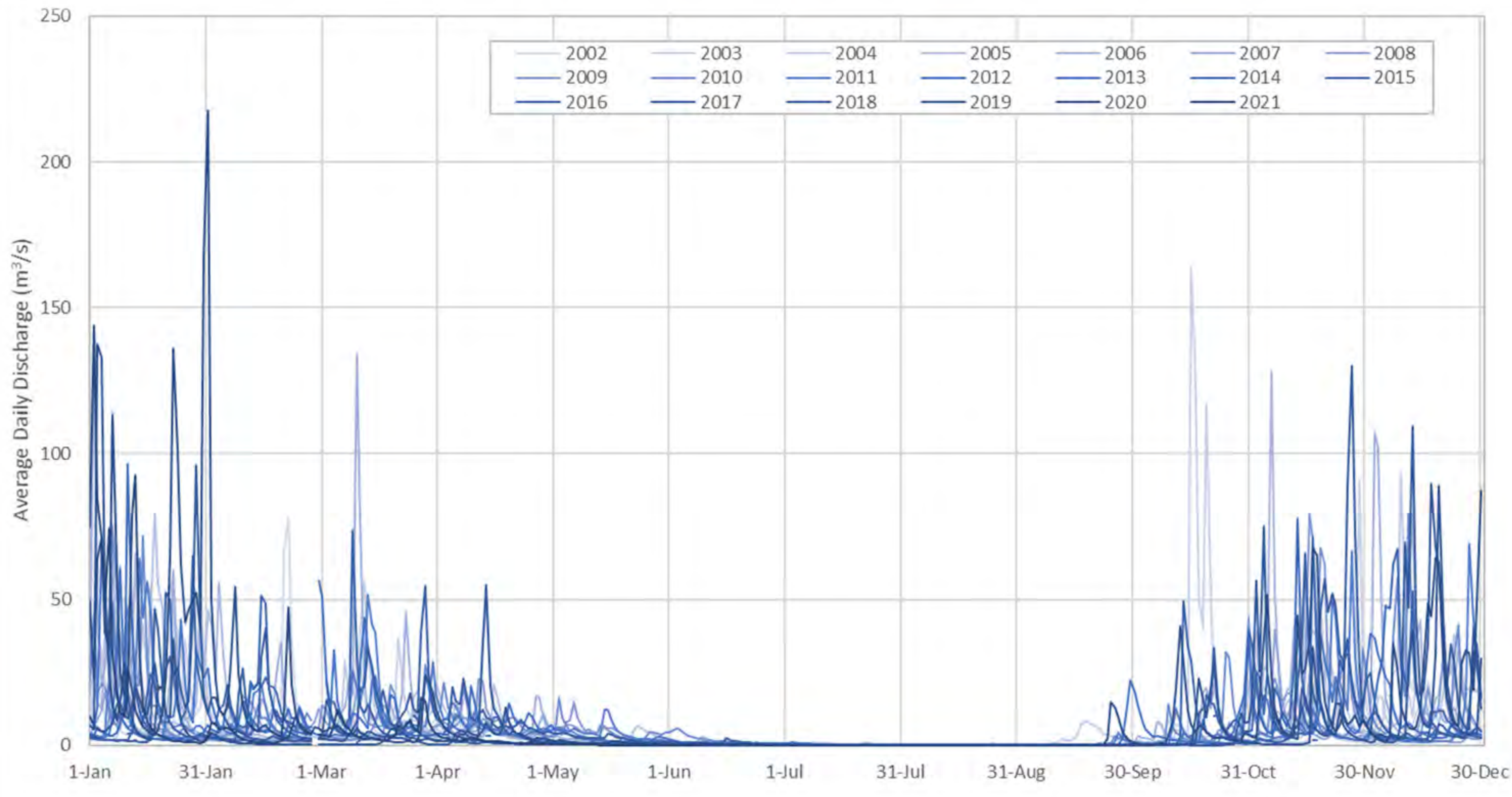


Figure 4.4: Leech River Daily Average Discharge (January 2002 to June 2021, Data Provided by CRD)

Sooke River Watershed

The Sooke Watershed generally drains north to south. Judge Creek flows into Sooke Lake Reservoir from the north. The main tributary, Rithet Creek, flows into the reservoir from the west and contributes approximately 25% of the reservoir inflows. The watershed contains several lakes, in addition to the Sooke Lake Reservoir which is the largest waterbody within the watershed (**Table 4.7**). Water from the Council Lake watershed (located east of the Sooke Lake Reservoir) is routinely diverted to the SLR through Main No.12 and a channel. Water from the Sooke Lake Reservoir intake tower is conveyed to the Head Tank. The Head Tank pressurized Kapoor Tunnel which conveys water to the Goldstream Disinfection Facility. The Coastal Western Hemlock bio-geoclimatic subzones located within the watershed are Eastern Very Dry Maritime (CWHxm1) and Western Very Dry Maritime (CWHxm2; FLNRORD 2018).

Hydrometric stations where historical flow data has been collected within the Sooke River Watershed are summarized in **Table 4.9**. Hydrometric data collected at the Rithet Creek hydrology station (located upstream of the confluence with the Sooke Lake Reservoir) provided by CRD are shown in **Figure 4.5** (note this data has not been reviewed for quality assurance and quality control). These records indicate the mean annual discharge at the station is approximately 0.70 m^3/s and mean annual runoff is 1,266 mm (based on a watershed area of 17.4 km^2; CRD 2021b). Runoff in the Rithet Creek catchment is estimated to be between 71% to 82% (KWL 2016) of recorded precipitation (at Sooke Lake Dam).

Table 4.7: Surface Areas of Major Waterbodies within the Sooke Watershed

Waterbody	Surface Area (ha)
Council Lake	14.2
Horton Lake	5.5
Jones Lake	8.0
Sooke Lake Reservoir	610[1]
Source: Acres 1999 [1] At high water mark elevation 186.75m	

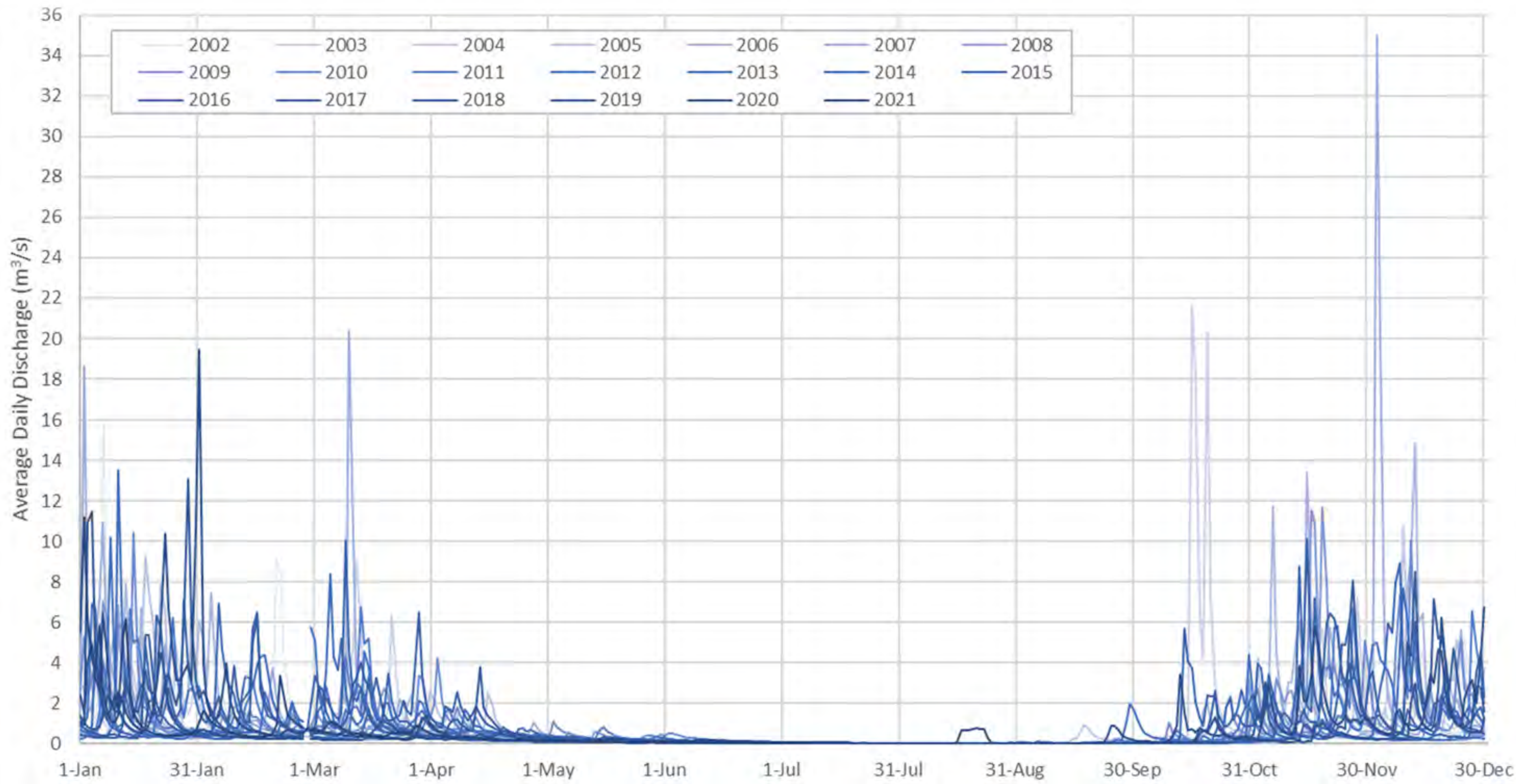


Figure 4.5: Rithet Creek Daily Average Discharge (January 2002 to June 2021, Data Provided by CRD)

Goldstream Watershed

The Goldstream Watershed is located east of the Sooke Watershed. There are eleven dams located within the Goldstream Watershed and four different reservoirs (Butchart Lake Reservoir, Lubbe Lake Reservoir, Goldstream Lake Reservoir and Japan Gulch Reservoir, See **Figure 4.1**). Butchart Lake Reservoir is located at the north end of the catchment and flows via a constructed surface channel into Lubbe Lake Reservoir before flowing through another surface channel to Goldstream Lake Reservoir (CRD 2021c). Goldstream Reservoir flows southeast into the Goldstream River. An intake from the Goldstream River diverts water into Japan Gulch Reservoir. Water from Japan Gulch Reservoir is screened before it flows into the transmission system upstream of the Goldstream Disinfection Facility. Downstream of Japan Gulch Reservoir intake, the Goldstream River takes a sharp turn as it enters Goldstream Provincial Park and flows north into Finlayson Arm in Saanich Inlet. Water from the Goldstream water supply area is currently used a secondary source and typically used during inspection and maintenance of the Kapoor Tunnel. Minimum environmental conservation flow requirements exist on the Goldstream River which contains salmon and the Howard English Fish Hatchery. On average 4.5 Mm^3Y of water is released (CRD 2021c).

Elevations within the watershed range from approximately 650 m at highest elevation portion of the catchment near Butchart Lake to below 135 m at the Japan Gulch Dam. The Coastal Western Hemlock biogeoclimatic subzones located within the watershed are Eastern Very Dry Maritime (CWHxm1) and Western Very Dry Maritime (CWHxm2; FNLRORD 2018).

Table 4.8: Surface Areas of Major Waterbodies within the Goldstream Watershed

Waterbody	Surface Area (ha)[1]
Butchart	70.9
Goldstream	76.2
Lubbe	53.8
Japan Gulch	2.2

Source: Acres 1999

[1] At high water mark elevation

Hydrometric stations where historical flow data has been collected within the Goldstream Watershed are summarized in **Table 4.9**. Reservoir elevations have been monitored within the Butchart, Lubbe and Goldstream Reservoirs beginning in either 2011 or 2012 (KWL 2017). Outflows from the Goldstream Lake Reservoir have been recorded since 2011 (KWL 2017). Runoff in the Goldstream Watershed is estimated to be 72% of precipitation in the catchment (between 2011 and 2016; KWL 2017).

Table 4.9: Historical Hydrometric Stations within the Leech, Sooke and Goldstream River Watersheds

Station Description	Station ID	Operator/Data Contributed by	Drainage Area (km^2)	Period of Record
Leech River Watershed				
Leech River at the Mouth	08HA017	n/a[3]	104[3]	1963 to 1966[3]
Jordan Meadows Tributary at WJ650	HY027	CRD	n/a	n/a
Leech River at Weeks Main (L504)	HY022	CRD	n/a	n/a
Chris Creek at Chris Creek Road	HY026	CRD	n/a	n/a
East Survey Mountain Creek	HY024	CRD	n/a	n/a
West Leech River vs West Leech Falls	HY029	CRD	n/a	n/a
Leech River at Intake Tunnel	HY017	CRD	n/a	n/a
Leech Water Level Sensor	HY007	CRD	n/a	n/a
Sooke River Watershed				
Judge Creek Hydromet Station	HY002	CRD	n/a	n/a
Rithet Creek Hydrology Station	HY001	CRD	n/a	2002 to 2021
Deception Creek Hydrology Station	HY008	CRD	n/a	n/a
Deception Dam	HY014	CRD	n/a	n/a
Sooke River (Victoria Water Supply)	08HA006	City of Victoria[3]	66.9[3]	1916 to 1966[3]
Sooke Lake Dam	HY010	CRD	7.08[2]	n/a
Council Creek Hydrology Station	HY003	CRD	n/a	n/a
Sooke River Hydrology Station	HY009	CRD	n/a	n/a
Sooke River near Sook Lake	08HA005	City of Victoria[3]	77.7[3]	1916 to 1966[3]
Sooke River above Todd Creek	08HA018	n/a[3]	n/a[3]	1963 to 1965[3]
Sooke River above Charters River	08HA059	n/a[3]	262[3]	1989 to 1997[3]
Goldstream River Watershed				
Butchart Dam	HY013	CRD	n/a	2011 or 2012[1] to present

Station Description	Station ID	Operator/Data Contributed by	Drainage Area (km^2)	Period of Record
Lubbe Dam 1	HY011	CRD	n/a	2011 or 2012[1] to present
Goldstream Dam	HY015	CRD	n/a	2011[1] to present
Goldstream River Hydrology Station	HY004	CRD	n/a	1998[1] to unknown
Goldstream River Turbidity	HY016	CRD	n/a	n/a
Japan Gulch Reservoir	HY005	CRD	22.4[2]	n/a
Lubbe Dam 4	HY012	CRD	n/a	n/a
Goldstream River in Goldstream Provincial Park	08HA039	BC MoE[3]	n/a[3]	1976 to 1978[3]

Notes:
BC MoE: British Columbia Ministry of Environment
n/a: data unavailable
[1] KWL 2017
[2] CRD 2014
[3] Water Survey of Canada (Environment and Climate Change Canada) Historical Database (Canada 2021b)

4.2.2 Climate Change Impacts on Source Water Quantity

Regional projections of potential climate change (PCIC 2021) relevant to water quantity within the WSAs are summarized in **Table 4.10**. Potential impacts specific to the projected climate change are shown in **Table 4.11.**

Future temperatures within the Capital Regional District are projected to increase, under a high emissions scenario relative concentration pathway (RCP) 8.5, in every season and throughout the 21st century (Table 4.3; PCIC 2021). RCP 8.5 is the radiative forcing scenario consistent with current greenhouse gas emissions trends and is generally considered the most relevant for design and assessment (EGBC 2020). The greatest temperature increases are expected during summer months (June through August). Predicted changes in total annual precipitation within the Capital Regional District range from minor increases in the 2020s to increases of 2.3% in the 2050s and 8.0% in the 2080s (Table 4.3; PCIC 2021). Annual total precipitation is expected to increase overall. However, seasonal distributions are projected to change with decreasing precipitation during summer months and increasing precipitation in winter months (Table 4.3; PCIC 2021).

Table 4.10: Projected 50th Percentile Increase from 1961-1990 Baseline (PCIC 2021)

Period	Temperature (°C)			Precipitation (%)		
	2020s	2050s	2080s	2020s	2050s	2080s
Dec to Feb	+1.5	+2.6	+4.7	+2.5	+2.3	+10
Mar to May	+1.6	+2.5	+4.1	-0.63	+3.7	+1.2
Jun to Aug	+1.7	+3.1	+4.7	-7.3	-11	-19
Sep to Nov	+1.5	+2.6	+4.1	-1.8	+5.6	+11
Annual	+1.5	+2.7	+4.3	+0.54	+2.3	+8.0
Source: PCIC 2021, 12 ensemble projection using RCP 8.5 (high emissions) greenhouse gas scenario						

Table 4.11: Potential Climate Change Impacts on Water Quantity

Projected Climate Change	Hydrologic Response	Potential Impact
Increased Precipitation	• Increased runoff / flooding • Wetter storm events • Possible increase in saturated soil • Increased erosion	• Flooding frequency/magnitude may increase • Seasonal water quality may be reduced • Stream bank erosion may increase • Increased sediment accumulation in stream and riverbeds may occur • Increase in turbidity, organics and colour in raw water • Erosion may increase, possible impacts on fish habitat • Water quality may be negatively affected by nutrient and input runoff • Excess water may require new storm water management infrastructure/diversion • Steep slopes may be destabilized
Increased Temperatures	• Earlier freshet • Extended dry season • Drier droughts • Increased evaporation and evapotranspiration	• Water supply may be reduced, increased evaporation • Storage reservoir demand may be increased • Water use restrictions may need to be tightened • Increased risk of wildfires which could alter hydrologic regime • Algae growth more prominent
Sources: PCIC 2021, CRD 2017 and CRD 2018, Stantec		

4.2.3 Sooke Watershed Drought Safe Water Supply Yield

The Sooke Lake Reservoir water balance was developed and simulated with daily timesteps using GoldSim software (a dynamic simulation software package) to confirm that the Sooke Lake Reservoir has sufficient water yield to supply its existing demands under drought conditions.

CRD (2021d) monitors inflows and calculates timeseries of daily atmospheric inflows into the Sooke Lake Reservoir (i.e., equivalent of influent runoff plus direct precipitation minus evaporation) during 2002 through 2020 based on daily monitored outflows and water levels. Monthly summary statistics of these back calculated atmospheric inflows are shown in **Table 4.12** and graphs of these daily inflows are shown in **Figure 4.6**.

Table 4.12: Sooke Lake Reservoir Daily Atmospheric Inflow by Month (2002 to 2020 Data Provided by CRD) (Mm^3)

Month	Average	Minimum	Maximum
Jan	22.9	11.7	38.8
Feb	11.1	4.0	26.6
Mar	12.6	3.8	23.3
Apr	5.7	1.5	11.1
May	1.6	-0.01	4.3
Jun	0.24	-0.51	1.73
Jul	-0.40	-0.74	0.01
Aug	-0.47	-0.96	0.05
Sep	0.26	-0.45	1.57
Oct	4.2	0.12	26.3
Nov	14.4	3.6	34.9
Dec	17.5	3.0	31.2
Annual	**89.7**	**50.5**	**122.2**
Source: CRD 2021			

The historical (2010-2020) average annual demands from the Sooke Lake Reservoir include 46.6 Mm^3Y to the Head Tank, 1.5 Mm^3Y for the District of Sooke supply via Main No.15 , and 5.4 Mm^3Y fish release for environmental conservation flow needs (**Table 4.13**). Monthly distribution of these demands is shown in Table 4.13.

Table 4.13: Existing Demands from Sooke Lake Reservoir (Mm^3)

Month	Head Tank[1]	Sooke Supply[1]	Conservation Release[2]	Total
Jan	2.8	0.10	0.72	3.62
Feb	2.7	0.09	0.83	3.62
Mar	3.0	0.10	0.83	3.93
Apr	3.2	0.11	0.83	4.14
May	4.3	0.14	0.73	5.17
Jun	5.1	0.16	0.25	5.51
Jul	6.1	0.18	0.10	6.38
Aug	5.8	0.18	0.10	6.08
Sep	4.3	0.13	0.12	4.55
Oct	3.4	0.11	0.17	3.68
Nov	3.0	0.10	0.22	3.32
Dec	3.0	0.10	0.52	3.62
Annual	**46.7**	**1.5**	**5.4**	**53.6**

Note:

[1] Average of 2010-2020 values taken from CRD 2021d

[2] Taken from Appendix 2 of CRD 2019

Daily simulation of the Sooke Lake Reservoir water balance with 19 years of atmospheric inflow data (**Figure 4.6**) and existing demands (Table 4.6) shows that the lowest Sooke Lake Reservoir water levels occur in fall (between late September and early November). The reservoir starts filling with winter precipitation and completely fills 18 of the 19 simulation years (i.e., 95% of years), except 2009 which followed 2008 (an approximate 1-in-50-year dry annual precipitation year; **Figure 4.7**). With normal climate inflows in 2009, the reservoir fills again in 2010 (see Figure 4.7). Every year, including 2009 when the reservoir does not fill, all existing demands in Table 4.6 can be supplied by the reservoir (i.e., no supply deficits). Therefore, the Sooke Lake Reservoir has sufficient water yield to supply its current demands under drought conditions.

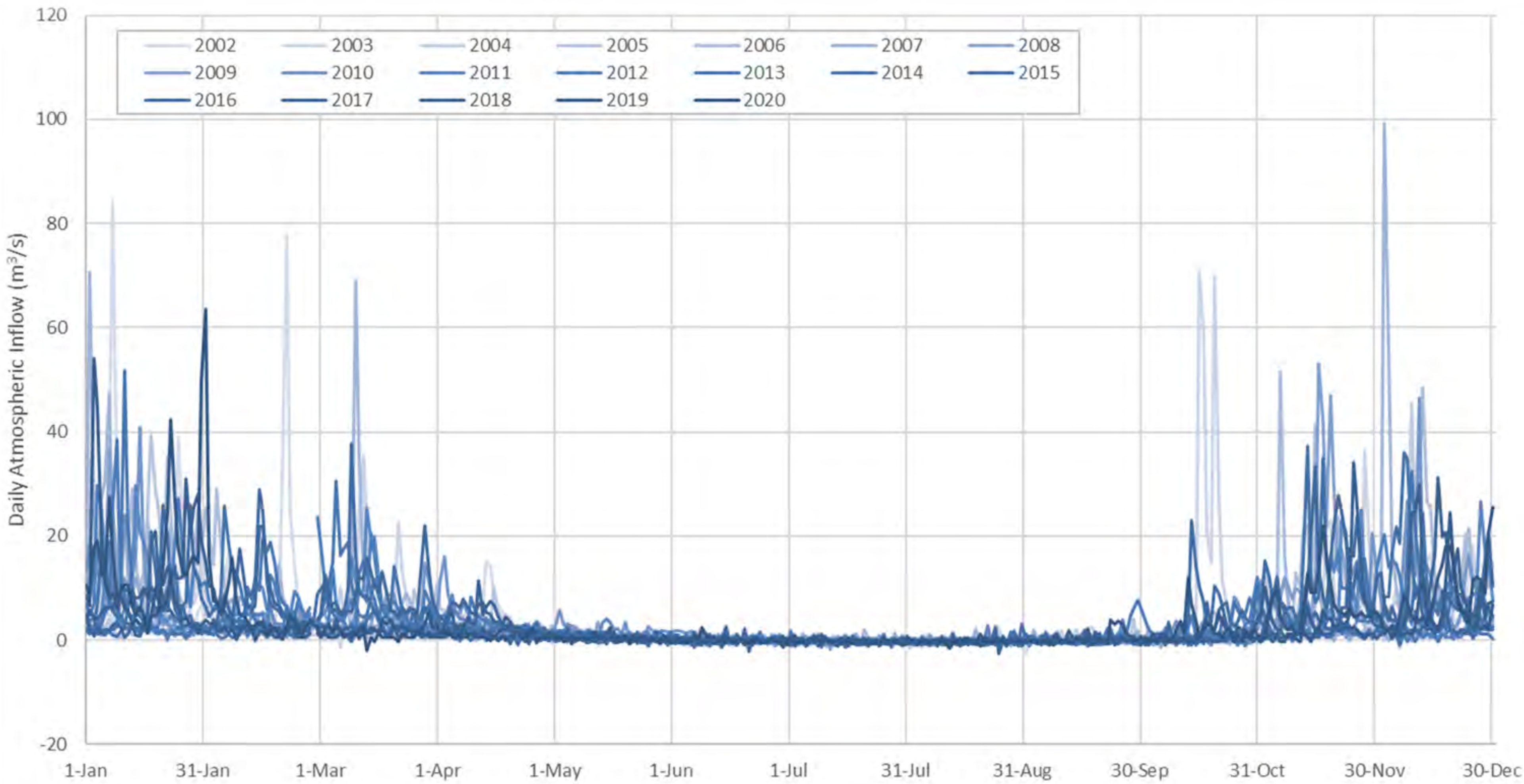


Figure 4.6: Sooke Lake Reservoir Daily Atmospheric Inflow during 2002 to 2020 (CRD 2021)

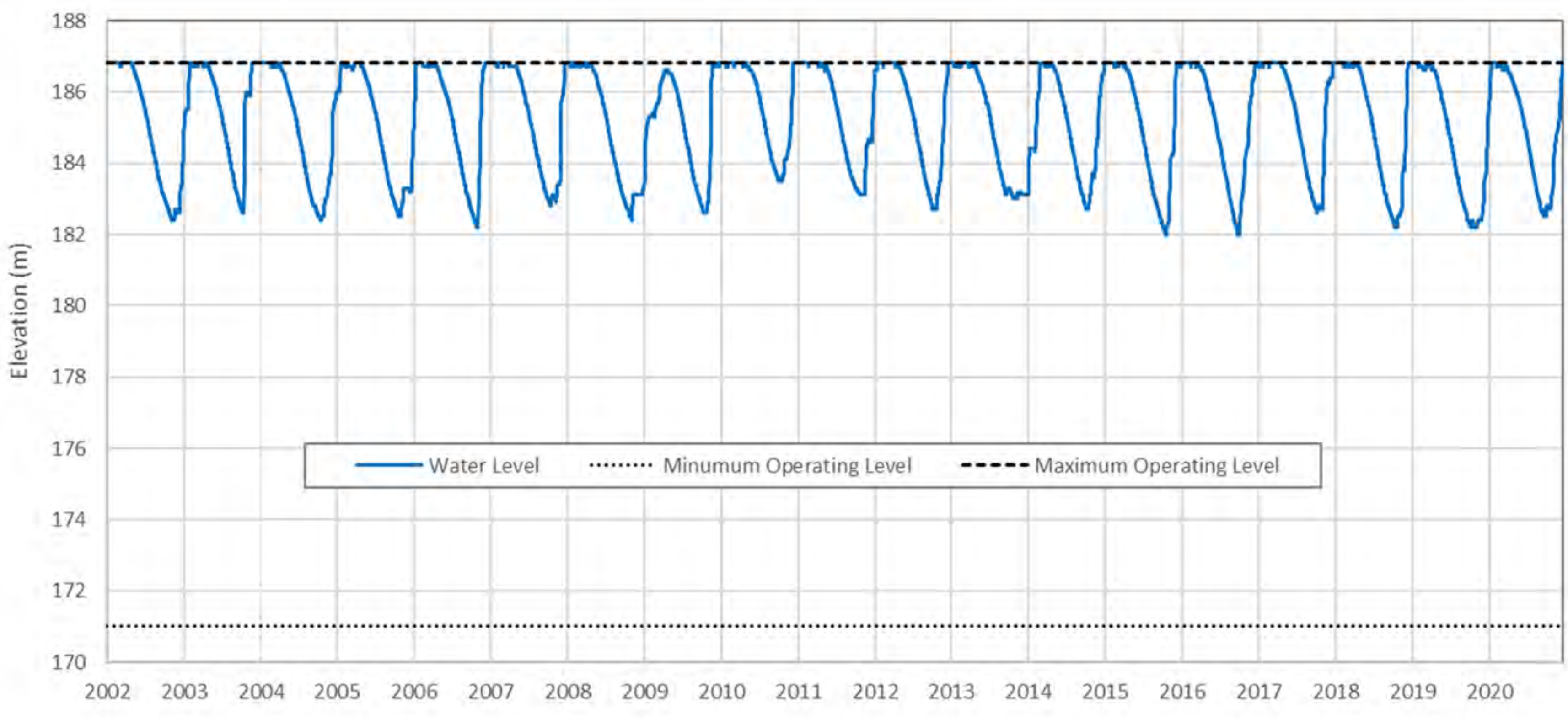


Figure 4.7: Simulated Water Level in Sooke Lake Reservoir with Existing Water Demands and 2002-2020 Atmospheric Inflow

4.2.4 Adequacy of Sources to Meet Future Demands

4.2.4.1 Sooke Watershed

The Sooke Lake Reservoir water balance model (Section 4.2.3) was run under the existing demand scenario as well as five increased demand scenarios where the Head Tank and JDFWD supply demands were increased (ranging from 10% to 50% increase, **Table 4.14**) to assess the adequacy of Sooke Lake Reservoir to meet future increased demands. In all scenarios, the conservation flow release demand was assumed to be constant per existing releases (as shown in Table 4.14).

Table 4.14: Simulated Water Level in Sooke Lake Reservoir with Existing Water Demands and 2002-2020 Atmospheric Inflow

Scenario	RWS Head Tank Demand Mm^3	RWS JDFWD Supply Demand Mm^3	Total
Existing Demand	46.6	1.5	48.1
10% increased Demand	51.3	1.7	53.0
20% increased Demand	55.9	1.8	57.7
30% increased Demand	60.6	2.0	62.6
40% increased Demand	65.2	2.1	67.3
50% increased Demand	69.9	2.3	72.2
Note: Conservation release demand is 5.4 Mm^3Y (Table 4.6) for all scenarios			

As noted in Section 3.0, the projected 2050 demand assuming a 1.25% population increase is 74 Mm^3Y (see Figure 3.4). This is more than the estimated 40% yield capacity of 67.3 Mm^3Y recommended as the maximum additional withdrawal from Sooke Lake Reservoir. Additional water sources such as augmentation with flows from Leech watershed, further demand reduction or other potential sources should be planned for development within the next 25 years to ensure that future demands can be met. Continued water conservation efforts and achieving a modest demand reduction to 300 L/c/d would allow the Sooke watershed supply to be adequate until the year 2060.

Table 4.15: Preliminary Estimates of Monthly Change in Sooke Lake Reservoir Inflow due to Climate Change by 2080s

Month	Reservoir Inflow Change (m^3/s)
Jan	0.745
Feb	0.374
Mar	0.041
Apr	-0.011
May	-0.070
Jun	-0.300
Jul	-0.270
Aug	-0.376
Sep	0.081
Oct	0.438
Nov	0.801
Dec	0.612
Annual	**0.172**

Note:

Flow changes were calculated by applying projected percent changes to monthly precipitation and evaporation estimates, averaged over the 2002 to 2020 period.

The Sooke Lake Reservoir fills 17 of the 19 simulation years (i.e., 90% of years) under the 30% and 40% increased demand scenarios, and 12 of the 19 simulation years (i.e., 63% of years) under the 50% increased demand scenario (**Table 4.16**).

Figure 4.8 shows simulated water levels in the reservoir for a 1:50 year dry annual precipitation year (2008) followed by a normal precipitation year (2009) under different demand scenarios. It is seen that in all scenarios with up to 40% increased demand, a normal year after a 1:50 dry year can fill the reservoir (i.e., effects of the 1:50 year dry year on water levels will be mitigated after one year). Therefore, it is anticipated that the Sooke Lake Reservoir has sufficient water yield to supply a demand up to 40% higher than existing demand. This estimate accounts for climate change and is for a 1:50 year drought condition which is considered suitable for assessing adequacy of water sources at the master planning level. This assessment should be considered as being preliminary and further analysis is recommended (e.g., detailed hydrologic modelling-based water balance and detailed environmental effects assessment). It is noted that CRD does not operate the SLR below 175 m as a precautionary measure for potential water quality reasons. Low water levels below 175 m may have a greater potential to promote algae growth in shallower sections of the reservoir.

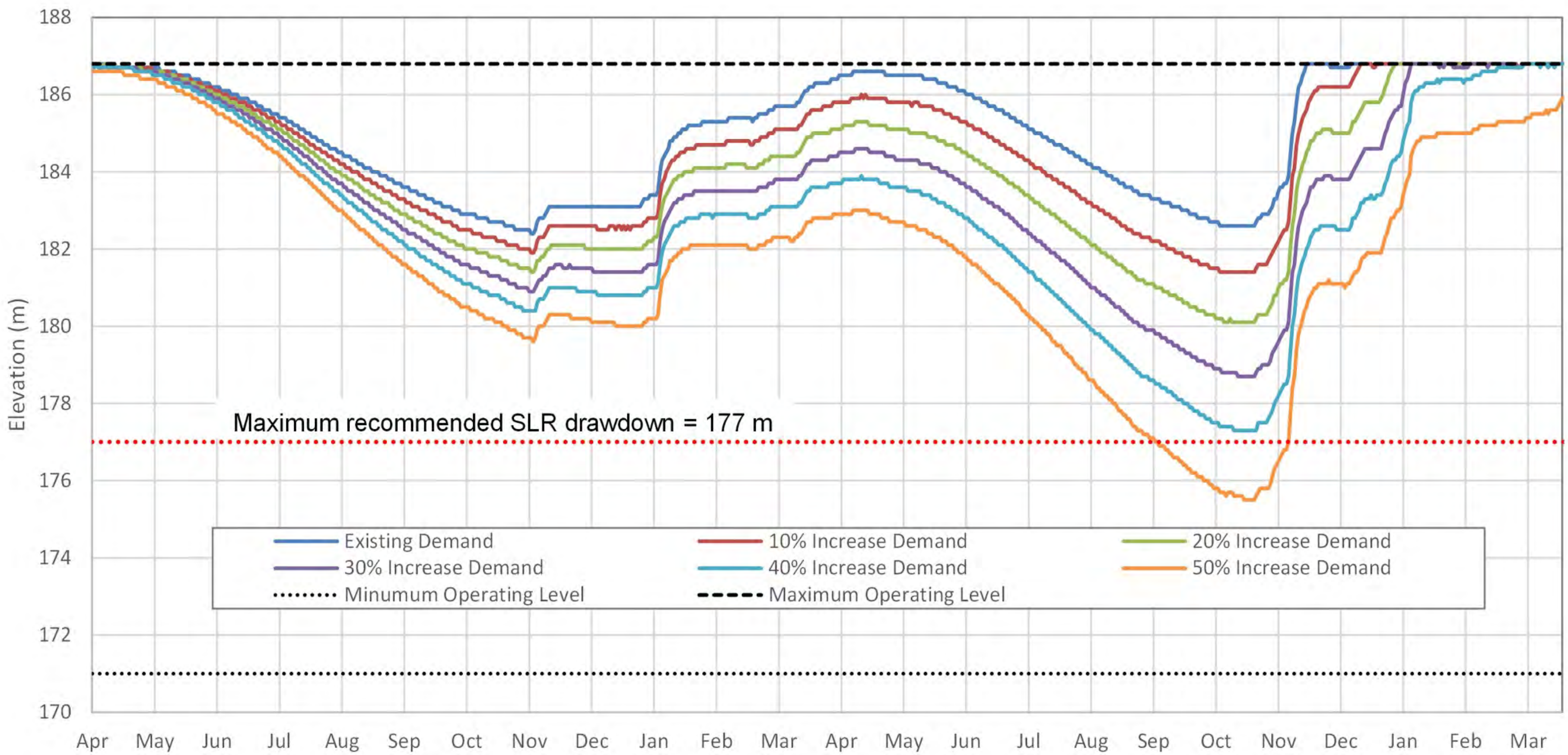


Figure 4.8: Simulated Water Level in Sooke Lake Reservoir for a 1:50 Dry Precipitation Year Followed by an Average Precipitation Year with different Demand Scenarios

Table 4.16: Number of Years (within the 19 Simulation Years) that the Reservoir Does Not Fill (Does not Reach the Maximum Operating Level of 186.75 m)

Scenario	No. of Not Filled Years[1]
Existing Demand	1 (5%)
10% increased Demand	1 (5%)
20% increased Demand	1 (5%)
30% increased Demand	2 (10%)
40% increased Demand	2 (10%)
50% increased Demand	7 (37%)

Notes:

[1] Number of not filled years are also shown in the form of percent in parentheses (% of simulation years when the reservoir does not fill).

A preliminary analysis was conducted to estimate the implications of climate change for the adequacy of Sooke Lake Reservoir to meet future (increased) demands Table 4.3 shows that by the 2080s, precipitation is expected to increase by 11% in fall, 10% in winter, and 1% in spring, and decrease by 19% in summer (annual precipitation is expected to increase by 8%). In addition, ClimateBC estimates (Wang et al. 2016) show that by the 2080s, evaporation in this region can increase by up to 10%. With these projections, it is expected that the fall and winter high flows increase, and summer low flows decrease by the 2080s.

As mentioned in Section 4.2.3, the Sooke Lake Reservoir water balance is based on back-calculated reservoir net inflows, not on a hydrologic model with direct precipitation and evaporation inputs. To assess climate change effects on the water balance, the percent changes previously mentioned (of precipitation and evaporation) were applied to monthly estimates of precipitation and evaporation (averaged over the 2002-2020 simulation period). These monthly average flow change estimates **(Figure 4.9)** were applied to all of the 19 water balance simulation years to estimate the preliminary effects of climate change on the Sooke Lake Reservoir water balance.

Figure 4.9 shows simulated water levels in the reservoir for a 1-in-50-year dry annual precipitation year (2008) followed by a normal precipitation year (2009) under the 40% increased demand scenarios, with and without climate change effects. In the summer of first year (1-in-50-year dry annual precipitation year, under the existing climate conditions), water levels of the climate change scenario are lower than those of the scenario without climate change. This is expected because under the climate change scenario summers are expected to experience lower precipitation and higher evaporation. However, because the climate change scenario also expects higher fall and winter flows, water levels under the climate change scenario become higher by the end of the winter than those without the climate change scenario. By the end of the second year (a normal climate year, under the existing climate condition), the reservoir fills under both scenarios (with and without climate change). Therefore, it is anticipated that effects related to climate change will not significantly impact the adequacy of Sooke Lake Reservoir to meet future demands. This is a preliminary assessment that requires further analysis (e.g., hydrologic modelling-based water balance with direct climate change parameters). The analysis assumes that normal precipitation periods occur following a 1:50 year dry annual precipitation year. It does not consider extended extreme events which extend over a period of several years as experience to date has shown that this type of scenario has not occurred.

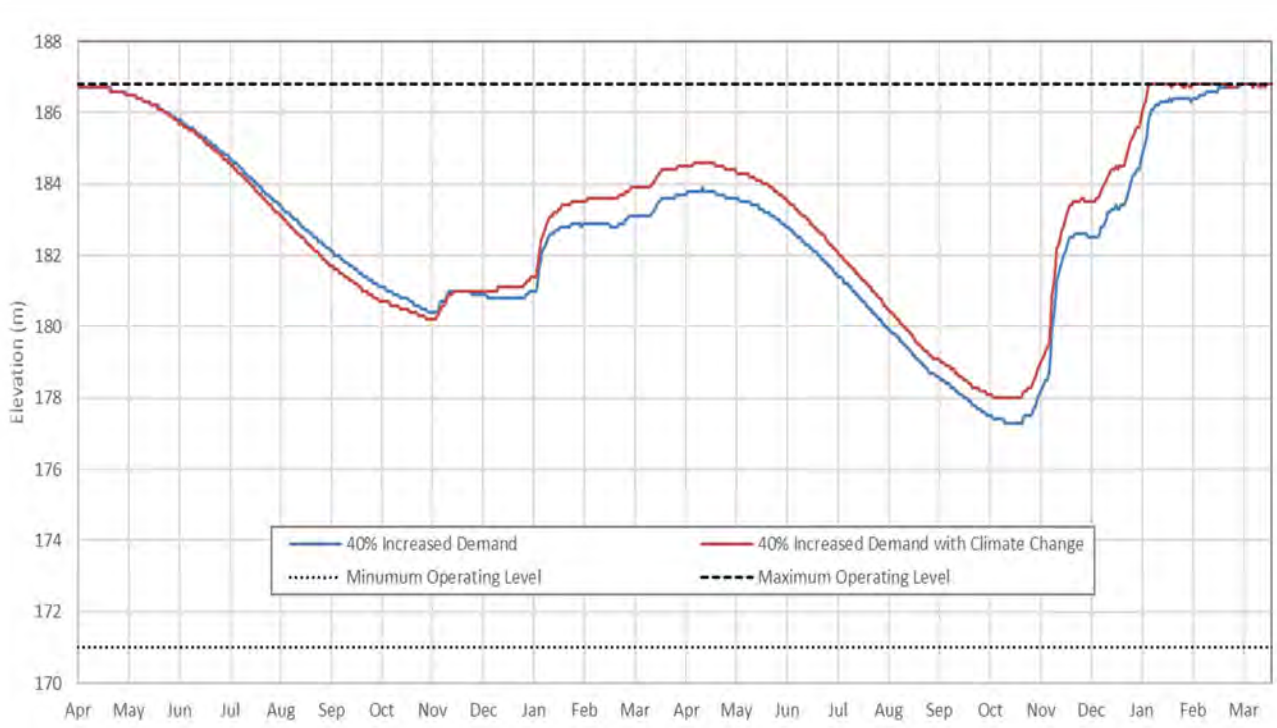


Figure 4.9: Simulated Water Level in Sooke Lake Reservoir for a 1:50 Dry Precipitation Year Followed by an Average Precipitation Year with 40% Increased Demand, With and Without 2080s Climate Change Scenarios

4.2.4.2 Leech Watershed

The hypothetical (assuming a dam is constructed in the future) Leech River Reservoir water balance was simulated with daily timesteps using GoldSim software to assess the potential for supplying water demands from the Leech watershed. The water balance model estimates the annual demand (with monthly distributions similar to those of the RWS Head Tank Demand in Table 4.6) that can be supplied by a hypothetical reservoir on Leech River. Analysis of the geotechnical, slope stability or other dam considerations are not part of this study and may impact the feasibility of dam construction on the Leech River. These issues would be investigated in preliminary design to assess the feasibility of dam construction on Leech River.

A time series of daily streamflows from the Leech River hydrology station (located downstream of the Leech Tunnel) during 2002 to 2021 provided by CRD are available (**Figure 4.4**). From this time series, 17 years (2002-2013 and 2016-2020) have complete daily streamflow data and were used for water balance modelling.

Conservation flow needs (i.e., fish release flows) that should be released from the hypothetical reservoir were calculated based on the British Columbia Environmental Flow Needs (EFN) Policy (BC FLNRO & BC MOE 2016). Based on the lowest risk level of the EFN Policy, if the inflow to the hypothetical reservoir is less than 20% of the mean annual discharge, the fish release should be 100% of the inflow. If the inflow to the hypothetical reservoir is greater than 20% of the mean annual discharge, the fish release should be 85% of the inflow (i.e., 15% of the inflow can be stored in the reservoir to supply the demand). Since CRD already has a licenced allocation of 30.8 Mm^3 for this source, the CRD should initiate discussions with the Province regarding this allocation when completing further future assessments on the development of the Leech River watershed as a long term water source for drinking water. The CRD should confirm with the Province that the allocated water license extraction from Leech River will be available given the Water Sustainability Act which has been implemented since completion of the 1994 Plan.

Daily simulation of the hypothetical Leech River Reservoir water balance with 17 years of inflow data (**Figure 4.4)** and different reservoir storage volumes shows that by increasing the active storage volume of the hypothetical Leech River Reservoir to 13 Mm^3, the reservoir can supply up to 15 Mm^3Y of demand. Increasing the active storage volume beyond 13 Mm^3 does not increase the annual demand that can be supplied (15 Mm^3/Y; **Figure 4.10**). Therefore, developing a reservoir with an active storage volume of greater than 13 Mm^3 is not expected to result in more water supply yield. Preliminary assessment of the topography suggests that a 60m to 100m dam is required to develop the 13 Mm^3 active storage. Further detailed studies are required to determine the volume of the reservoir, as well as height of the dam, required to supply the 15 Mm^3Y demands. Pending the outcome of discussions with the Province regarding the EFN Policy it may be possible to increase the withdrawal to the licensed amount of 30.8Mm^3Y as community drinking water supply is a typically a high priority use.

The hypothetical Leech River Reservoir with an active storage volume of 13 Mm^3 (or greater) fills 16 of the 17 simulation years (i.e., 94% of years) when the annual demand is 15 Mm^3 Y (**Table 4.17; Figure 4.11**). An arbitrary maximum volume of 300 Mm^3 (greater than the minimum required 13 Mm^3) was used in Figure 4.11 just for illustration purpose. The number of years that the reservoir does not fill increases if the annual demand increases beyond 15 Mm^3 (Table 4.17). For example, with an annual demand of 20 Mm^3, the reservoir would fill 7 of the 17 simulation years (i.e., 47% of years; Table 4.17; Figure 4.10).

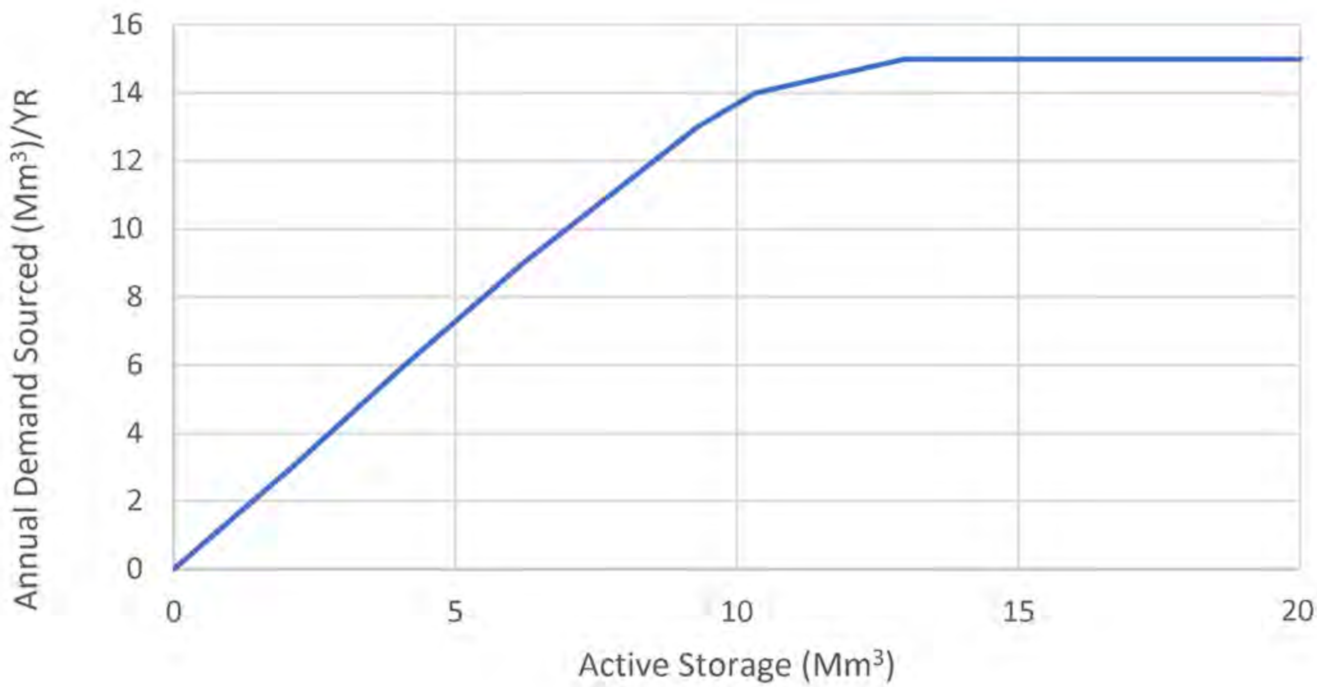


Figure 4.10: Potential Annual Demand Sourced by Leech River for Different Active Storage Scenarios

Table 4.17: Number of Years (within the 17 Simulation Years) that the Reservoir with Active Storage Volume

Annual Demand (Mm^3/yr.)	No. of Years (Percent of all Simulated Years)
12	0 (0%)
15	1 (6%)
17	2 (12%)
20	9 (53%)

Like the method described for the Sooke Lake Reservoir (Section 4.2.4.1), a preliminary analysis was conducted to estimate the implications of climate change for the adequacy of a hypothetical Leech River Reservoir to meet the 15 Mm^{3}Y demand.

With this method, the monthly average flow change estimates (due to climate change impacts by the 2080s) for the hypothetical Leech River Reservoir are shown in **Table 4.18.** These monthly changes were applied into all 17 water balance simulation years to estimate preliminary effects of climate change on the hypothetical Leech River Reservoir water balance.

Figure 4.12 shows simulated water levels in the reservoir during the 17 years of simulation with and without climate change. Minimum reservoir levels under the climate change scenarios are lower than those of the without climate change scenario because the climate change scenario has lower precipitation and higher evaporation in the summer. However, because of the higher fall and winter flows, the maximum water levels in the climate change scenario are the same as (or higher than) those of the without climate change scenario. Based on Figure 4.12, two differences between the scenarios with and without the climate change are as follows:

1. The climate change scenario requires 15 Mm^3 of active storage (compared to 13 M^3 active storage required for the scenario without climate change) to supply a 15 Mm^3Y demand.
2. Under climate change scenario, the reservoir fills every year (compared to the without climate change scenario, which does not fill in one year). The difference is the result of higher fall and winter flows predicted under the climate change scenario.

Like the Sooke Lake Reservoir analysis, this is a preliminary assessment that requires further analysis (e.g., hydrologic modelling-based water balance with direct climate change parameters).

Table 4.18: Preliminary Estimates of Monthly Change in Hypothetical Leech River Reservoir Inflow

Month	Reservoir Inflow Change (m^3/s)
Jan	0.979
Feb	0.494
Mar	0.056
Apr	-0.007
May	-0.076
Jun	-0.364
Jul	-0.318
Aug	-0.451
Sep	0.134
Oct	0.591
Nov	1.057
Dec	0.807
Annual	0.242

Note:

Flow changes were calculated by applying projected percent changes to monthly precipitation and evaporation estimates, averaged over the 2002 to 2020 period.

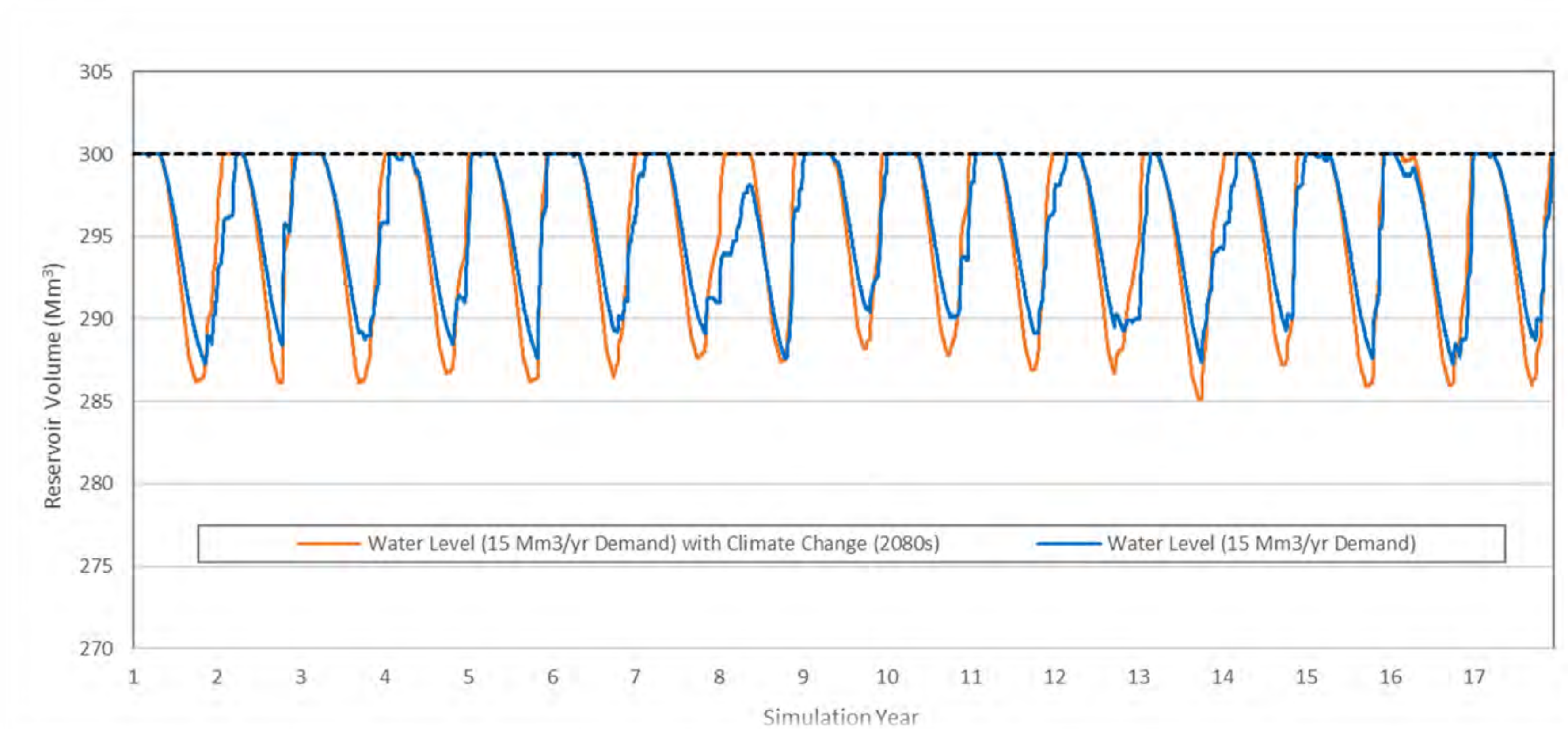


Figure 4.11: Simulated Water Level in a Hypothetical Leech River Reservoir with an Arbitrary Maximum Volume of 300 Mm^3 under the 15 Mm^3Y and 20 Mm^3/yr Demand Scenarios. The arbitrary maximum volume of 300 Mm^3 (greater than the minimum required 13 Mm^3) was used for illustration purposes only.

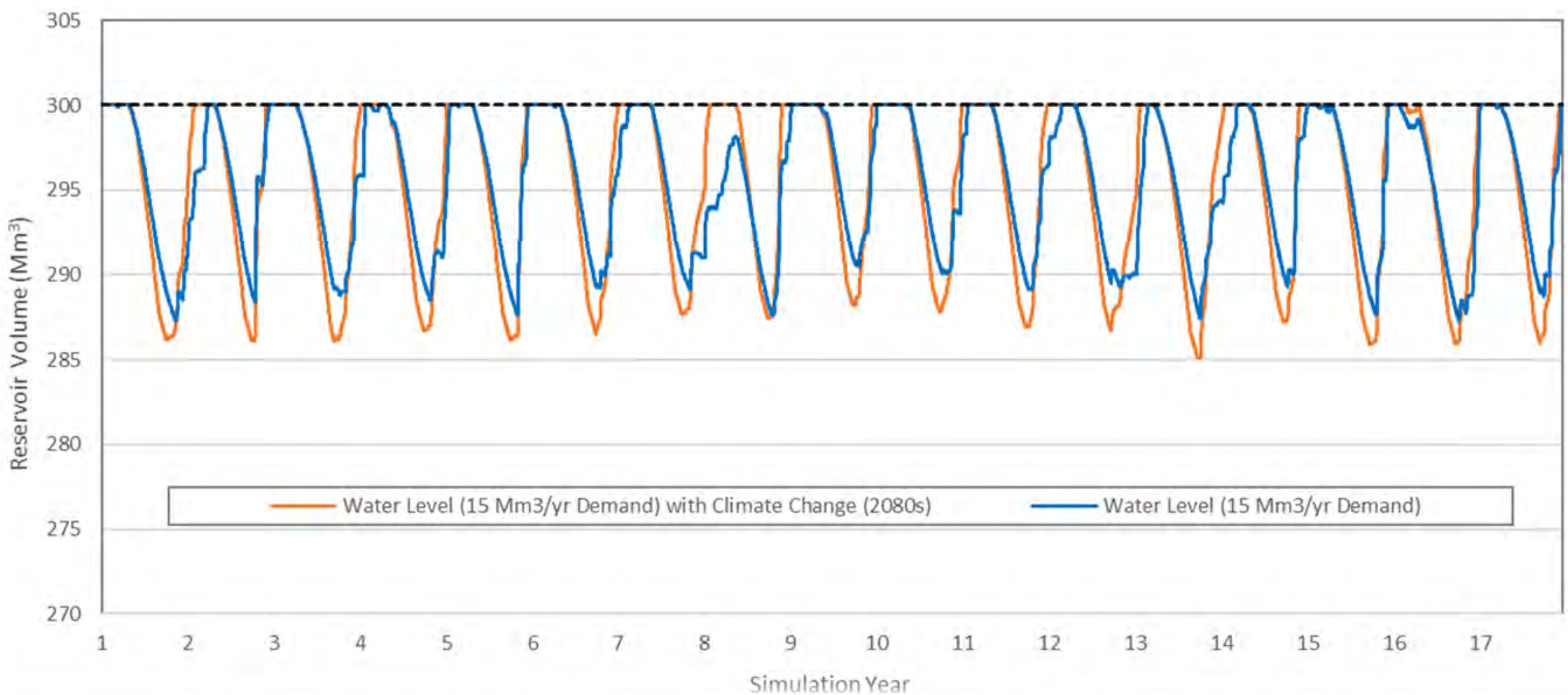


Figure 4.12: Simulated Water Level in a Hypothetical Leech River Reservoir with 300 Mm^3 under the 15 Mm^3Y Demand, with and without 2080s Climate Change Scenarios

4.2.4.3 Considerations for Concurrent Use of Sooke and Leech Watersheds

Sections 4.2.4.1 and 4.2.4.2 provide preliminary assessment for the adequacy of Sooke and Leech watersheds to meet future water demands. Conclusions provided in those sections assumed that the Sooke Lake Reservoir and hypothetical Leech River Reservoir would be operated independently to meet the water demands.

There is potential to increase the total water supply yield from the Sooke and Leech watersheds, and/or improve the reliability of water supply yield by concurrent use of these reservoirs in tandem or parallel configurations. This potential can be further investigated by an operational water balance model that considers different options and operating rule curves for concurrent operation of these reservoirs or direct diversion of Leech River water to SLR. The operational water balance model would be more accurate and reliable if it is developed based on a detailed hydrologic model and hydroclimatic data from each watershed.

We understand CRD does have a qualified hydrologist on staff who can provide guidance on stream monitoring and interpretation of available data collected in each watershed. It is recommended that all hydroclimatic data collected in the WSAs during the recent years (20 years if possible) be reviewed by CRD's qualified professional considering the data collection standards (e.g., RISC 2018). Hydroclimatic data that passes such a quality review should be compiled into summary reports that can be used for multiple purposes, including hydrologic and water balance modelling. We are advised by CRD that data collection and analysis for all hydroclimatic stations in the WSAs is compliant with the provincial standards (e.g., RISC 2018). This data should be consolidated in monthly and annual reports for future use and reference. Any future stations installed in the watershed should also meet provincial standards.

4.3 Water Licences

CRD has numerous water licences from a variety of sources with largest being Sooke, Goldstream River and Waugh Creek, Goldstream Dams and Lakes and Leech River. The CRD has water licences on all of its major water sources which outline the allowable waterworks drafts from each source. CRD has provided a listing of existing licences currently used as well as those that are not currently used, as shown in **Table 4.19**.

Table 4.19: CRD Water Licences

Related Dam	Stream Name	Water Licence	Cubic Metres per Year	Water Use
Licenses Currently Utilized for Drinking Water				
Sooke Lake Dam	Sooke Lake	C117626	5,554,360	Conservation
Sooke Lake Saddle Dam	Sooke Lake	C117626	89,862,718	Storage – Non Power
	Sooke Lake	C117626	60,790,315	Waterworks
	Council Creek	F021627	4,977,969	Waterworks
	Council Creek	C041347	175,154	Conservation
	Council Creek	C041347	2,644,006	Waterworks
	Council Creek	C041348	2,837,004	Storage – Non Power
Deception Gulch Dam	Deception Gulch	C117628	4,101,321	Conservation Storage
Goldstream Lake Dam	Goldstream River	C130779	6,660,802	Storage
Lubbe Dam #1	Waugh Creek	C130779	3,207,053	Storage – Non Power
Butchart Dam #1	Goldstream River	C130779	4,193,838	Storage – Non Power
Japan Gulch Dam	Goldstream River	C130779	117,181	Storage – Non Power
Licenses Not Currently Utilized for Drinking Water				
Jack Lake Dam	Waugh Creek	C130779	42,616	Storage – Non Power
Humpback Dam	Waugh Creek	C130779	616,741	Storage – Non Power
Cabin Pond Dam	Goldstream River	C130779	67,842	Storage – Non Power
	Goldstream River and Waugh Creek	F021630	15,911,315	Waterworks
Charters River Dam	Charters River	C043293	829,661	Waterworks
	Charters River	C043294	74,009	Storage – Non Power
Other	Leech River	C052452	30,837,000	Storage Waterworks - 2005
	Leech River	C052452	30,853,449	Waterworks

The CRD has licensed water supply rights for Leech River and lakes within the Leech watershed. These are not currently used for drinking water supply but may be incorporated into the RWS system in the future once the Leech watershed supply is developed. The BC Water Sustainability Act and BC Environmental Flow Needs Policy may limit the water extraction from Leech even though the CRD has a water license of 30.8 Mm^3Y from this source. Discussions should be held with the Province to confirm that the Leech River water license volume will be available for use by RWS in consideration of new regulations that were introduced after the license was issued.

4.4 Water Supply Dams

4.4.1 Introduction

The Integrated Water Services Department (IWS) of the Capital Regional District (CRD) manages 22 dams, 15 of which are directly related to the Regional Water Supply (RWS) system for the purpose of creating water storage to meet the annual and seasonal water demands of the customers. The history of many of these dams date back well over a century and **Table 4.20** provides some detail of the existing RWS dams including the Dam Failure Consequence Classification, year(s) of construction and other details. **Figure 4.13** illustrates the location of each of the dams.

There are three (3) dams within the Sooke Lake Watershed that impound the Sooke Lake and Deception Gulch Reservoirs. There are eleven (11) dams in the Goldstream Watershed that create Butchart Lake, Lubbe Lake and Goldstream Lake Reservoirs. Japan Gulch Dam and Reservoir are located downstream of the Goldstream Lake Reservoir. In addition, there are several dams that have been retired from service or have been decommissioned including Charters River Dam. Additional details are contained in two recent RWSC staff reports of 2017[1] and 2019[2]. No dams exist within the Leech watershed although proposed dams were considered in the 1994 Plan.

Table 4.20: Summary of Regional Water Supply Dams

	Name	Consequence Rating	Year Constructed - Original / Upgraded	Dam Crest Width	Dam Crest Length	Dam Crest Elev. / Height
1	Sooke Lake Dam	Extreme	1970 / 2002	7.3m to 10m	533m (includes 63m spillway)	El. 190.75m / 24.75m
2	Sooke Lake Saddle Dam	Very High	2002	5m to 14m	1080m	El. 190.75m / varies up to 16m
3	Deception Gulch Dam	Very High	1979 / 1981 / 2002	7m	460m	El. 189.50m / 24m
4	Japan Gulch Dam	Significant	1900 / 1995	6.1m	97.5m	El. 134.6m / 12.5m
5	Charters River Dam	High	1976	0.91m	30.48m (includes spillway)	El. 83.23m / 16.76m
6	Goldstream Lake Dam & Spillway	High	1892 / 1995	5m	302m	El. 459.96m / 12.0m
7	Lubbe Lake Dam 1	High	1900 / 1995	5m	63m	El. 482.34m / 12.2m
8	Lubbe Lake Dam 2	Significant	1900 / 1995	4m	28m	El. 481.1m / 3.0m
9	Lubbe Lake Dam 3	Significant	1900 / 1995	4m	29.5m	El. 481.1m / 3.0m
10	Lubbe Lake Dam 4	Significant	2019*	5m	48m	El. 481.3m / 10m
11	Butchart Lake Dam 1	High	1900 / 1995	5m	60m	El. 546.6m / 11m
12	Butchart Lake Dam 2	High	1900 / 1995	5m	40.2m	El. 546.6m / 14.6m
13	Butchart Lake Dam 3	Low	1900	3.5m	17.4m	El. 545.1m / 1.8m
14	Butchart Lake Dam 4	Significant	1900	5m	48.5m	El. 545.2m / 7.3m
15	Butchart Lake Dam 5	Significant	1900 / 1995 / 2021	4.5m	157m	El. 545.4m / 7.3m

*Original dam was removed and replaced in 2019

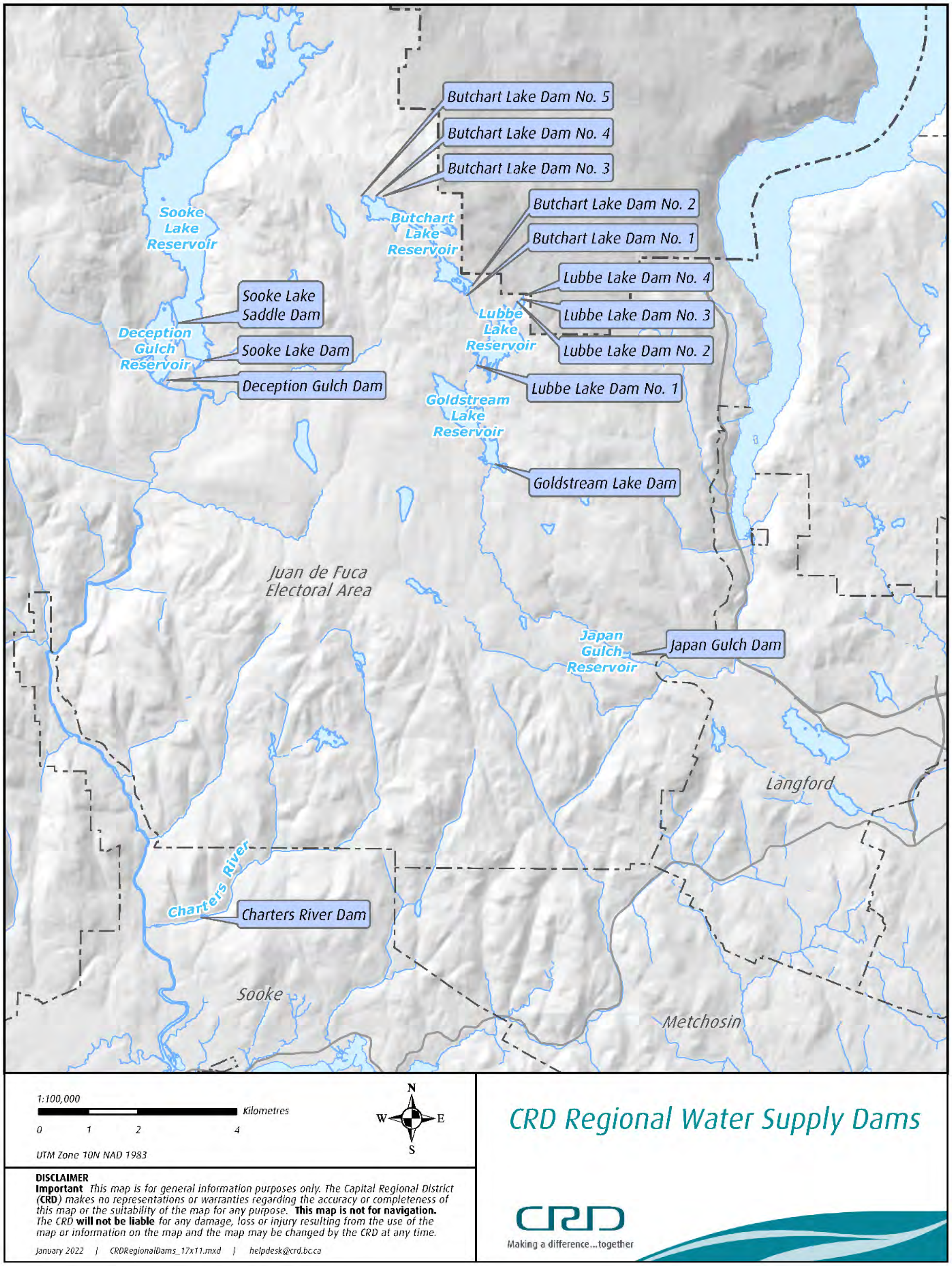


Figure 4.13: CRD Regional Water Supply Dams Locations

In general, dams may have one or more intended purposes including creating water storage for domestic and agricultural water supply, flood control, irrigation, downstream conservation (fisheries) flows and hydro-electric power generation. The purpose of the RWS service dams is primarily for domestic or drinking water supply and they provide a lesser amount of water for domestic irrigation and agricultural use. A historical exception was the hydro-electric works that predate the CRD ownership and have long since been decommissioned or abandoned (i.e., Cabin Pond head pond, penstock, and power station at Japan Gulch Reservoir).

4.4.2 Dam Safety Legislative and Regulatory Framework

Dams in the Province of British Columbia are legislated and regulated under the Water Sustainability Act (WSA) and its related Dam Safety Regulation (DSR). The WSA and DSR are enforced by Provincial Dam Safety Officers (DSO) within the Ministry of Forests, Lands, Natural Resource Operations and Rural Development. The WSA allows for the issuance of water rights licenses to water suppliers by the Province for three general purposes including use, storage, and diversion of surface water and hence the linkage to dams and storage reservoirs. A fourth type of applicable water license is for conservation normally reserved to provide downstream flows for fisheries and ecology. The existing water licenses issued to the CRD by the Province are discussed in greater detail in Section 4.3 and outlined in Table 4.20.

The DSR identifies specific obligations for dam owners including:

- Determination of the Dam Failure Consequence Classification defined by:
  1. Loss of Life
  2. Environmental
  3. Cultural Values, Infrastructure and Economics
- Responsibilities for dam condition and safety
- Preparation and updating of an Operation, Maintenance and Surveillance manual
- Preparation and updating of a Dam Emergency Plan
- Site surveillance and formal inspections
- Dam Safety Reviews and reporting
- Maintenance of dam safety records

The CRD staff consider the DSO to be important stakeholders in the management of the dams and CRD staff provide information to the DSO as required by the DSR. Regular activities undertaken by CRD staff to meet regulatory requirements for active and retired dams where necessary include:

- Routine inspections of dams and spillways
- Surveillance and reporting
- Preventative maintenance
- Exercising of valves and appurtenances
- Seasonal adjustments to flow releases

- Corrective action and capital improvements as required
- Internal (CRD) dam safety auditing

Beyond the legislative and regulatory obligations, the dams are assessed against technical performance standards of the Canadian Dam Association (CDA), the International Commission on Large Dams (ICOLD), and Engineers and Geoscientists of British Columbia (EGBC).

4.4.3 Dam Safety Investments and Related Strategic Plan Objectives

As a result of the seasonal variation of the annual hydrological cycle, water storage created by dams is required to meet the current and future water demands as discussed in greater detail in Section 4.1. Impounding of raw water has some positive effect on raw water quality in terms of reducing the velocity of the flow and allowing the opportunity for suspended particulate matter in the water column to settle-out. The dams and related storage reservoirs provide for a level-of-security and redundancy of water supply. Prior to the 2002 commissioning of the raised Sooke Lake Dam, the water service was in a situation whereby the water demand was approaching the Sooke watershed's available water yield and additional storage was required to capture additional water in the winter precipitation season. After raising of Sooke Lake Dam, the CRD has benefited from two decades of relief from drought and water demands.

The Goldstream Watershed dams were deemed to be at risk of failure due to seismic forces and failure modes and in the 1990's the Province ordered the draining of the Goldstream reservoirs. Negotiation between the CRD and the Province resulted in the reservoirs being maintained at a reduced volume until such time that investments were made to improve the seismic performance of these dams. By the mid-1990's most of the Goldstream Watershed dams were upgraded by raising the height to achieve greater freeboard and buttressing was constructed to increase the performance and reliability of the back-up water supply to Sooke Lake Reservoir.

Significant dam related capital investments in the recent decades include the following:

1. Seismic and mechanical improvements of the Goldstream Dams (mid-1990's – 1994 Plan Alternative A, Project "a")
2. Raising of Sooke Lake Dam and Sooke Lake Saddle Dam (2002- 1994 Plan Alternative A, Project "e")
3. Replacement of Lubbe Dam #4 (2019)
4. Foundation Grouting/Rehabilitation of Butchart Dam #5 (2021)

In addition to physical improvements, many studies, assessments, and reports have been commissioned to analyze the dams for failure modes and performance relative to dam safety standards. A summary of completed studies follows:

1. Updated Dam Safety Reviews for all RWS dams in the past decade
2. Probabilistic Seismic Hazard Assessment (PSHA) for Sooke Lake Dam, Sooke Lake Saddle Dam and Deception Gulch Dam (2017)
3. Probable Maximum Precipitation (PMP) and Probably Maximum Flood (PMF) hydrological studies and spillway discharge capacity assessments (2016 and 2017)

4. Dam Breach and Inundation Zone Mapping studies for the Sooke Watershed and the Goldstream Watershed. These studies as well as Dam Safety Reviews confirm the Dam Failure Consequence Classification
5. Dam surveillance instrumentation improvements for real-time dam performance information
6. Improvements to Dam Emergency Plans, Operation, Maintenance and Surveillance Manuals, updating of Standard Operating Procedures, etc.

4.4.4 Dam Safety Risk Management and Mitigation

The CRD has considered the potential implications should one or more dams fail, but in context of the function of the dams and with limited redundancy, the CRD should continue to diligently operate, maintain, and conduct surveillance of the dams. Further to the obligation to have a Dam Emergency Plan should a dam failure occur, the CRD has Business Continuity Plans and Emergency Management Plans. Identified dam safety risks are managed and use the approach to “reduce risk as low as reasonably practicable” (ALARP). The CRD staff continue to develop a dam safety management system and risk-informed decision-making process to prioritize and resolve dam safety issues. The comprehensive Dam Safety Program and obligations of the Regulation require the dams to continuously be assessed for risks through routine surveillance and Dam Safety Reviews. In addition, the AWWA J100 assessment recently conducted by the CRD included dam safety risks and means to mitigate risk.

The CRD should consider the short-term and long-term effect should one or more of the dams fail or be taken-out-of-service. Under the current operating procedures, Sooke Lake Reservoir is the primary water source. Should Sooke Lake Dam or Sooke Lake Saddle Dam fail, current opportunities for secondary water supply include the use of the Goldstream supply which has limitations and is unable to convey water to the JDFWD. Customer demand for water and stored volume will determine the duration for which water is available. The CRD has ability to impose consumption restrictions during an emergency. The 1994 Plan included an option for obtaining water from the north basin of Sooke Lake Reservoir and this option is discussed in Section 4.5 of this report. In the extreme event that Sooke Lake Dam and/or Saddle Dam breaches and the stored water is released or unavailable, the natural north basin could be a source of interim water until infrastructure is re-established.

Fully respecting the loss of life and environmental consequences, the more significant implications of dam failure for the Region include the loss of drinking water supply, fire protection by municipal distribution systems, and supply of water for commercial and institutional use.

The benefit of the Goldstream water supply and dams has been raised in relation to the life-cycle costs and it has been concluded that the Goldstream supply is required and hence management of the Goldstream dams should carry on.

4.4.5 The Future of Water Supply and Dams

This section discusses the past, present and future water supply. There are several phases post raising of Sooke Lake Dam (2002). Phase 1 – 2002 to present day – under the current operating modes, Sooke Lake Reservoir is used as the primary water supply with the Goldstream system as secondary. The Leech Watershed is not currently used (intentionally). In Phase 2, SLR can supply the annual demand until the demand scenario increases by 40% which is expected to occur by 2045 at current per capita demand rates. In the Phase 2 scenario whereby the water demand increases, Sooke Lake Reservoir will reach a threshold whereby the available /sustainable yield of Sooke Watershed will be exceeded. In the distant future, Phase 3 will require additional storage in the watersheds, just like what was experienced leading up to the raising of SLD in 2002. Phase 3 would likely include the incorporation of the Leech WSA into the RWS.

The 1994 Plan proposed accessing water from the north basin of Sooke Lake Reservoir and since then, Sooke Lake Dam was raised, and the primary water supply, SLR, has been able to satisfy the demand. The concept of accessing water from the north basin is explored in Section 4.5. The reasons for accessing this water are aligned with the 2017 Strategic Plan, but it should be noted that the north basin should not be relied upon for additional water supply (quantity above safe drought yield) without augmentation with Leech River flows as the yield and sustainable volume is finite from the watershed areas draining into SLR. It should be noted that there is an opportunity to supplement water supply from the Leech Watershed to the Sooke Lake Reservoir via the existing Leech Tunnel, but water supply is limited in summer high demand months due to the seasonal hydrological cycle and lack of storage and potential water licensing policy.

It is recommended that a water balance or optimization study be completed to explore how to operate to the full benefit of the three existing watersheds. Reservoir Operating Rules (Standard Operating Procedures) should be established to manage the current water balance and to prepare for the future. It is also recommended that opportunities for additional storage be explored to take full advantage of available water yield in the future. More specifically, it is recommended that a study be commissioned to identify storage opportunities within each of the three existing watersheds.

Options to create additional storage include:

1. Deception Gulch Reservoir - rehabilitation and recommissioning of Deception Gulch Dam (including dredging),
2. Sooke Lake Dam (and Sooke Lake Saddle Dam) - raising of Sooke Lake Dam and its Sooke Lake Saddle Dam. It should be noted that the option of raising Sooke Lake Dam and Sooke Lake Saddle Dam was explored in 2016 and limitations and implications of additional raising of Sooke Lake Dam were identified. See report of March 16, 2016.
3. 1994 Plan options – complete except for Leech Watershed dam/storage options which require detailed study including hydrological water balance models and geotechnical assessments.
4. Numerous additional small dams, all watersheds (e.g., Council Lake, etc.)
5. Leech Watershed – the topography and geology provide for challenging conditions to create storage with dam structures. Unlike the topography of the Sooke Lake basin, the topography in the Leech Watershed is steep and incised and therefore the resulting volume of storage for height of dam (and volume) is not as efficient as Sooke Lake Reservoir. The geology has been described as unconducive to founding dam structures and slopes are unstable which could result in realizing various dam failure modes and geoscientists continue to map-out and characterize the Leech River Fault. Further

detailed assessment by geotechnical engineers and dam specialists is required to determine the feasibility of dam construction.

6. Integration of “off-catchment” water and reestablishment of decommissioned dams and reservoirs (e.g., Jack Lake, etc.). Many old dams and reservoirs were decommissioned or removed from service for good reason related to water quality and that the land ownership was not fully the CRD’s. Taking advantage of current off-catchment watershed may be an opportunity in the distant future and these sources may become more viable post commissioning of future water filtration.

4.4.6 Climate Change

Climate change implications were discussed in Section 4.2, and from a dam perspective PMP and PMF studies are routinely conducted. It is recommended that the review of PMP and PFM and the effect on existing works (e.g., spillway capacity) and operating rules (e.g., Reservoir Operating Rules) be conducted to adapt to the potential implications of climate change relative to dam safety.

4.5 Water Source Development Requirements

4.5.1 Sooke Lake Reservoir Deep Northern Intake

A 2021 study by Stantec concluded that a proposed deep northern intake into Sooke Lake Reservoir would provide significant benefits in terms of emergency water supply, redundancy, short term emergency supply during drought conditions and improvements in water quality.

The criteria for sizing of the intake is design consideration. From a sizing perspective, it would be desirable to size the intake pipe to provide full redundancy of the intake capacity for 2100 MDD. The intake could then be used to supply directly to the Head Tank or a second redundant connection to the transmission system. Sizing of tunneled intakes should consider a longer supply horizon as the mobilization and capital costs for MTBM mobilization and shaft construction are significant. It is recommended that the tunnel be sized for a year 2100 MDD flow of 730 MLD. This flow would require an intake diameter of 2.4 metres based on acceptable design velocities.

If the intake is to be used for emergency water supply purposes only, in the event that the intake tower or Kapoor Tunnel are out of service, then possibly a smaller diameter intake and lower Level of Service could be considered such as supply of 2100 ADD, provided CRD is willing to have policies in place for demand management during emergency situations. Since the length of the intake pipe is not significant and most of the cost is associated with construction of the intake shaft and MTBM mobilization, a conservative sizing approach is warranted on the intake to provide future flexibility for additional water supply extraction from Sooke Lake Reservoir once Leech River flows are diverted to SLR in the future. A decision on providing a lower level of service and appropriate sizing for a smaller redundant transmission system can be made during preliminary design but it would be preferable to make the intake no smaller than 1.8 m diameter. This size would be adequate to convey the 2100 ADD of 377 MLD from the intake, enough to provide a resilient source of supply.

Stantec investigated a potential site for a deep northern intake. The site is located approximately 2 km north of the CRD boat launch facility on the east side of Sooke Lake Reservoir as shown in **Figure 4.1.4.** A feasible configuration of the tunnel is to have the MTBM launching shaft at the small landform on the east side of Sooke Lake Reservoir. This site has good access for construction and laydown. A hard rock MTBM would be launched from the land side towards the lake to excavate the tunnel. The length of tunnel is estimated to be approximately 300 m. As the slope of the lakebed appears to be relatively gentle per the bathymetry shown, a receiving trench/pit in the lake may be needed to provide a nearly vertical or steeply sloped face that would be appropriate for the MTBM to exit into the lake. Given our understanding about the local geology, rock excavation is anticipated for the receiving trench excavation. As the elevation of water intake is set at approximately elevation 150m, the tunnel invert elevation would be at about 147.6m to provide for the 2.4m diameter steel pipe. The intake level may be adjusted slightly to accommodate design configuration for the intake screens. Final elevation of intake would be selected following detailed water quality studies.

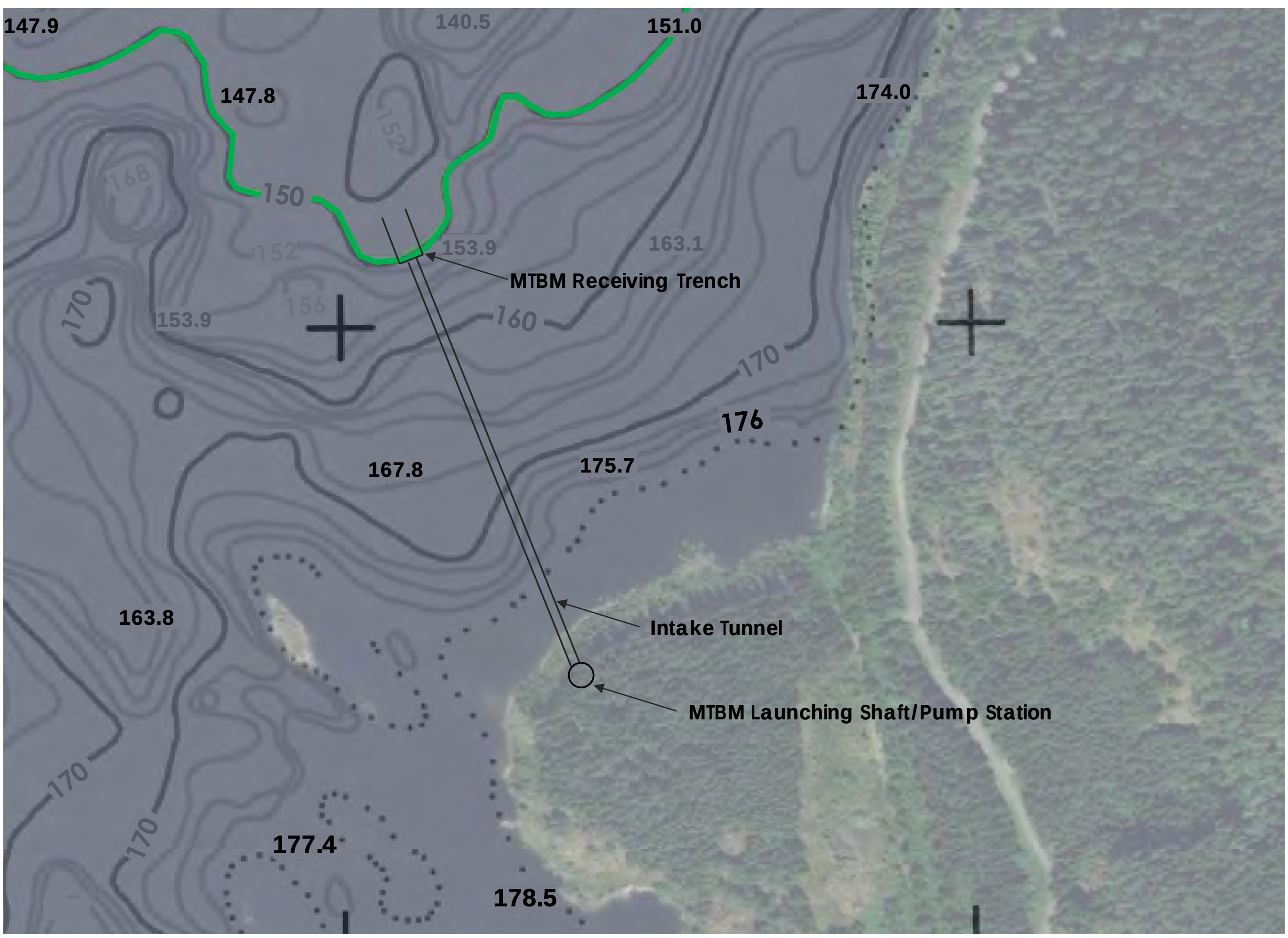


Figure 4.14: Conceptual Intake Tunnel Configuration

The CRD has advised that the suggested location is across from Rithet Creek and concern has been expressed regarding the impacts on water quality. Rithet is still a significant distance from the proposed intake, but it would be prudent to determine if there are any water quality impacts in future investigations at the proposed intake site.

Seasonal water quality sampling at the location of the proposed second intake is warranted and recommended. The sampling should be completed during wet weather conditions to determine if there are any seasonal influences on water quality from watershed creeks draining into the SLR.

The geological conditions along the intake tunnel are anticipated to be in hard rock and well below the water table. Microtunnelling is expected to be the most feasible construction method. Should a longer intake be required, or if the intake is integrated within part of a larger tunneled conveyance project, large diameter TBM tunneling methods may also be used. For a short intake, large diameter TBM tunneling is expected to be prohibitively expensive. Recent experience at Comox and Campbell River has shown microtunnelling to be a cost-effective construction method for shorter intakes.

Another potential viable option for an intake to access deeper sections of Sooke Lake Reservoir is the installation of a HDPE float and sink marine intake pipe. The intake pipe would be sunk to the bottom of the lake and would be cost effective to install in comparison to tunneling. This intake pipe would extend to deep water in the northern basin of Sooke Lake reservoir, and it could be connected to the existing intake tower or the Head Tank. The final location for a second intake will involve further study including water quality assessments, geotechnical assessments, constructability evaluations and cost comparisons.

The 1994 Plan investigated the option of installing a floating intake for emergency water supply from the deeper northern portion of the SLR. This type of intake is currently used for emergency water supply by the Seattle Public Utilities Commission on their Chester Morse Lake source. Such a facility is typically constructed on a barge and equipped with flexible or hinged pipe connections such that the pump station can be operated over variable water levels. The intake would still be equipped with fish screens using an air burst wedge wire type screen. With this option there is also the possibility of using a floating, flexible HDPE discharge pipe which would eliminate the requirement for trenching or a float and sink marine pipeline. The discharge pipe could be connected to the existing SLR intake tower or the Head Tank. **Figure 4.15** shows a floating pumping station installed on a barge. For the SLR, intake screening would be located below the barge and the pump station would be located offshore in deeper sections of the reservoir.

Figure 4.15: Floating Pump Station

4.5.2 Goldstream Reservoirs

Water supply from the Goldstream Reservoirs discharges to Goldstream River and flows into Japan Gulch Reservoir. A screen is located adjacent to Japan Gulch Dam and following screening the water is discharged to the transmission system upstream of the Goldstream Disinfection Facility. The Goldstream Reservoirs serve as a valuable secondary source and this system used when Kapoor Tunnel is taken out of service for inspection or maintenance. The RWS must be operated at a lower HGL of 132m when the Goldstream system is used as Japan Gulch Reservoir provides the driving head for the system when Kapoor Tunnel and the Head Tank are taken off line. These reservoirs can supply demand for several weeks depending on water demands in the system. The combination of the three Goldstream reservoirs provides 10 Mm^3 of additional storage for the RWS. The storage is not sufficient to meet summer demands, but it is adequate as a secondary or emergency supply for a short duration. The source is not used during high flow periods when Goldstream River Canyon is prone to slides which impact water turbidity. The installation of a proposed transmission main directly from Goldstream Lake Reservoir to Japan Gulch as suggested in the 1994 Plan would eliminate this issue and make it a more reliable source. An intake into Goldstream Lake and a screening system would also be required.

4.5.3 Leech River Watershed

As noted in Section 4.2.4.2 the Leech River watershed has a significant catchment area that could serve as a potential future drinking water source. In the summer months there is little inflow into the watershed; thus, storage is required to maximize use of this source. There are reported slope stability issues within some sections of the watershed and the slopes are steep making development of storage more difficult and costly because a high dam would be required to achieve any appreciable storage (see Section 4.1.5).

The hydrological modeling completed as part of this study indicates that the potential yield from this watershed is 15 Mm^3Y if it can be captured, stored, and transferred to the Sooke Lake Reservoir via Leech Tunnel. Since inflows into the watershed cease in the summer months, a high dam could be constructed to maximize the potential for development of this source or water could be diverted using a direct intake in Leech River when water is available during the months of October to April. Geotechnical and stability assessments will be required to further assess the feasibility of dam construction at the Leech watershed. Other considerations, such as the Water Sustainability Act and the requirement to meet environmental flow needs may impact the quantity of water that can be extracted from this source for drinking water use. Further study and discussions with the Province are required to confirm the options to be studied can be permitted under the Water Sustainability Act.

Another option for use of Leech water would be seasonal diversion of water supply to Sooke Lake Reservoir. This would be accomplished with a direct intake into the Leech River with diversion through the Leech tunnel via Deception Gulch Reservoir or a pipeline along the north side of the Sooke Lake Reservoir. The diversion would enable the Sooke Lake Reservoir to be replenished quicker which would be an advantage during dry years or extended multi- year drought conditions. Storage development within Leech watershed would provide the most benefit for maximizing use for drinking water supply but development of a dam within this watershed may prove challenging and costly. Further feasibility assessment of dam construction in Leech watershed is required and could be completed as part of a hydrology water balance model and operating rules for the concurrent use of Leech River and SLR.

5.0 DRINKING WATER QUALITY AND TREATMENT

5.1 Drinking Water Quality Guidelines

5.1.1 Drinking Water Guidance in British Columbia

The quality requirements of drinking water in British Columbia are governed by the Provincial Drinking Water Protection Act (DWPA) and Drinking Water Protection Regulation (DWPR). The DWPA and DWPR define potable water as "*safe to drink and fit for domestic purposes without further treatment*." Criteria for potability are based on verification monitoring of bacteriological indicators in finished water as well as the Federal Guidelines for Canadian Drinking Water Quality.

The Drinking Water Protection Officer (DWPO) issues an annual Operating Permit which covers a 12-month period from March 31 to March 31 for municipal water systems in British Columbia. The water purveyor must pay an annual renewal fee and abide by the conditions of the permit. The water system purveyor must operate the water system in compliance with the conditions of the Operating Permit.

The Public Health Engineer issues a Construction Permit for any new construction, alterations or extensions following the review of design reports, design drawings and specifications for any proposed waterworks improvements. All works must be designed and sealed by a professional engineer registered in the Province of British Columbia.

5.1.2 Surface Water Treatment Objectives in British Columbia

Administration of drinking water guidance and development of policy resides with the Provincial Ministry of Health, while responsibility for implementation resides with the regional health authorities and their Drinking Water Officers (DWPOs). Island Health Authority (IHA) administers the DWPR for communities on Vancouver Island and adjacent area surrounding Kingcome on the mainland. The DWPOs may impose terms and conditions upon the construction and operating permits of water supply systems which may include treatment, monitoring, and water quality objectives.

While DWOs are conferred a degree of discretion in applying terms and conditions, guidance on exercising such discretion consistently and based on established policy is provided by the Ministry of Health through the *Drinking Water Officers' Guide* (DWOG) first published in 2007 and updated in August 2017. The contents of the DWOG are deemed "guidelines" under Section 4 of the DWPA, but DWPOs may deviate from them based on a sound rationale including risk to public health.

Part B of the DWOG includes the key technical document *Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia*, first published in 2012, which describes the minimum goals for pathogen risk reduction from surface water sources. Ultimately, these objectives rely on the *Guidelines for Canadian Drinking Water Quality* as a reference for potability. Due to the difficulties in directly measuring waterborne pathogens, health-based treatment objectives are used as specifications for finished water and may be described as the "4-3-2-1-0" guideline. This guideline consists of the following minimum general treatment objectives:

- 4-log (99.99%) reduction or inactivation of enteric viruses
- 3-log (99.9%) reduction or inactivation of *Giardia* cysts and *Cryptosporidium* oocysts
- Two treatment processes (pathogen barriers) for surface water
- Less than or equal to one nephelometric turbidity unit of turbidity (≤ 1 NTU)
- No detectable *E. coli* (Escherichia coliform), fecal coliform, and total coliform

The DWOG also discusses the minimum conditions that should be considered for filtration exemption. These conditions are equivalent to the USEPA Filtration Avoidance Criteria discussed below. It is also acknowledged that increased threats identified by routine assessment and ongoing monitoring may necessitate filtration if the risk of adverse source water quality and public health risk is increased. The Medical Health Officer makes a determination that treatment is required. The DOWG, Part B, Section 4 outlines a risk based decision tree to guide the determination of corrective actions for drinking water and ultimately public health protection.

In 2022, the British Columbia Ministry of Health released two guideline documents for consideration when designing new water treatment facilities. These documents can be downloaded from the Ministry website and titles are provided below.

1. *Guidelines for Ultraviolet Disinfection of Drinking Water* (2022)
2. *Guidelines for Pathogen Log Reduction Credit Assignment* (2022)

The Sooke Lake and Goldstream Reservoirs water quality and CRD's primary and secondary disinfection practices currently meet the requirements of the DWPA and DWPR. The Goldstream River does experience high turbidity levels when landslides occur in the Goldstream River canyon, but the RWS does not use water from this source during high turbidity events.

5.1.3 Guidelines for Canadian Drinking Water Quality

Guidelines for Canadian Drinking Water Quality and the supporting Guideline Technical Documents are developed collaboratively by the Federal-Provincial-Territorial Committee on Drinking Water with the support of Health Canada. The current document and its predecessors have served as a reference for Canadian drinking water quality guidelines since 1968. The guidelines consider microbiological, chemical, physical, and radiological parameters.

It is widely acknowledged that the most significant risks to public health from drinking water pertain to microbiological hazards due to their association with acute and potentially severe adverse health effects. Guidelines for drinking water safety are expressed in terms of indicator and surrogate parameters, as well as general reduction requirements due to the difficulties in directly and rapidly detecting and measuring the wide range of disease causing bacterial, protozoan, and viral pathogens in water. Guidelines for the key parameters involved in producing microbiologically safe drinking water are summarized below:

- **Enteric Viruses**: A health-based treatment goal of at least 4-log removal and/or inactivation of enteric viruses is required to produce water with an acceptable risk. Routine monitoring is currently not feasible. Source protection and treatment measures should be implemented to reduce the risk when source waters are subject to fecal contamination or if enteric viruses have been responsible for prior outbreaks.

- **Enteric Protozoa – *Giardia Lamblia Cysts and Cryptosporidium Oocysts***: A health-based treatment goal of at least 3-log removal and/or inactivation of cysts and oocysts is required to produce water with an acceptable risk. This is based on a typical concentration for cyst/oocyst occurrence of 10 per 100 L in raw water. A greater log removal and/or inactivation may be required depending on source water quality. Treatment barriers and source protection measures should be implemented when source waters are subject to fecal contamination or if the water system has been implicated in previous waterborne outbreaks caused by *Giardia* or *Cryptosporidium*.
- ***E. coli* , Fecal and Total Coliforms**: A maximum acceptable concentration (MAC) for *E. coli*, fecal and total coliforms in drinking water is none detectable per 100 mL. Although most strains of *E. coli* are harmless, some strains have been found to cause severe gastrointestinal disease and even death in some cases. *E. coli* monitoring serves as an indicator of recent fecal contamination, and testing provides information on source water quality, treatment effectiveness, and the integrity of the transmission/distribution system. Fecal coliforms indicate the present of animal or human fecal contamination. Total coliforms are naturally occurring in surface water and soil and serve as indicators of treatment effectiveness and distribution system integrity but do not directly imply a health risk when present. Sudden changes in total coliform levels in source waters signals a change has occurred which merits further investigation. Presence in finished water may be due to a breach of treatment or distribution system integrity. Testing of *E. coli* and total coliforms provides a check that the system producing and delivering drinking water is intact, safe and under control.
- **Turbidity**: The continuous monitoring of turbidity is an easily measured surrogate for particulate or suspended matter that may potentially indicate source water quality changes, be used to monitor effectiveness of treatment and serve as a trigger for corrective actions when turbidity values deviate from established limits. Turbidity particles have also been shown to potentially shield pathogens from disinfectants and reduce the efficacy of UV and chlorine disinfection. Treatment specific turbidity limits for filtration systems are provided based on associated health-based pathogen removal goals. It is recommended that finished water entering distribution system maintain a turbidity less than or equal to1.0 NTU for effective disinfection.

Other related guideline technical documents include Quantitative Microbial Risk Assessment (QMRA) used to develop health-based treatment goals, Natural Organic Matter (NOM) and its impact on treatment effectiveness, by-product formation and aesthetics; and biological stability of drinking water distribution systems (in preparation).

The Sooke Lake Reservoir water quality and CRD’s treatment (disinfection) practices currently meet the requirements of Health Canada’s *Guidelines for Canadian Drinking Water Qualit*y (see Section 5.3.1 for details of existing RWS treatment).

5.1.4 Design Guidelines for Drinking Water Systems in British Columbia

BC Design Guidelines, largely based on (US) Ten States Standards and modified for British Columbia, have been developed for the Ministry of Health. A recently released document (see Section 5.1.2) includes coverage of filtration exemption requirements that are consistent with the USEPA filtration avoidance criteria and the policy described in the DWOG. Canada does not have the same avoidance regulations as the US, which define strict monitoring and protection requirements for unfiltered sources. Currently, there is no formal written exemption agreement with Island Health Authority that articulates filtration exemption conditions specific for the CRD, or which describes an agreed timetable for implementation of filtration. The Medical Health Officer can at his/her discretion, based on risk assessment, request that the CRD implement filtration. The CRD should start planning for future filtration so that sufficient planning, pilot studies and investigations (which can take many years) can be completed to enable CRD to quickly proceed to implementation should the Medical Health Officer direct CRD to install filtration.

5.1.5 Filtration Avoidance Criteria in the United States

Although the US drinking water regulations do not apply in Canada, it is useful to review US regulations as Canadian guidelines are influenced by US guidelines. As part of the US Safe Drinking Water Act (SDWA), the USEPA promulgated the *Surface Water Treatment Rule* (SWTR) in 1989 to address the risk of waterborne pathogens using performance-based targets for treatment expressed in terms of required reductions of *Giardia lamblia* cysts and enteric viruses. The required reductions specified for treated water required at least 3-log (99.99%) for *Giardia lamblia* and 4-log (99.99%) for enteric viruses. While these reductions were to be achieved by a combination of filtration and disinfection, recognition of high-quality protected source waters and adequate disinfection practices allowed the establishment of filtration avoidance criteria (40 C.F.R. §141.71(a) and (b)).

A total of eleven filtration avoidance criteria were established by the 1989 SWTR and retained by its subsequent enhancements. Two criteria concern source water quality, four criteria establish minimum levels of disinfection, and five criteria involve watershed protection and system operation. These criteria may be summarized as follows:

1. Low levels of source water fecal bacterial indicators
2. Low levels of source water turbidity
3. Adequate inactivation of Giardia, Cryptosporidium, and enteric viruses
4. Redundant disinfection equipment to ensure reliability
5. Adequate and consistent disinfectant residual levels at the entry point
6. Adequate disinfection residual levels throughout the distribution system
7. Adequate watershed protection and control
8. Adequate performance on annual on-site inspections
9. No evidence of waterborne disease outbreaks
10. Low levels of total coliform bacteria within the distribution system
11. Compliance with the disinfection by-products rules

The technical details of these criteria are provided in **Table 5.1.**

Table 5.1: USEPA Filtration Avoidance Criteria for Surface Waters

Source Water Quality		RWS Meets Criteria?
1	No more than 10% of samples taken prior to disinfection may contain fecal coliform concentrations more than 20 CFU/100 mL in any six-month period.	✓
2	Turbidity cannot exceed 5 NTU in samples taken prior to disinfection (with an exception for unusual and unpredictable events).	✓
Disinfection System		**RWS Meets Criteria?**
3	Must meet 3-log inactivation of *Giardia lamblia* cysts in at least 11 out of any preceding 12 months and 4-log virus inactivation every day but one during any given month.	✓
4	Must either be redundant in design or provide for the automatic shut-off of flow if the concentration of residual disinfectant falls below 0.2 mg/L.	X
5	Must not permit the residual disinfectant concentration entering the distribution system to fall below 0.2 mg/L for more than four continuous hours.	✓
6	Residual disinfectant concentration must not be undetectable in 5 percent of the samples taken during any month for 2 consecutive months.	✓
Watershed Protection and System Operation		**RWS Meets Criteria?**
7	Must have a comprehensive watershed control program that meets mandated standards designed to minimize the infiltration of the source by *Giardia lamblia* and enteric viruses.	✓
8	System must be inspected annually by the state enforcement authority to insure the efficacy of the watershed control program and disinfection procedures	✓
9	System must not have been identified as responsible for an outbreak of waterborne disease, or if it has, it must have implemented corrective measures adequate to prevent a recurrence.	✓
10	The system must remain in compliance with the MCL for total coliform concentrations in the distribution system.	✓*
11	The system must meet the MCL for disinfection by-products in the distribution system (THMs and HAAs).	✓

*RWS complies with applicable Canadian regulations for total coliform concentrations
Sooke and Goldstream watersheds meet the USEPA Filtration Avoidance Criteria for Surface Waters

The 1996 amendments to the SDWA directed the USEPA to address the threat of *Cryptosporidium*. The *Interim Enhanced Surface Water Treatment Rule* (IESWTR), promulgated in 1998, extended existing watershed control requirements for *Giardia lamblia* to also include *Cryptosporidium*.

The 1996 SDWA amendments also relaxed the filtration avoidance criteria for surface water systems, permitting State discretion to allow alternatives, due in part to the efforts of several large unfiltered systems including Seattle, New York City, Portland, Boston, and San Francisco. A new category termed "*limited alternative to filtration*" was created (SDWA Amendments of 1996, Sec. 106). A system must have "*uninhabited, undeveloped watersheds in consolidated ownership, and having control over access to, and activities in, those watersheds*" to qualify for alternative treatment. In such cases, State established alternatives to filtration would be permitted if the quality of the source water and the alternative treatment are deemed to ensure greater removal or inactivation of regulated pathogens than would be achieved by the combination of filtration and chlorination.

In 2006, the USEPA promulgated the *Long Term 2 Enhanced Surface Water Treatment Rule* (LT2) to require public water systems to implement more stringent treatment for *Cryptosporidium*. The LT2 builds on the previous filtration avoidance criteria of the SWTR to require all unfiltered systems to inactivate *Cryptosporidium* in addition to other previously specified pathogens using acceptable disinfection technologies. Criteria were developed to award *Cryptosporidium* inactivation credit for UV irradiation, ozone, or chlorine dioxide-based processes. Unfiltered systems must apply at least two distinct disinfectants to meet the inactivation requirements for *Cryptosporidium* (2- or 3-log), *Giardia lamblia* (3 log), and enteric viruses (4-log). Each of two disinfectants must achieve the entire inactivation requirement for one of the three pathogen groups. The degree of treatment for *Cryptosporidium* depends on oocyst levels in the source water as determined by monitoring. If the mean source water level is equal or less than 0.01 oocyst/L (i.e., 1 oocyst per 100 L), then at least 2-log inactivation is required, while for higher levels at least 3-log inactivation is required. Major unfiltered systems in the US developed UV disinfection facilities to comply with the LT2 rule, including the San Francisco (Tesla) and New York City (Catskill-Delaware). These systems are similar to the RWS Goldstream and Sooke River Road Disinfection Facilities.

Several large water utilities continue to supply unfiltered water to their customers. All these supplies involve extensive source water protection and watershed management, source water quality monitoring, and multiple disinfection processes, notably all including UV and chlorine disinfection, the same as the disinfection practices used by the CRD. Most of these operate more than one source with the other source or sources being filtered. A summary of the largest unfiltered systems in North America is provided in **Table 5.2**.

Table 5.2: Unfiltered Water Supplies Summary

Metropolitan Area	Treatment Facility	Capacity (MLD)	Unfiltered Capacity (% Total)	Population (Million)	Treatment
Vancouver	Coquitlam	1,200	40	2.5	O_3-UV-Cl_2
Seattle	Cedar	680	60	4.0	O_3-UV-Cl_2
Boston	Carroll	1,040	100	4.9	O_3-UV-Cl_2
San Francisco	Tesla	1,200	85	2.7	UV-Cl_2
New York City	Catskill-Delaware	9,000	90	8.4	UV-Cl_2
Victoria	Goldstream /SRRDF	605/20	100	0.4	UV-Cl_2[b]

a. O_3 – ozone, UV – Ultraviolet light, Cl_2 – Chlorine
b. CRD also uses ammonia to provide a chloramine secondary residual in the transmission system.

Several water supplies, largely in the Pacific Northwest, have been converted from unfiltered to filtered supplies over the past two decades. A summary of these is provided in **Table 5.3**.

Table 5.3: Conversions from Unfiltered to Filtered Supplies

Metropolitan Area	Treatment Facility	Capacity (MLD)	Year Activated
Seattle	Tolt	450	2001
Vancouver	Seymour-Capilano	1,800	2010
Tacoma	Green River	570	2015
New York City	Croton	1,100	2015
Nanaimo	Nanaimo	120	2016
Comox Valley	Comox Valley	75	2021
Portland	Bull Run	550	2027*

*Anticipated completion

5.1.6 Beyond Regulations

The source water quality from RWS's primary Sooke Lake Reservoir supply is considered relatively high, with turbidity averaging well below 1.0 NTU and virtually undetectable levels of *Giardia* cysts and *Cryptosporidium* oocysts for several decades. Goldstream watershed has a similar water quality when it is used in the RWS system but does experience higher turbidity during wet weather when it is not typically used in the RWS system. Leech River water does experience higher turbidity levels and colour following flash rainstorms. Council Lake water is mixed with SLR water and water quality is good. There is no significant water quality information available from Council Lake Reservoir. However, for all sources, average values of turbidity and infrequent tests of highly infectious but poorly recovered pathogens do not provide the most useful statistics for making decisions potentially impacting the public health of a large population. In addition, flashy sources such as Leech River can have higher first flush turbidity levels and are expected to have a higher potential for pathogens. Brief periods of high turbidity and high pathogen counts can pose a significant risk to consumers. As articulated by an expert panel convened by the USEPA in 1991 to evaluate the continued filtration avoidance by New York City, unlike trace chemical contaminants that pose a risk from long-term exposure, risks due to pathogens are not mitigated by hundreds of days of low turbidity and low counts of microbes (Okun et al. 1997).

One of the filtration avoidance criteria of the SWTR relates to the absence of waterborne outbreaks. According to the British Columbia Centre for Disease Control, British Columbia has historically had higher reported cases of giardiasis and cryptosporidiosis than other parts of Canada, likely due to the absence of filtration on sources serving several large populations. BC communities which have previously experienced outbreaks include Penticton, Barriere, and Kelowna. It is widely acknowledged by public health professionals that most cases of waterborne infection and most community waterborne outbreaks are never detected. Active community waterborne disease surveillance is used by several US water supply systems. In New York City, coordinated public health programs are used to better detect the occurrence of waterborne outbreaks. Evidence from such programs provides information supporting continued filtration avoidance.

The CRD drinking water quality from the Sooke Lake Reservoir is very good and it is difficult to provide economic justification for construction of filtration at this time. The secondary Goldstream Reservoir source is also good but at times it is subject to turbidity fluctuations during wet weather as a result of slides in the Goldstream River Canyon so it cannot be used reliably during wet weather without filtration. The current disinfection facilities are capable of satisfying Island Health treatment guidelines. Addition of future sources like Leech River will, however, likely require installation of filtration to meet current guidelines due to elevated levels of colour and at times turbidity. Other factors such as water quality changes due to climate change could also have future impacts on source water quality. Natural disasters such as wildfires could also have negative impacts on water quality.

Another consideration when assessing treatment requirements involves the uncertainty of future conditions. The most cost-effective treatment approach depends on the expected watershed and raw water quality conditions 20 years or more into the future. Risks to future watershed health and its water quality may be greatly diminished by proactive and preventative measures that provide multiple barriers to microbial pathogens and other hazards. The addition of filtration in combination with disinfection processes would provide a robust multiple-barrier system able to better mitigate potential source water quality impairment and protect public health. Addition of filtration would increase the reliability of finished water quality and improved water quality despite adverse watershed conditions reducing the vulnerability of the current system.

5.2 Existing Source Water Quality

5.2.1 Sooke Lake Reservoir Raw Water Quality

As the CRD's primary water source, the greatest amount of water quality data is available for the Sooke Lake Reservoir. As is typical of such reservoirs in the Pacific Northwest, available data demonstrates relatively high-water quality, with low turbidity, low alkalinity and favorably low bacterial indicators, nutrients, and organic matter. Notably, mineral content, as measured by total dissolved solids (TDS) is also quite low.

The historical raw water quality entering the Goldstream Disinfection Facility, largely or exclusively from Sooke Lake Reservoir, over the period of 2010 to 2019 is summarized in **Table 5.4**.

Table 5.4: Historical Raw Water Quality Information – Sooke Lake Reservoir

Parameter	Unit	Average	Minimum	Maximum	GCDWQ MAC
pH		7.3	NA	7.6	7.0-10.5
Colour	True Colour Units	6.4	ND	15.2	<15 (AO)
Alkalinity, Total	mg/L as $CaCO_3$	15.3	8.84	19.1	-
Hardness	mg/L as $CaCO_3$	17.3	ND	20.9	-
Total Dissolved Solids (TDS)	mg/L	27	ND	48	<500 (AO)
Total Organic Carbon (TOC)	mg/L as C	1.90	0.82	3.29	-
Dissolved Organic Carbon (DOC)	mg/L as C	1.72	ND	3.34	-
Conductivity, at 25˚C	µS/cm	42.2	27.5	62.9	-
Turbidity, Grab Samples	NTU	0.31	0.17	2.7*	<1
Ultraviolet Transmittance (UVT)	%	88.6	0.2*	94.4	-
Algae	Refer to 2020 *Greater Victoria Drinking Water Quality Annual Report*				

*Suspect data anomaly

Turbidity has consistently been observed to be below 1.0 NTU, as demonstrated by direct sampling data from Sooke Lake Reservoir over the five-year period from 2016 to 2021. The results of 561 readings in the south forebay and 220 readings in the North Basin are summarized in **Table 5.5.**

Table 5.5: Turbidity Sampling Data

Turbidity (NTU)	Sooke Lake Reservoir	
	South Forebay	North Basin
Average	0.34	0.30
Maximum	0.60	0.65
Minimum	0.20	0.16

The turbidity levels in the south forebay and north basin are similar with the north basin being only slightly lower. For the south forebay routine monitoring of raw water for *E. coli*, as a bacterial indicator of fecal contamination, is conducted at least 255 times per year and consistently demonstrates very low incidence of positive detections.

Monitoring for protozoan parasites has been conducted eight times per year and includes *Giardia* cysts *Cryptosporidium* oocysts. Despite processing a minimum of 100 L per sample, two decades of data have largely failed to detect either parasite in the Sooke Lake Reservoir. It is likely that these parasites are present at levels below the detection limit associated with the sample size and method used and that their concentrations may be elevated following severe storm events.

Limited monitoring of tributary creeks in 1999 did report positive detections of *Giardia* cysts, which is expected due to the ubiquitous nature of this parasite among wild animals in the watershed. While it is likely that the typical *Cryptosporidium* oocyst levels in the Sooke Lake Reservoir are relatively low (that is < 0.01 oocyst/L) and pose a low risk given existing watershed management practices and treatment barriers, the typical range of their concentrations at the existing and potential deep intake locations are unknown. More frequent sampling using larger sample volumes and capturing severe storm events would be useful. Also, it is critical to conduct recovery efficiency tests with each sample to convert detected numbers to concentration values. This practice has not been done despite the recovery efficiency for the conventional method (USEPA method 1623) ranging from 40% to 60% under ideal conditions and < 5% under adverse conditions.

Data collected during the 2016 to 2021 period for total phosphorus (TP) and Chlorophyll-a, the limiting nutrient for biological growth and surrogate for algal concentrations, respectively, are summarized in **Table 5.6**. The data supports the classification of Sooke Lake Reservoir as oligotrophic (i.e., relatively low in plant nutrients and containing abundant oxygen) in the deeper sections of the reservoir.

Table 5.6: CRD Sampling Data for Period 2016 to 2021 in Relation to Oligotrophic Status

Parameter	Sooke Lake Reservoir		Oligotrophic Lake Survey*	
	South Forebay	North Basin	Mean	Range
TP *mean* (µg/L as P)	3.3	4.5	8.0	3.0 – 17.7
Chlorophyl-a *mean* (µg/L)	1.1	0.9	1.7	0.3 – 4.5
Chlorophyll-a *max* (µg/L)	3.1	2.5	4.2	1.3 – 10.6

*As cited by Wetzel 2001

Data for raw water total organic carbon (TOC) and UV absorbance averaged 1.9 mg/L and 0.05/cm over the period 2010 to 2019. The average specific UV absorbance (SUVA) is 2.6 L $mg^{-1}m^{-1}$ which suggests that humic acids comprise a moderate contribution to TOC. This is significant in evaluating the impact of TOC on existing and potential treatment. Humic acids will typically dominate conventional coagulant demands and the low alkalinity conditions will impose additional constraints on coagulant type and dose.

Temperature is an important water quality parameter in terms of both aesthetic and operational considerations. Sooke Lake Reservoir experiences thermal stratification from spring to fall with the current intake depleting the cooler hypolimnetic waters by July. After such a depletion, the intake is essentially drawing from the fully mixed epilimnion at an elevated temperature. The aesthetic objective of less than 15 °C is then exceeded for up to several weeks. This not only impacts consumer satisfaction but increases the rate of biological growth and monochloramine residual decay, both of which increase the risk of nitrification occurring in the distribution system. Data from the north basin suggest that the hypolimnion extends below 20 m from the surface and water there remains between 5 ˚C and 10 °C throughout the year. Dissolved oxygen readings from the deep basin confirm that the hypolimnion remains aerobic consistent with the oligotrophic status and minimizing the risk of iron and manganese solubilization from the benthic deposits.

It should be noted that while a deep northern intake (see Section 4.5) would increase the accessible volume in the Sooke Lake Reservoir in an emergency or severe drought condition, cycling of the reservoir poses a risk to water quality and replenishment of the reservoir on an annual basis and is not recommended. When summer demands peaked in 1998, an extreme drawdown of the reservoir level coincided with heavy rains causing serious erosion of the exposed shoreline and resulting in numerous consumer complaints regarding highly coloured and turbid water. As the TSD in 2050 will exceed that of 1998, the likelihood of such a scenario repeating during a combined drought and high demand condition will increase. However, the resulting drawdown may not be as significant due to the raising of the Sooke Lake Dam that was completed in 2002 and planned reservoir operations and balancing procedures. Diversion of Leech River would also assist in replenishing Sooke Lake Reservoir following a drought period.

5.2.2 Proposed SLR Deep Northern Intake Impacts on Water Quality

A limited sampling program of samples taken from the north basin of the Sooke Lake Reservoir and drawn from depths of greater than 20 m suggest that the impacts on overall water quality maybe favorable (Stantec 2021 Tech Memo). Further seasonal water sampling and water quality data will be required to confirm extraction from deeper depths will yield better water quality on a consistent basis. Due to thermal stratification during the approximate period of May to October, the hypolimnion remains low in temperature (5 to 10 °C) and is well oxygenated. At such depths, water is below the photic zone with low algae concentrations. Due to the oligotrophic conditions, there is insufficient microbial activity to deplete the dissolved oxygen sufficiently to produce anoxic conditions, a drop in oxidation-reduction potential (ORP), or the solubilization of iron and manganese that may be present. However, it is likely that the sediments deposited at the lake bottom are delicate and easily resuspended if sufficient fluid movement were present. Thus, drawing water from the north basin at depths greater than 20 m, yet also sufficiently above the bottom, is anticipated to provide the highest quality water from Sooke Lake Reservoir if used year-round.

Additionally, drawing water from the north basin would improve water quality in the RWS transmission, as well as distribution and storage tanks operated by municipalities. Water would more consistently be supplied below the aesthetic temperature objective of 15 °C, improving consumer satisfaction. Colder water would also decrease the rate of biological activity, thereby reducing the rate of bacterial growth both in the water and within biofilms at pipe surfaces. The colder water would also result in a slower decomposition of the residual disinfectant, allowing greater persistence to the extremities of the system thereby further suppressing biological activity.

5.2.3 Goldstream Watershed Raw Water Quality

The available data for water quality from the Goldstream Watershed lakes reveals a comparable quality to that of the Sooke Lake Reservoir, featuring the low mineral content typical of lakes from this region. The most vulnerable element of this source is the Goldstream River stretch from the Goldstream Reservoir to the Japan Gulch Reservoir, for which run-off and erosion following precipitation events may result in elevated turbidity due to active landslides in the Goldstream River Canyon. Such events typically occur from late fall to early winter months, while turbidity is lowest during summer months when intense precipitation events are rare. There are currently no reservoir operating rules for this system, and it is most often used in the wintertime during scheduled shutdowns for inspection and maintenance of the Kapoor Tunnel. The reservoirs then refill while winter rains are predominant and are available to use in the summer if required. It can also be used for emergency purposes for a short period if required. The CRD collects limited water quality data from the Goldstream Reservoir (monthly) and Butchart Reservoir (quarterly). Data is not collected from Lubbe Reservoir. In 2020, the CRD completed the *Goldstream System Water Quality Assessment Study* which generally indicates good water quality in the Goldstream watershed. The Japan Gulch Reservoir because of its shallow depth is subject to occasional algal blooms in the summer months.

5.2.4 Leech River Raw Water Quality

Historical water quality data from the Leech River and watershed was limited until the CRD completed a *Water Quality Analyses Report* in October 2021. Efforts are currently underway to better understand the quality of water available from the Leech watershed and the report provides a good starting point. A review of available data indicates that during non-storm periods the water has relatively low turbidity and colour levels, but these do increase with wet weather during first flush rainfall events after long periods of dry weather. Colour levels exceeding 15 TCU aesthetic objective have been reported in over 58% of samples taken during the recently completed water quality study. The relevant water quality parameters, particularly colour and turbidity, are higher in value generally relative to the Sooke Lake Reservoir and prone to rapid increases and subsequent declines following major storm events. Both the quality and quantity of water available from the Leech Watershed is assumed to be “flashy”. Continued sampling of this potential future source is desired to provide a baseline of data for assessing future treatment requirements of this source.

Over 85% of the Leech watershed forested areas had been harvested by the time of the first CRD land purchase in 2007. Ongoing efforts to restore and rehabilitate the watershed are expected to improve water quality. Such improvements are a long-term endeavour that may yield higher quality water in the future when the Leech watershed is required to augment source water capacity. Increased treatment requirements will depend on the actual water quality observed from the Leech watershed and how it will be stored and used relative to the Sooke system.

5.2.5 Source Water Protection

The control and protection of the source waters is a key element of the CRD’s disinfection approach (ultraviolet light, chlorine, and ammonia) and maintaining the use of these sources without filtration. The CRD owns approximately 98% of the watershed lands draining into the Sooke and Goldstream water supply reservoirs. About 92% of the Leech watershed catchment upstream of the Leech Tunnel inlet is owned by the CRD and currently being restored for future use. A closed watershed policy restricts activities within the Greater Victoria Water Supply Area to those related to water supply functions and other authorized uses and prohibits public access.

CRD policy includes not only extensive source water protection but also the comprehensive concept of stewardship. As described in the Greater Victoria Water Supply Area Management Plan, stewardship of the water supply area is defined as:

> *The caring, thoughtful, and cautious management of the watersheds, ecosystems and processes that sustain source water quality, other important ecosystem goods and services, and cultural values, to ensure a safe and sustainable water supply and healthy ecosystems for future generations.*

CRD efforts to protect the watersheds and source water quality include:

- Security gates and fencing at key access points and video surveillance at key facilities
- Watershed patrols to monitor conditions and deal with unauthorized access and emergency situations
- Wildfire prevention, preparedness, detection, and rapid initial attack and suppression capabilities, supplemented by a response agreement with BC Wildfire Services
- Post-wildfire response capability to minimize impacts to water quality in source reservoir (e.g., silt curtain deployment)
- Hazardous spill prevention, preparedness, and response capabilities
- Forest management and restoration, including monitoring and managing forest health issues and invasive species
- Forest fuel management in key areas to protect water supply reservoirs and key facilities and infrastructure
- Active management of wild and domestic animal species that pose a risk to water quality
- Management of existing road network to provide access to water supply infrastructure and facilities and for emergency response while minimizing disruption to watershed hydrology
- Commissioning of consultant reports to evaluate impacts of climate change on water quality (Pinna Sustainability 2017 and Aquatic Scientific Consulting Ltd., 2019)
- Research and monitoring to better understand environmental changes and the relationships between ecological conditions and water quality.

5.3 Treatment Requirements

5.3.1 Existing Water Disinfection Facilities

Water from the Sooke Lake Reservoir enters the intake tower in the forebay of the south basin and is screened through 14-mesh traveling screens (0.5 mm openings). Screened water is then largely conveyed by twin pipelines (Main No. 10 and No. 11) to a head tank feeding the Kapoor Tunnel that conveys water to the Goldstream Water Disinfection Facility. A connection for main No. 15 diverts water prior to the Head Tank and is conveyed to the Sooke River Road Disinfection Facility via main No 15. (see **Figure 5.2).** During maintenance of the head tank and Kapoor Tunnel, or during an emergency, the Goldstream watershed is used via an intake in Japan Gulch reservoir which is diverted through 14-mesh traveling screens prior to entering the Goldstream Disinfection Facility.

In both the Goldstream and Sooke River Road disinfection facilities, UV light and free chlorine are applied in sufficient dose to achieve a 3-log inactivation of *Giardia* and *Cryptosporidium* and a 4-log inactivation of enteric viruses. Chlorination at the Goldstream facility uses bulk sodium hypochlorite while at the Sooke River Road facility, sodium hypochlorite is generated on-site from sodium chloride (salt). Following contact time adequate to achieve 4-log inactivation of viruses, ammonia is added to form monochloramine as a secondary residual disinfectant in the transmission and distribution systems. Turbidity in the source waters is less than 1 NTU.

The locations of the Goldstream and Sooke River Road disinfection facilities are indicated on **Figure 5.1**. The Goldstream facility produces approximately 97% of the supply for the Regional Water Supply Service, with Sooke River Road supplying approximately 3%. The Goldstream disinfection facility can draw water from the Goldstream watershed which has been done routinely during the multi-day inspections of the Kapoor Tunnel that have occurred almost annually. The Sooke River Road disinfection facility is currently unable to utilize the Goldstream watershed source and only draws water from Sooke Lake Reservoir.

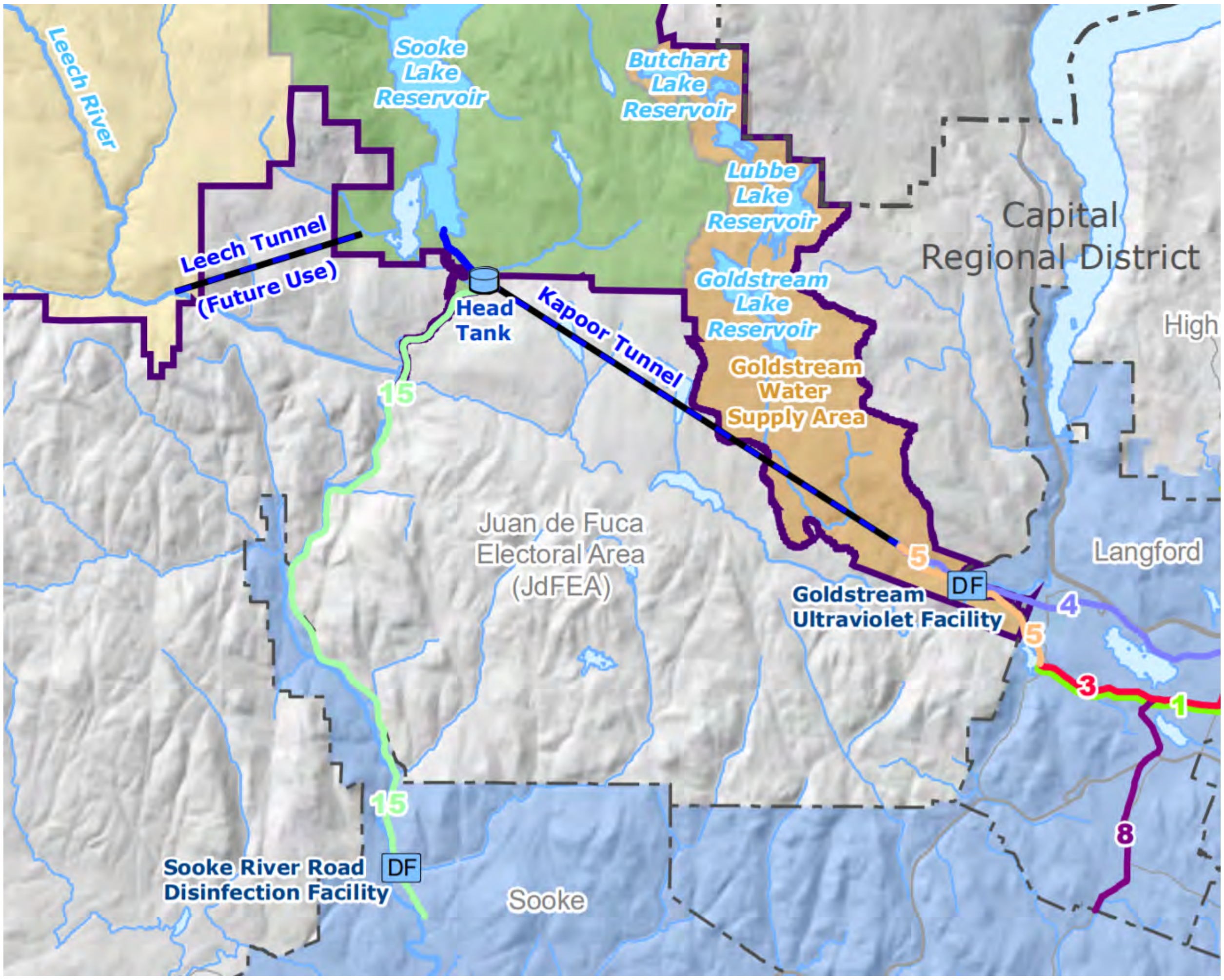


Figure 5.1: Locations of Existing Goldstream and Sooke River Road Disinfection Facilities

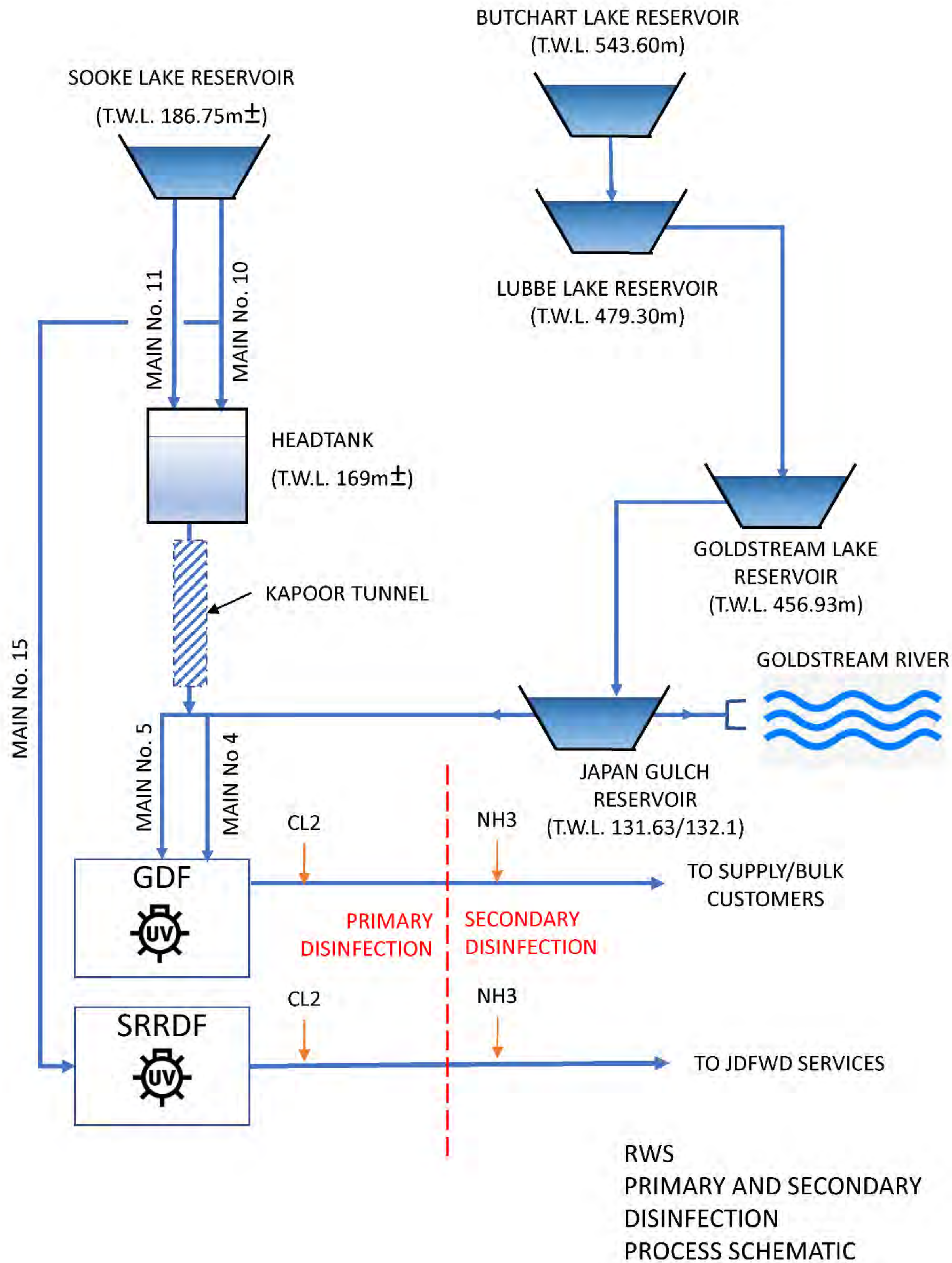


Figure 5.2: RWS Existing Disinfection System Schematic

5.3.2 Risks to Water Quality

Multiple risks and risk scenarios from climate change exist that would present a greater challenge to an unfiltered water supply than one which includes filtration. These typically involve a greater probability of impairment in water quality and efficacy of disinfection due to increases in particulate matter derived from (autochthonous) or transported to (allochthonous) the reservoirs. While the Sooke Lake Reservoir currently provides an excellent source of water which meets Provincial and Federal drinking water quality guidelines, introduction of additional water from Leech River watershed in the future will almost certainly result in degradation of water quality unless filtration is added.

A changing climate will impact both the quantity and quality of water flowing into CRD reservoirs. Changes to temperature regimes and shifts in precipitation patterns will likely result in direct and indirect hazards to CRD and its water supply. **Table 5.7** outlines typical climate parameters and their associated hazards, and details where these could impact source water quantity and quality.

Table 5.7: Climate Impacts on Water Source Quantity and Quality

Climate Parameter	Climate Hazards (Direct and Indirect)	Water Source Quantity Impacts (Y/N)	Water Source Quality Impacts (Y/N)
Temperature	Aquatic Invasive Species	Y	Y
Precipitation	Drought/Water Shortages	Y	Y
Temperature	Wildfires / Ash / Slope Erosion	Y	Y
Precipitation	Flooding and Extreme Precipitation	Y	Y
Precipitation	Landslides/Slope Failure	Y	Y

5.3.2.1 Climate Change

The CRD completed an initial assessment of climate projections for the region by the 2050s and 2080s. The projection for the 2050s included:

- A significant increase in average daytime high and nighttime low temperatures
- A significant reduction in summer precipitation and more prolonged dry periods
- A slight increase in overall precipitation in fall, winter, and spring
- An increase in the intensity, duration, and frequency of major rainfall events

These changes influence the complex physical, chemical, and biological processes occurring in the watersheds of the GVWSA, and limnological conditions of the Sooke Lake Reservoir in particular, that will impact water quality. Such changes include:

- Increased water temperature
- Lower dissolved oxygen levels at the reservoir bottom during summer months
- Lower summer water levels due to increase demand and evaporation
- Changes in the timing and duration of stratification of the water column

- Increased nutrient input from watershed sources and sediment release
- Increased turbidity due to increased storm intensity and soil erosion
- Increased algal biomass due to increased temperature and nutrients
- Longer duration algal blooms and likelihood of taste and odour events

Changes in temperature and precipitation events will impact watershed and limnological conditions that will ultimately impact source water quality and the type and extent of treatment required to produce the finished water quality needed to meet regulatory and public health requirements.

5.3.2.2 Droughts

In general terms, drought may be defined as a deficiency in precipitation over an extended period on a timescale ranging from a few months to extending over many years. Records indicate at least four interannual periods of drought lasting for several years in the Sooke Lake Reservoir Watershed over the past century, including 1928-1930, 1940-1942, 1991-1995, and 2001-2003. Climate change impacts are anticipated to increase the frequency and duration of such droughts. Diversion of Leech River water into the SLR would assist in curtailing impacts from extended year droughts because Leech watershed water could be used to fill the SLR.

Three major impacts of prolonged and extreme droughts include the desiccation of riparian vegetation that stabilize stream banks, increased likelihood of erosion, severe drawdown of the reservoir level impacting its chemistry and ecology, and most importantly, the increased likelihood of large-scale catastrophic wildfires in the watershed which could adversely impact water quality.

5.3.2.3 Wildfires

Dryer conditions prevailing over forested watersheds increase the likelihood of large-scale fires. The consequences of dryer conditions would potentially pose immediate and long-term impacts on source water quality due to increased sediment, organics, and ash. Wildfires spanning the watershed will produce large quantities of ash and alter the landscape for many years following the fire. Following wildfires, increased erosion and sediment transport to the reservoir is likely to continue until vegetation is restored and soils are restabilized. The transport of such material to the reservoir will likely result in increased turbidity and an increase in nutrient availability that may alter the trophic state of the reservoir. Such changes would necessitate augmenting treatment with filtration beyond the existing disinfection facilities to achieve required finished water quality objectives for the Regional Water Supply. The potential for wildfires is real as can be seen by the fires which ravaged the interior of British Columbia and other parts of the US Pacific Northwest in 2021.

Wildfires have the potential to increase erosion in watersheds which could impact turbidity levels and the introduction of light weight ash into the reservoir. Water filtration processes are designed to cope with these changes although the addition of different coagulant aids or filter aids may be required to deal with ash.

5.3.2.4 Severe Storms

Climate change impacts anticipate changes in the storm events with increased variability due to longer dry periods and shorter more intense wet periods. A substantial volume of precipitation may be delivered within a period of a few days via the phenomenon of an atmospheric river or "pineapple express" and such events have been experienced in November 2021. Climate modeling has suggested that most heavy and extreme precipitation events will be due to atmospheric rivers. Severe storms increase the tendency for run-off induced erosion, particularly when following drought conditions, and consequently can impact water quality parameters in the reservoir such as turbidity, colour, and nutrients.

Wind is a natural factor influencing forest structure in the Pacific Northwest. Severe wind events tend to be more common than wildfires and may result in large-scale increases in the windthrown trees when soils are saturated. Windthrow events expose forest soil and can destabilize riparian areas which can impact reservoir processes. The accumulation of windthrown trees increases the availability of fuel and severity of subsequent wildfires. Uprooting and destabilized stream beds and shore areas increase the impact of erosion from subsequent storm events. The combination of more intense wind and rainstorms may increase the likelihood of impacts on water quality.

Sustained wind over the surface of a reservoir may induce internal movement of water that disturbs thermal stratification and alters nutrient cycles. Severe winds may cause surface levels to rise on the lee end of the reservoir where water accumulates. The accumulated mass of water may then be pulled downward by gravity, encounter the denser metalimnion and flow back in the opposite direction of the wind. If sustained, such a condition may result in the entrainment of the epilimnion and lowering of the thermocline. Sustained winds may also establish standing waves or seiches both at the surface and internally within the layer separating the epilimnion and hypolimnion. Severe winds thus have the potential to disrupt the structure and cycling of materials within a reservoir, resulting in potential adverse effects on water quality.

Increasing frequency of severe storms and degradation in source water quality will increase the pressure to move to more robust treatment processes such as filtration.

5.3.2.5 Changes in Watershed Land Use

In many watersheds, potential land use changes are significant variables influencing risks to water quality. The CRD is in the enviable position that ownership and control of the water supply area are secured for the long-term management to preserve water quality within the active Sooke and Goldstream watersheds and to enhance the water quality available from the Leech watershed upon completion of major rehabilitation efforts. As commercial activities, including forestry and mining activities, are prohibited and access by the public is restricted, direct human induced changes to the watershed are not anticipated.

5.3.2.6 Seismic Risks

Seismic risks are present in the CRD WSA due to the existence of faults adjacent the Goldstream watershed, Leech River Valley and Sooke Lake Reservoir. Seismic events, depending on their severity, have the potential to impact water quality. Landslides in watersheds, breaks in pipes and damage to facilities all have the potential to impact drinking water quality and the level of service provided to RWS customers. Because water supply infrastructure is critical to post-disaster recovery and life safety, it is prudent to consider seismic threats and mitigation at the master planning, preliminary engineering, and detail design of any water supply project.

The location of faults relative to critical RWS facilities including the Sooke Lake Dam and major transmission mains are shown in **Figures 5.3** and **5.4** for the west and east water supply areas. It is noted that fault lines cross main of the transmission mains or are adjacent to RWS dams and Kapoor Tunnel.

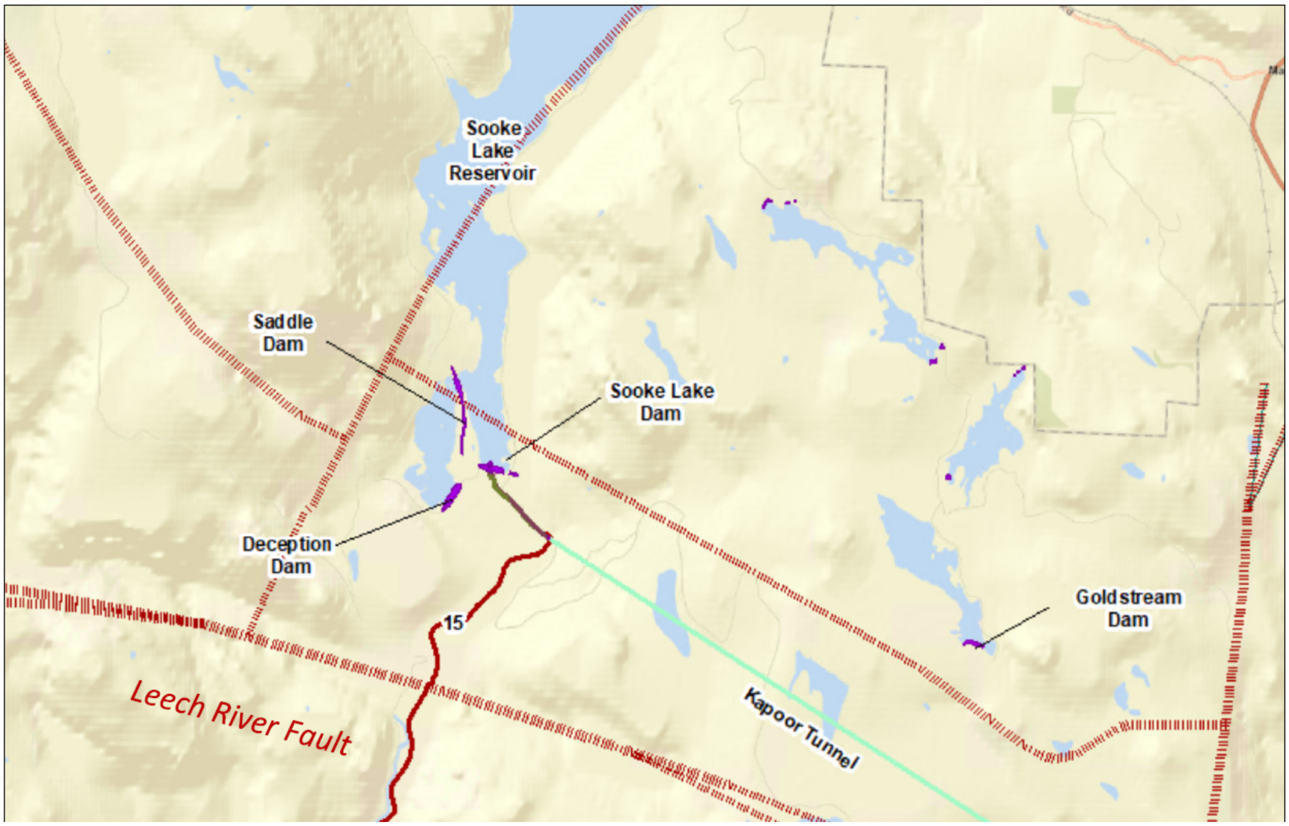


Figure 5.3: Faults in the CRD Supply Area (West)

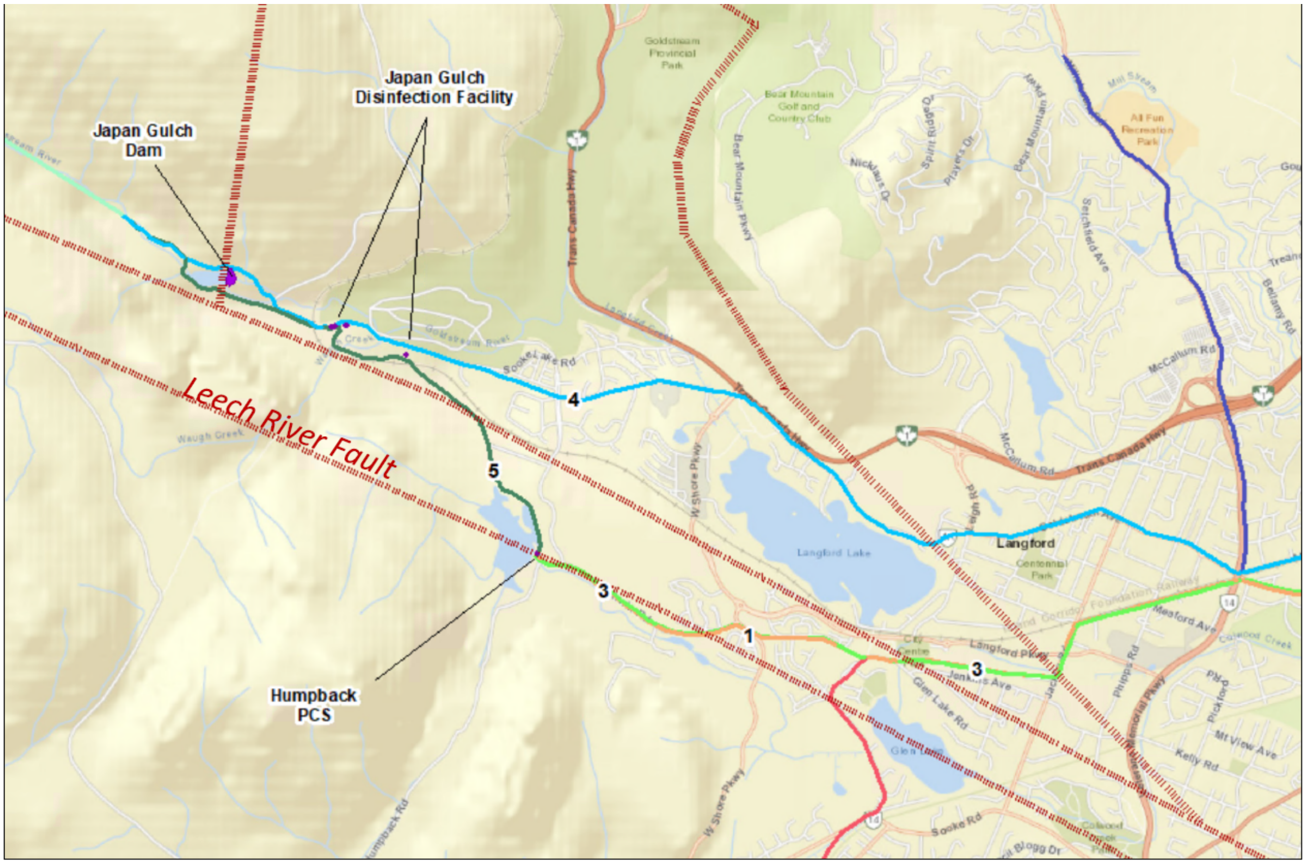


Figure 5.4: Faults in the CRD Supply Area (East)

Two new potentially active faults which could increase the seismic hazard to southern Vancouver Island have been identified in recent years. They are the Devil's Mountain Fault (DMF), that passes through the eastern Strait of Juan de Fuca, and the Leech River Valley Fault (LRVF) located west of Victoria (see **Figure 5.5**). Given the proximity of RWS water infrastructure, contribution of these two faults to the seismic hazard is likely to be significant. In particular, several of CRD's transmission mains cross these faults.

Figure 5.5: Leech River Valley – Devil's Mountain Fault System (Halchuk et al., 2019)3

5.3.3 Seismic Risk to Existing Facilities

The expected performance requirements of the various CRD water infrastructure could be defined in accordance with the following guidelines and Code:

- Dams: Canadian Dam Association guidelines (CDA. 2007)
- Pipelines American Lifelines Alliance guidelines (ALA, 2005)
- Buildings and other structures: National Building Code of Canada (NBCC, 2015)

Table 5.8 summarizes the expected Performance Level or Importance Category and the Annual Exceedance Probability (AEP) of the earthquake design ground motions based on the provisions of CDA (2007), ALA (2005) and NBCC (2015).

Table 5.8: Performance Level of CRD Water Infrastructure

CRD Water Infrastructure	Performance Level or Importance Category	Annual Exceedance Probability
Dams	Post Disaster	1/10,000
Pipelines – Major Water Body Crossings	Post Disaster	1/10,000
	Class IV	1/2,475
Pipelines – Water	Class IV	1/2,475
	Class III	1/975
Water Disinfection Plants	Post Disaster	1/2,475
Pump Stations, Chambers	Post Disaster	1/2,475
Tanks	Post Disaster	1/2,475
Buildings	Post Disaster	1/2,475
	Normal	1/2,475

Notes:

1. **Post Disaster:** Structures with Post Disaster Performance Level or Importance Category are structures that are essential to the provision of services after an earthquake and are defined in Table 4.1.2.1 of NBCC (2015) with seismic design per section 4.1.8 with special considerations noted in 4.1.8.10.2. Only facilities critical to the continuous operation of the systems shall be considered as Post Disaster.

2. **Normal:** Structures with Normal Performance Level or Importance Category are typical structures, not designated as “Post Disaster” or “High” structures and are defined in Table 4.1.2.1 of NBCC (2015) with seismic design per Section 4.1.8. Note that a water treatment plant designated as “post-disaster” may have “normal” structures on site. Only structures critical to the continuous operation of the systems as determined by CRD should be considered as “post-disaster”.

3. **Class III Pipelines:** Critical pipelines serving a large number of customers and presenting significant economic impact to the community or a substantial hazard to human life and property in the event of failure. These pipelines are intended to not experience damage that would result in loss of pressure integrity during and following ground motions with AEP of 1/975.

4. **Class IV Pipelines**: Essential pipelines required for post-earthquake response and recovery and intended to remain fully functional and operational during and following ground motions with AEP of ½,475 or 1/10,000. The Kapoor Tunnel would be an essential conveyance for the RWS.

5.3.4 Objectives of Water Treatment

Treated water objectives include the minimum pathogen reduction requirements and the specifications for finished water. The pathogen reduction requirements include those for enteric viruses and protozoan parasites, with a minimum of 4-log and 3-log, respectively. The key parameters for finished water quality are summarized in **Table 5.9**, based on regulations, guidelines, and aesthetic standards.

Table 5.9: Finished Water Quality Requirements and Regulated Objectives

Parameter	Unit	Value	Regulated Guideline Objectives	Monitoring Frequency
E. Coli	CFU/100 mL	None detected	None detected	Daily
Total Coliform	CFU/100 mL	None detected	None detected	Daily
Average Daily Turbidity	NTU	< 0.3	< 1.0 (unfiltered) <0.3 filtered	Continuous
Average Alkalinity	mg/L as $CaCO_3$	> 15	None	Daily
pH		7.5 – 10.5	7.0 -10.5	Continuous
DOC	mg/L	< 1.0	None	Weekly
True Colour	colour units	< 15	< 15	Weekly
Iron	mg/L	< 0.30	<0.30	Monthly
Manganese	mg/L	< 0.02	< 0.02	Monthly
Minimum total chlorine	mg/L	1.0 – 2.0	0.1-2.0	Continuous at clear well outlet
Taste and Odour		Acceptable	Acceptable	5 days per week
UVT% @254 nm		88-92	None	Continuous

5.3.5 Treatment Process Considerations

The raw water from Sooke Lake Reservoir and Goldstream watershed is a high-quality source with low turbidity and as such is appropriate for selection of an indicative direct filtration process, pending confirmation by piloting studies and detailed process and cost evaluations. Recent water quality sampling by the CRD on the Leech River indicates that the source does see elevated levels of colour and at times turbidity during first flash runoff. While some colour will be removed by coagulation and flocculation processes the use of a sedimentation or flotation process will likely be required. A dissolved air flotation process would deal with colour, mid level turbidity values of up to 100 NTU and it would also provide pre-treatment of algae. Planning for water treatment should include space and provision for sedimentation unit processes should they be necessary in the future. The raw water also has low alkalinity, typical of upland reservoirs in the Pacific Northwest, which may possibly impact coagulation and limit the dose of common coagulants such as alum. Consideration must be given to selection of high basicity coagulants such as aluminum chlorohydrate (ACH) and/or possible alkalinity adjustment in the raw water and finished water.

Elevated colour levels as are present in Leech River and algae concentrations in the SLR can impact the efficiency of the treatment process. These parameters should be monitored during plant operations to assess any changes in long term water quality. Identification of optimal process conditions to mitigate impacts of algae may be evaluated during piloting over the spring and summer period. If the CRD proceeds with the deep northern intake in the future the potential for elevated algae concentrations will be reduced.

The Goldstream watershed water quality has been impacted by slides in the Goldstream River Canyon during wet weather but normally this source has not been used during those periods. The water quality during summer periods is similar to that of the SLR. Future water filtration will assist in dealing with high turbidity from the Goldstream watershed.

Potential future augmentation of source supply capacity using the Leech River watershed may impose more challenging treatment conditions depending on the timing of water draws from the Leech system and how it is incorporated into the Sooke supply. Selective transfer of water during higher quality periods could be considered but such transfers would require careful water quality monitoring and may not align with demand requirements. Water quality improvement during short storm events may be achieved by selective diversion of Leech River water and blending of Leech water into Sooke Lake Reservoir. A recent study completed by CRD indicates that the water quality in the Leech River can change quickly following rainstorms producing higher turbidity and colour exceeding drinking water quality objectives. However, though the Leech system is anticipated to yield water of lower quality than that currently available in the Sooke Lake Reservoir, it is generally considered good raw water source quality by objective water quality standards and not anticipated to present a significant challenge to conventional treatment with granular media filtration. Review of water quality data indicates that there may be a requirement to incorporate a flotation or sedimentation process into the filtration plant. The final process selection will be the subject of future pilot studies and preliminary design work.

5.3.6 Water Treatment Process Options

5.3.6.1 Water Treatment Plant Capacity

The treatment options considered will be sized to satisfy the forecasted maximum day demand (MDD) of the 2050 design horizon. Using the intermediate 1.25% annual demand growth projection scenario developed, the 2050 MDD firm capacity is 390 MLD. This is the net treatment capacity that must be provided, and an option specific process design capacity will be required to compensate for internal plant water uses due to filter backwashing. This is typically around 5% of MDD plant capacity so for planning purposes a plant with a net process capacity of 410 MLD (390 MLDx1.05) is recommended.

5.3.6.2 Filtration and Disinfection

For the CRD's Regional Water Supply, augmentation of treatment to provide filtration will have the primary benefit of adding an additional barrier against microbial pathogens, particularly *Giardia* and *Cryptosporidium*. In addition, changes in raw water quality over existing conditions to climate change, wildfire and slope failures in the watersheds could drive the future requirement for filtration. The use of Leech River water in the future will likely require installation of filtration as the source can have elevated levels of turbidity and colour following rainfall events. Additional aesthetic benefits may result from the removal of fine particulate and colloidal matter. These include decreased accumulation of organic matter in the distribution and storage system, including planktonic detritus and aquatic invertebrates. This will improve the general cleanliness of the distribution and storage system which will result in reducing the frequency of required cleaning, improving the stability of disinfectant residuals, diminishing the rate of biological activity and risk of nitrification, avoiding aesthetic issues due to deposit resuspension, and improving the consistency and reliability of finished water quality. If filtration is implemented, the role of UV disinfection in protecting the public from the risk of protozoan pathogens becomes a second treatment barrier depending on the ultimate process selection. However, the combination of filtration and UV disinfection would provide much better treatment resiliency (consistent with the 2017 RWS Strategic Plan) and two independent barriers to protozoa. It is assumed here that existing disinfection systems using UV and chlorine will be continued. However, a more detailed analysis may be justified to reevaluate this assumption on a cost-benefit and life cycle cost basis during preliminary design of facilities.

Filtration has traditionally implied granular media filtration typically using a sand and anthracite filter media. This is the most common and cost effective treatment approach for large facility similar to the size required for the RWS. Membrane filtration has increasingly proven a viable option for many smaller to mid size systems but is not expected to be cost effective for the RWS. Another possible treatment scheme is the application of biological filtration, which involves granular media filters serving to remove both particulates and readily available organic matter, producing a biologically stable finished water. Biological filtration typically involves ozonation prior to filtration and uses granular activated carbon (GAC) as a filter media. While such systems have been in use since the 1950s in many European countries and more recently in North America, experience has shown that for high quality, low TOC waters such as that of Sooke and Goldstream reservoirs, the cost is not justified, and this option will not be considered further at this time.

Regardless of the ultimate selection of treatment process technology, provisions for advanced pretreatment processes should be included in the design in the event that raw water quality continues to decline. Future piloting studies and preliminary designs will ultimately provide the final selection of the treatment process for the CRD. At the master planning level, the potential treatment processes are evaluated based on their ability to provide satisfactory performance based on experience with similar water quality. This approach is considered suitable for master planning level efforts but will require confirmation by pilot studies.

5.3.6.3 Granular Media Filtration (Options 1 and 2)

Cost effective filtration at large scale has most commonly been achieved using gravity based granular media filtration. The granular media filter bed uses a combination of sand and anthracite with total media depths varying from 750 mm to 2000 mm. Deeper filter media designs have been shown to achieve higher filtration rates and hence smaller overall footprint than shallower filter media designs. Granular media filtration is a physicochemical process also referred to as chemically assisted filtration. Removal of particulates relies on proper chemical pre-treatment, primarily the addition of a coagulant to the raw water to destabilize particulate and colloidal matter, allowing aggregation and capture by filter media. Capture of particles occurs throughout the depth of a filter by adherence of particulates to media granules. Eventually, the available sites for particle capture are depleted and the filter must be backwashed to remove accumulated particulates during fluidization and agitation of the packed bed. Once the media is cleaned, it is allowed to resettle into a packed bed, and filtration resumes. A brief period follows known as filter ripening, often with a filter to waste period, during which coagulated water is passed through the media to prepare it for particle capture. The filter effluent is wasted during ripening, often being recycled to the front of the plant. Filtered or finished (post disinfection) water is used to backwash filters, and the backwash wastewater is treated and typically recycled to the front of the plant. Based on extensive industry experience and research investigations, it is generally accepted that optimized chemically assisted filtration can achieve 3 to 5 log removal of *Cryptosporidium* oocysts and *Giardia* cysts, as well as filter effluent turbidities below 0.1 NTU. Conventional filtration is preceded by flocculation and clarification to reduce the particulate load to the filters and extend the filter production time between backwashing. The omission of clarification is referred to as direct filtration. The omission of both flocculation and clarification is referred to as in-line or contact filtration.

Granular media filters have been installed at a number of locations in British Columbia including Metro Vancouver's Seymour Capilano Filtration Plant, Comox Valley Regional District, District of Sechelt, District of Port Hardy, and the City of Penticton.

A clarification or flotation process is required when higher turbidity and colour levels must be removed. Several types of clarification are available. These include the conventional gravity sedimentation, dissolved air flotation (DAF), and various forms of solids contact clarification. Extensive North American experience has been evaluated in terms of relevant raw water quality parameters and used to develop selection criteria for the various granular media filtration pre-treatment process options (Valade et al. 2009), as shown in **Figure 5.6**. This figure provides general guidance for process selection but site specific pilot studies covering a range of seasonal raw water quality are recommended.

Based on the SLR and potential future Leech River source water quality in the GVWSA, the two most likely process choices for granular media filtration are direct filtration, with the possibility of future addition of DAF clarification when Leech River water is introduced into the SLR.

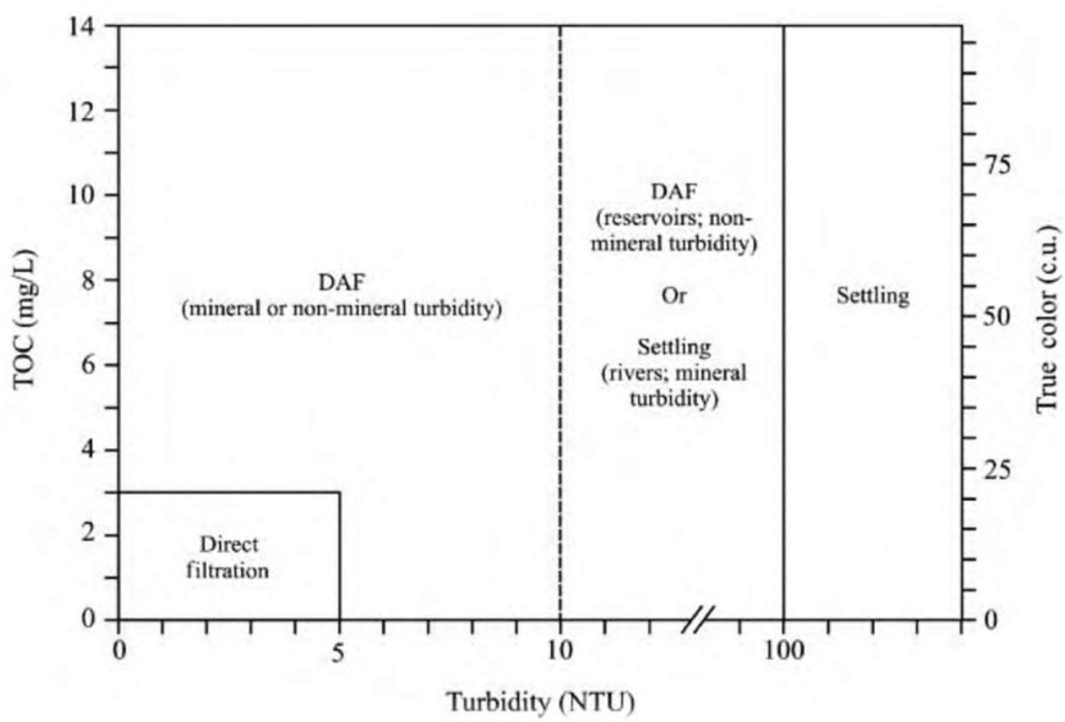


Figure 5.6: Process Selection Based on Average Water Quality (Valade et al. 2009)

All treatment options should be reviewed against the requirements of the recently published (2022) Drinking Water Officers guidance documents prepared by the Province of British Columbia and titled *Guidelines for Ultraviolet Disinfection of Drinking Water and Guidelines for Pathogen Log Reduction Credit Assignment.* Commonly referenced as the “4-3-2-1-0” guidance criteria are summarized below along with a summary of how the various treatment processes compare against these criteria. The comparison assumes that all options use free chlorine for virus reduction and only direct filtration options would employ UV as a second barrier to provide additional inactivation requirements for cryptosporidium and giardia protozoa. In many instances the addition of an additional treatment process, such as UV, will result in treatment levels which exceed the “4-3-2-1” guidance criteria. It is noted however, that DAF and Membranes would not require UV to meet guidance criteria and direct filtration would only require 0.5 log UV inactivation to meet requirements.

Table 5.10: BC “4-3-2-1” Guidance Criteria

	Criteria	Direct Filtration	DAF Filtration	Membranes
4	Log (99.99 Percent) Reduction Enteric Viruses	4 (chlorine)	4 (chlorine)	4 (chlorine)
3	Log (99.9 Percent) Inactivation of Giardia / Cryptosporidium Protozoa	2.5 (0.5 log UV)	3	4
2	Barriers of Treatment	2	2	2
1	Less than 1 NTU turbidity and target of 0.1 NTU for filtered water sources	1	1	1
0	Detectible *E Col*i, total coliform, and fecal coliform	0	0	0

5.3.6.4 Direct Filtration (Option 1)

Direct filtration is a process which uses granular media filtration and is considered most suitable for relatively stable sources that consistently demonstrate low turbidity and low organic matter. The process is simple and involves coagulation / flocculation, filtration, and disinfection. The Sooke Lake Reservoir and Goldstream average water quality is consistent with the recommendations for direct filtration. The complete process would include coagulant addition and flash mixing, flocculation, and direct filtration. Direct filtration would likely not be a suitable candidate once Leech River is brought online due to elevated colour levels however mixing Leech River and Sooke Lake water may produce a raw water that is treatable with direct filtration. This can be confirmed during pilot testing. The timing and provision for the addition of a colour removal pre-treatment process such as sedimentation or dissolved air flotation could be determined once pilot studies are completed, and once additional water supply is required beyond the safe yield available from Sooke Lake Reservoir.

The available *Giardia* and *Cryptosporidium* records for Sooke Lake Reservoir suggest that the water would fall into Bin 1 of the USEPA LT2 Rule for filtered systems. Health Canada guidelines require a minimum of 3-log total removal of *Giardia* cysts and *Cryptosporidium* oocysts. Provided filtered effluent turbidity limits are achieved, direct filtration may receive 2.5-log removal credit for oocysts. This would relax the inactivation requirements of subsequent UV disinfection or provide additional redundancy in treatment barriers. Virus inactivation would be obtained chiefly by using free chlorine, though 1.0-log credit is provided to direct filtration for virus removal. For all options, if the filtration plant is located at Japan Gulch the existing Goldstream UV Disinfection Facility and chlorination systems can be incorporated into the process to meet the log inactivation requirements. It is noted that the RWS is able to take advantage of its transmission pipelines to provide adequate CT. This is a significant advantage because pipelines are a more efficient contactor than tanks which require baffling to obtain adequate contact residence time. Adequate CT for virus inactivation can also be provided by a dedicated contact volume which forms part of the clearwell equalization storage for a water treatment plant. Such clearwells are often baffled to improve the contact time which are essential to meeting the effective contact time or "T" requirement of CT calculations.

The resulting treatment objectives for a direct filtration treatment scheme are outlined in **Table 5.11**. Such an arrangement would exceed provincial requirements for pathogen removal but meet the 4-3-2-1-0 guideline for having at least two barriers for each pathogen category. UV would be required to meet the 3 log inactivation requirements for *Giardia* and *Cryptosporidium* protozoa.

Table 5.11: Log Inactivation / Removal Credits for Direct Filtration - Option 1

Parameter	Treatment Process				Total	No. of Treatment Processes
	Treatment IHA	Direct Filtration	UV Disinfection	Free Chlorine		
Giardia/Crypto	3	2.5	0.5	0	3.0	2
Viruses	4	1	0	4	5	2

The hydraulic loading rate or filtration rate for direct filtration currently ranges from 10 to 30 m/h with deeper bed filters often achieving higher filter rates. While higher rates may result in smaller plant size and associated cost savings, achieving consistent low turbidity filter effluent is highly dependent on proper chemical pre-treatment and usually requires use of filter aid polymers. The recently commissioned Comox Valley direct filtration plant is designed with a filtration rate of 15 m/h. Metro Vancouver's Seymour-Capilano Filtration plant uses 15 m/h in winter and 20 m/h in the summer. For a process capacity of 410 MLD, a total filtration surface area of 1,140 m^2 is required. Experience has shown that for a facility of the proposed size, the number of filters should not be less than 8 nor greater than 12. Also, provision of the process capacity should be achieved with one filter out of operation. Thus, using 12 filters total with 11 filters able to achieve the process capacity results in an area of 104 m^2 per filter. The total filter surface area required is 1,248 m^2.

Several assumptions must be made to estimate the total land area required. For each filter, additional area is required to accommodate the necessary channels and piping for filter influent, effluent, and backwash water provision, backwash wastewater conveyance, filtration to waste, air scour blowers and other appurtenances. It is also assumed that coagulant addition would utilize existing piping upstream of the plant. Backwash water would be supplied by gravity from elevated storage or from backwash pumps drawing directly from the clearwell.

Significant cost savings are achievable with granular media filtration at larger scales, particularly at filter areas in the vicinity of 100 m^2 or greater. To alleviate the challenges of backwashing large filters, a common design includes two cells within a single filter box using a common central gullet allowing each cell to be backwashed independently. Savings achieved from increased scale must be balanced with operational and staging considerations and would require more detailed evaluation during design development.

Flash mixing followed by flocculation is assumed. Flocculation time for direct filtration typically ranges from 10 to 20 minutes over two to four stages, with decreasing mixing energy in each stage. Flocculation is commonly achieved by mechanical mixing with variable mixing energy input. The area required for flocculation is approximately 1,200 m^2 using a depth of 5 m for mechanical flocculation tanks and the process design flow of 410 MLD.

Residual waste streams must also be processed. These consists of spent filter backwash water, filter-to-waste water, and overflows from thickening and dewatering of solids removed from spent filter backwash water. Equalization storage of liquid residuals streams is usually required. Spent filter backwash water is usually settled by a dedicated clarifier, often with polymer aids to improve solids capture and recycled to the head of the plant. Solids are then concentrated in a gravity thickener and dewatered by centrifuge or another dewatering device. Polymer aids may be used at multiple points to improve solids capture and concentration. After appropriate processing, liquid streams are recycled to the front of the plant or discharged to the environment. The estimated area requirement for residuals is 2,000 m^2. The total area or footprint of the treatment and residuals facilities are estimated to require 6,748 m^2.

Due to the low alkalinity of Sooke Lake Reservoir and other sources (approx.15 mg/L as $CaCO_3$), common metal coagulants such as alum are unreliable without prior alkalinity addition. For low alkalinity waters, higher basicity coagulants, such as aluminium chlorohydrate (ACH) are preferred. The coagulant dose is estimated to be in the range of 5 to 10 mg/L, subject to confirmation by bench and pilot testing.

Pumping is required for several operations, though it can be minimized where possible using gravity and proper site planning. The main treatment process itself will be driven by gravity and require 4 to 5 m of head. Backwash pump size may be minimized using elevated storage which may also reduce overall footprint requirement. Key planning level process parameters are summarized in **Table 5.12**.

Table 5.12: Process Parameters for Direct Filtration - Option 1

Parameter	Total
Net Capacity	390 MLD
Gross Process Capacity	410 MLD
Coagulant Dose	5 – 10 mg/L
Chemical Rooms	300 m^2
Flocculation Time	20 min
Flocculation Process Area	1,200 m^2
Filtration Rate	15 m/h
Number of Filters	12
Area of each Filters	104m^2
Filtration Process Area	1,248 m^2
Residuals Processing Area	2,000 m^2
Operations Building	2,000 m^2
Total Treatment Process Area	**6,748 m^2**

5.3.6.5 Conventional Dissolved Air Flotation (DAF) Plus Filtration (Option 2)

Future raw water quality conditions may change sufficiently to challenge the performance of direct filtration. For example, increases in both the average and peak turbidity and TOC levels may increase due to changes in the watershed or incorporation of Leech River flows into Sooke Lake Reservoir. Water quality sampling by CRD in the Leech River has indicated elevated colour levels which normally require a clarification process such as gravity sedimentation or dissolved air flotation followed by granular media filtration. The most appropriate form of clarification is likely to be DAF (see Figure 5.6 above) because Leech and Sooke water have relatively low turbidity and will form small flocs which are easily floatable. The addition of DAF may be included in the initial design or provided as a subsequent retrofit, depending on the outcome of pilot investigations, timing of Leech River diversions to SLR, prevailing raw water quality and watershed conditions. The flocculation time for DAF is short and comparable to that of direct filtration, as the purpose of DAF would be to produce small aggregate floc for attachment to bubbles. The overall increase in treatment facility footprint is related to the DAF footprint. DAF filtration plants have been constructed at Port Hardy and Sechelt and have been very effective at removing high colour levels exceeding 100 TCU at these locations.

The provision of DAF clarification is recognized as having protozoan pathogen removing capabilities and enhancing the performance of filtration and improving UVT of the finished water overall. Consequently, the log reduction credits typically assigned such a process are slightly higher than those of direct filtration, provided the usual turbidity reduction performance is adequately achieved and verified on a continuous basis. Overall log reduction credits for Option 2 are shown in **Table 5.13.**

DAF could meet the Provincial treatment guidance requirements without UV, but provision of a second barrier would be considered resilient and robust treatment practice. In addition, if the plant is located at Japan Gulch, the existing Goldstream UV disinfection facilities can continue to be used.

Table 5.13: Log Inactivation / Removal Credits for Conventional DAF Filtration - Option 2

Parameter	Treatment Process				Total	No. of Treatment Processes
	Treatment IHA	DAF-Filtration	UV Disinfection	Free Chlorine		
Giardia/Crypto	3	3	Not required*	0	3	1*
Viruses	4	1	0	4	5	2

The practical range of hydraulic loading rate for high-rate DAF is 15 to 30 m/h with additional area required for saturators, air compressors, recycle pump systems, and DAF float residuals removal. The DAF area required is approximately one fifth of that required for filtration. A recycle flow for DAF must be provided for air saturation to produce 410 MLD for filtration. The recycle stream may be obtained from clarified or filtered effluent and typically amounts to 10% of the influent flow to the DAF. Thus, drawing the recycle stream from the DAF effluent, the total process capacity to the DAF units would be 430 MLD. At a loading rate of 20 m/h, this will require total DAF area of 900 m^2. This may be distributed between five DAF units, with a sixth redundant unit, yielding 180 m^2 per DAF and 1,080 m^2 total for all six DAF units. The total area for all processes including filtration for the DAF option is 8,320 m^2.

All other components as described for Option 1 would pertain to Option 2. If Option 1 is selected for implementation, the future provision for addition of DAF should be in included in the design. Two options for such a retrofit would be to reconstruct flocculation and DAF units upstream of the filters. A second option may be to apply the so-called DAF above filtration approach. Because the hydraulic loading rates for DAF and granular media filtration are comparable, it is possible to integrate DAF with filtration in the same filter box whereby the DAF separation occurs in the space above the filter media. The filter boxes are typically quite deep, 8 to 9 m, to avoid the potential for air binding in the filter media. This allows the saving of space and capital, as well as multiple other benefits. Several such facilities have been built or retrofitted in South Africa, Australia, and South America. This approach has been used in large plants where available space is limited, notably the Croton WTP serving New York City. The details of how future DAF augmentation are implemented, whether stand alone or integrated retrofit or constructed during the initial build, will depend on multiple site-specific factors, the outcome of pilot studies and will require separate detailed consideration. Process parameters for Option 2 are summarized in **Table 5.14.**

Table 5.14: Process Parameters for Conventional DAF Plus Filtration Option 2

Parameter*	Total
Net Capacity	390 MLD
Gross Process Capacity (DAF recycle flow included)	430 MLD
Chemical Rooms	300 m^2
Flocculation Process Area	1,200 m^2
DAF loading rate	20 m/h
Number of DAF units	6
Area per DAF unit	180 m^2
DAF Process Area	1,080 m^2
Filtration Process Area	1,240 m^2
Residuals Process Area	2,500 m^2
Operations Building	2,000 m^2
Total Treatment Process Area	**8,320 m^2**

5.3.6.6 Membrane Ultrafiltration (Option 3)

An increasingly competitive alternative to granular media filtration is pressure driven membrane filtration which includes microfiltration (MF) and ultrafiltration (UF) and removes particles by physical sieving at the interface of a fiber membrane having nominal pore sizes of 0.1 µm for MF and 0.01 µm for UF. Because MF and UF are similar in equipment design and operating characteristics and can be used interchangeably in most applications, they are commonly listed together as MF/UF. Two common configurations involve pressure vessels or submerged fibres, both involving assemblies of fibres into modules, with multiple modules assembled into skids or cassettes, and multiple skids or cassettes assembled into trains. In this way, a large surface area for filtration occupies a small footprint, providing significant benefit when space is limited. Currently, UF treatment is in service in Kamloops (160 MLD) and Nanaimo (120 MLD) and several other smaller locations.

MF/UF is an effective method of producing very low turbidity finished water (< 0.1 NTU), effectively providing an absolute barrier to protozoan oocysts. Direct challenge testing has been found to achieve > 6-log removal of *Cryptosporidium* and *Giardia*. Actual removal rates may be decreased significantly due to breaches in fibres or loose components. Membranes rely on the fact that they are a physical barrier and any breach or tear in a membrane or loose connections can allow small protozoa to pass through the membrane thereby compromising the treatment efficacy. Integrity testing is required to verify that the system is intact and to detect, locate, and correct any breaches. Direct integrity testing typically involves the pressurization of the fibres with air, isolation and measuring of pressure decay daily. The resolution of this verification method is limited which decreases the removal credit assigned in most jurisdictions to well below that demonstrated by challenge testing. Typical removal credits based on direct integrity testing are in the range of 3-log to 4-log for *Cryptosporidium* oocysts and *Giardia* cysts, depending on the product type. Indirect integrity testing is conducted continuously, often by turbidimeters to monitor the filtrate.

Regulations in the USA require continuous indirect integrity testing and at least daily direct integrity testing. The submerged UF type system such as the ZeeWeed 500d system by Suez or equivalent, is considered appropriate for Sooke Lake Reservoir water quality and this alternative is based on that system. Such systems have typically been assigned 4-log removal of oocysts on a product basis by challenge and integrity testing and validation. Overall log reduction credits for Option 2 are shown in **Table 5.15**.

Table 5.15: Log Inactivation / Removal Treatment Credits for Membrane Filtration - Option 3

Parameter	Treatment Process				Total	Total No. of Treatment Processes
	Treatment IHA	Ultrafiltration	UV Disinfection	Free Chlorine		
Giardia/Crypto	3	4	Not required*	0	4	1*
Viruses	4	0	0	4	4	1

The process layout assumes that the rejectate from membrane rinse water (equivalent to backwash in granular media filters) of the initial membranes is further processed by a secondary membrane stage thereby enabling recovery of most of the water. The permeate of the secondary stage is recycled to the head of the plant and blended with the raw water prior to coagulant addition and flash mixing. The rejectate of the secondary stage would contain a much higher concentration of solids and be processed by a dedicated DAF thickener. The float captured by the DAF thickener is accumulated in a storage tank until there is sufficient volume to operate a centrifuge dewatering system. The clarified DAF thickener subnatant is recycled to the front of the secondary membrane stage.

Pre-treatment would be like Options 1 and 2, involving a high basicity coagulant such as ACH at a relatively low dose and brief flocculation likely with a residence time of less than 10 minutes, possibly using only a single stage.

It is assumed the ZeeWeed 500d submerged UF system or equivalent is used for this facility, and that each cassette provides a net production of 2 MLD of permeate (or filtrate) using typical flux rate, backwash frequency, backwash duration, and transmembrane pressure. Optimization of these and other parameters may significantly increase the net production capacity of the system.

For an ultimate design flow of 390 MLD, this would require a total of approximately 200 cassettes for the primary stage. The secondary stage would consist of approximately 50 cassettes. It is important to note that once the tankage for each train has provided for the ultimate design flow, the staging of capacity increases is greatly simplified as it involves simply adding additional cassettes into available space in the tank of each train and arranging the required connections to feed, permeate, and air supplies. It is also of benefit to split the capacity into two independent treatment trains between the point of coagulant addition and conveyance of permeate to disinfection. Each train would involve a primary stage composed of 10 units with 10 cassettes in each, and secondary stage composed of 5 trains of 5 cassettes each. Each plant would also have a dedicated DAF thickener to process rejectate of the secondary stage. A common DAF solids storage tank and dewatering facility would likely be used for both trains.

Due to the modularity of UF systems, a reasonable estimate for the area requirement may be obtained using existing facilities. In this way, it is estimated that for a 390 MLD net capacity facility, involving coagulant addition and flash mixing, brief flocculation, primary and secondary UF stages, DAF thickening, and centrifuge dewatering, a total area of 7,850m^2 is required. Similar to other options, a 2,000 m^2 allowance is suggested for the operations building. This includes area provision for filtrate pumps, inlet and distribution channels, and clean-in-place (CIP) chemical storage.

Table 5.16: Membrane Total Treatment Process Area Information

Parameter*	Total
Net Capacity	390 MLD
Gross Process Capacity with recovery module	395 MLD
Flocculation Time	< 10 min
Flocculation Area	600 m^2
Chemical Rooms	350 m^2
UF system type	Submerged (Zeeweed 500d or equivalent)
Total number of primary cassettes	200 (2 x 10 trains x 10 cassettes)
Total number of secondary cassettes	50 (2 x 5 trains x 5 cassettes)
Membrane Area	3,400 m^2
Flux Rate	35 L/m^2/min
Typical Transmembrane Pressure	0.2 – 0.4 bar
Membrane Life	10 years
Residuals Area	1,500 m^2
Operations Building	2,000 m^2
Total Treatment Process Area	**7,850 m^2**

The three treatment process options considered are illustrated in **Figure 5.7.**

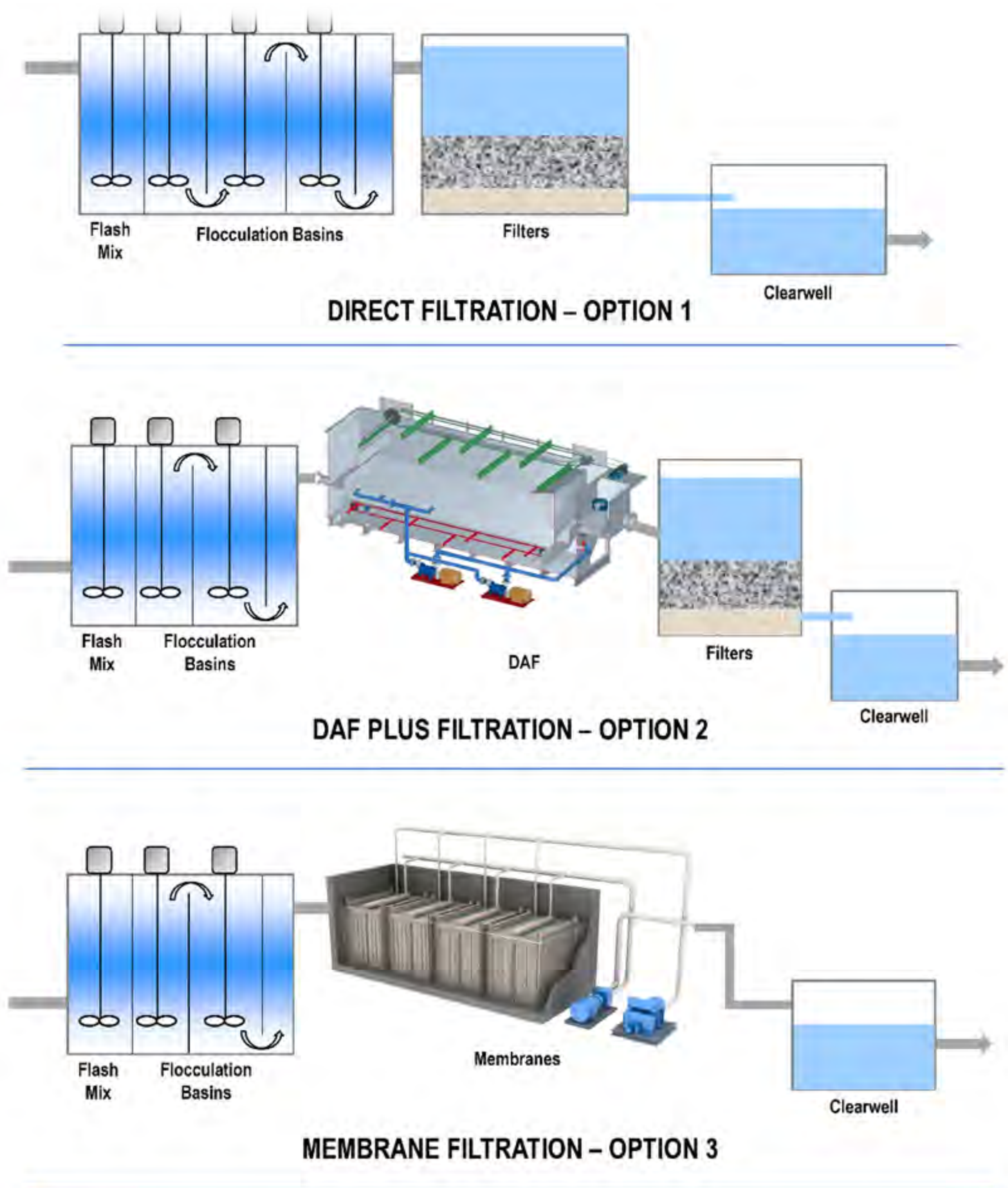


Figure 5.7: Treatment Process Options for Filtration

The three process options that have been considered are based on the raw water quality conditions in the Sooke Lake Reservoir, Goldstream Reservoirs, and the future Leech River source. The final selection should be made after detailed piloting studies are completed and should consider not only Sooke Lake Water but a blended source water with Sooke and Leech water. Once pilot studies are completed, preliminary designs can be completed for the selected treatment process using site specific process parameters. It is expected that the pilot program would focus on granular media filtration options as life cycle costs for membranes will be significantly higher.

All process options will be able to respond to post wildfire conditions provided the raw water quality does not deviate from established process performance design criteria for the selected process. The biggest changes in raw water quality could be potential increases in turbidity due to loss of forest cover or ash deposition in reservoirs. Short term changes in water quality can most likely be accommodated by more frequent backwashing of filters. A deep intake in SLR would also assist in maintaining raw water quality.

5.3.7 Residuals Treatment, Disposal, and Recycling

All filtration processes generate waste or residuals streams, consisting of solid-liquid flows of varying concentrations. These must be properly treated and disposed of, and the water recycled to the greatest extent practicable. The residuals streams for Options 1 and 2 include:

- Filter-to-waste
- Spent filter backwash water recycled to head of plant following pre -treatment (high rate settling and polymer addition)
- DAF clarifier float – Option 2 only
- Thickened solids overflow and dewatered solids centrate (supernatant)
- Dewatering waste (centrate)
- Sanitary wastes from washrooms and floor drains

In the case of Option 3 (Membranes), the residual streams include:

- UF reject water (primary and secondary stages, primary recycled through dedicated membrane module)
- Thickener float and subnatant
- Dewatering solids (centrate)
- Spent clean-in-place chemicals
- Sanitary wastes from washrooms and floor drains

For many facilities, sludge waste streams are commonly discharged to sanitary sewers or wastewater treatment facilities. Because of the hydraulic loading from backwash, backwash waters are rarely discharged to sewer and are often recycled to the head of the plant or returned to the receiving stream following pre-treatment. It is possible to reduce liquid discharge to less than 1% of the total flow and render it environmentally safe. This relatively smaller flow may be taken to sewer or treated and discharged to the environment. Dewatered solids with 20% to 25% solids may be ultimately disposed of to landfills or potentially used for beneficial purposes.

5.3.8 Proposed Filtration Plant Siting Considerations

Three options have been considered for siting of proposed water filtration plant including:

1. Adjacent to Head Tank south of Sooke Lake Dam (single centralized plant)
2. Adjacent to Japan Gulch Reservoir (single centralized plant)
3. Distributed plants – A large plant at Japan Gulch and a small plant at SRRDF

Table 5.17 summarizes the advantages and disadvantages of each filtration plant location.

Table 5.17: Comparison of Treatment Plant Siting Options

Plant Location (s)	Advantage	Disadvantage
Sooke Lake Dam Head Tank (Centralized Plant)	• Flow by gravity to Kapoor Tunnel and Sooke Transmission Main No. 15 • Flow by gravity to Kapoor Tunnel and downstream RWS transmission mains • Single plant serves both Greater Victoria and Sooke same as current RWS	• 3 phase power extension to plant is costly • Access road is long and would require significant upgrade • Travel time from Goldstream operations centre to plant; winter travel could be longer. • Site is remote • Decay of disinfectant requires higher dosage at plant • Not able to treat Goldstream water
Japan Gulch Reservoir (Centralized Plant)	• Site is easily accessible • 3 phase power can easily be extended • Close proximity to Goldstream Disinfection Facility	• Site elevation is around 130+- m so high lift pumping will be required to 169mHGL • A new east-west transmission main would be required to supply JDFWDS • Site is near flood inundation zone in the event of failure of Goldstream dams • Site is in close proximity to Leech River fault
Japan Gulch Reservoir and Sooke River Road Disinfection Facility (2 plants)	• Eliminates requirement to build transmission main to supply JDFWDS • Small membrane plant could be constructed adjacent to Sooke River Road Disinfection Facility • Power supply can easily be upgraded for new plants • Access to both treatment plant sites is good	• Would require operation of 2 water treatment plants • Additional operational and maintenance costs due to 2 plants • Two plants would be more costly to construct and operate

The Japan Gulch Reservoir location is considered the best available site for an expanded treatment facility at this time. Siting the plant at this location will require breaking the hydraulic gradeline of the transmission system to accommodate gravity granular media filtration. This location will require pumping to raise the HGL to 169m from approximately 124 m following filtration. Final site selection can be made as part of a water treatment plant preliminary design study. **Figure 5.8** provides an indicative potential sizing of a direct filtration facility in comparison to available sites adjacent to the Japan Gulch reservoir. **Figure 5.9** illustrates how the plant can be incorporated into the overall hydraulics of the RWS transmission system. A new balancing head tank (Stage 2 Balancing Tank in Figure 5.9) located near the Japan Gulch filtration plant site with a top water level elevation 169m could be constructed on the treated water pump station discharge mains to allow the RWS to operate hydraulically as it has for many years. This tank can also serve as a source of supply for backwashing filters. Experience at other locations has indicated that the sized of balancing storage is typically in the range of 10% of plant capacity. The final size of the balancing storage will be anticipated to range from 30 to 50 ML depending on the outcome of a hydraulic modeling study to optimize the sizing of the plant and Smith Hill balancing tanks.

The 1994 Plan recommended decommissioning of the Japan Gulch Reservoir and Dam. Decommissioning would free up valuable area for a new water filtration plant and future expansion area. The Japan Gulch site is downstream of the Goldstream dam failure flood inundation zone so a protection berm may be required as part of the design. Geotechnical and seismic evaluations of the site will also be required to confirm the viability of this site. If a transmission pipeline is built from the Goldstream Reservoir to Japan Gulch, the plant could also be constructed on the site where the current Japan Gulch reservoir exists.

The final site layout will be determined following preliminary design. The Howard English Fish Hatchery may have to be relocated to provided adequate space for the dam and reservoir decommissioning and a treatment plant construction near Japan Gulch.

Figure 5.8: Preliminary Layout of Direct Filtration Plant and Clearwell near Japan Gulch Reservoir (Indicative Siting for Footprint Estimates only)

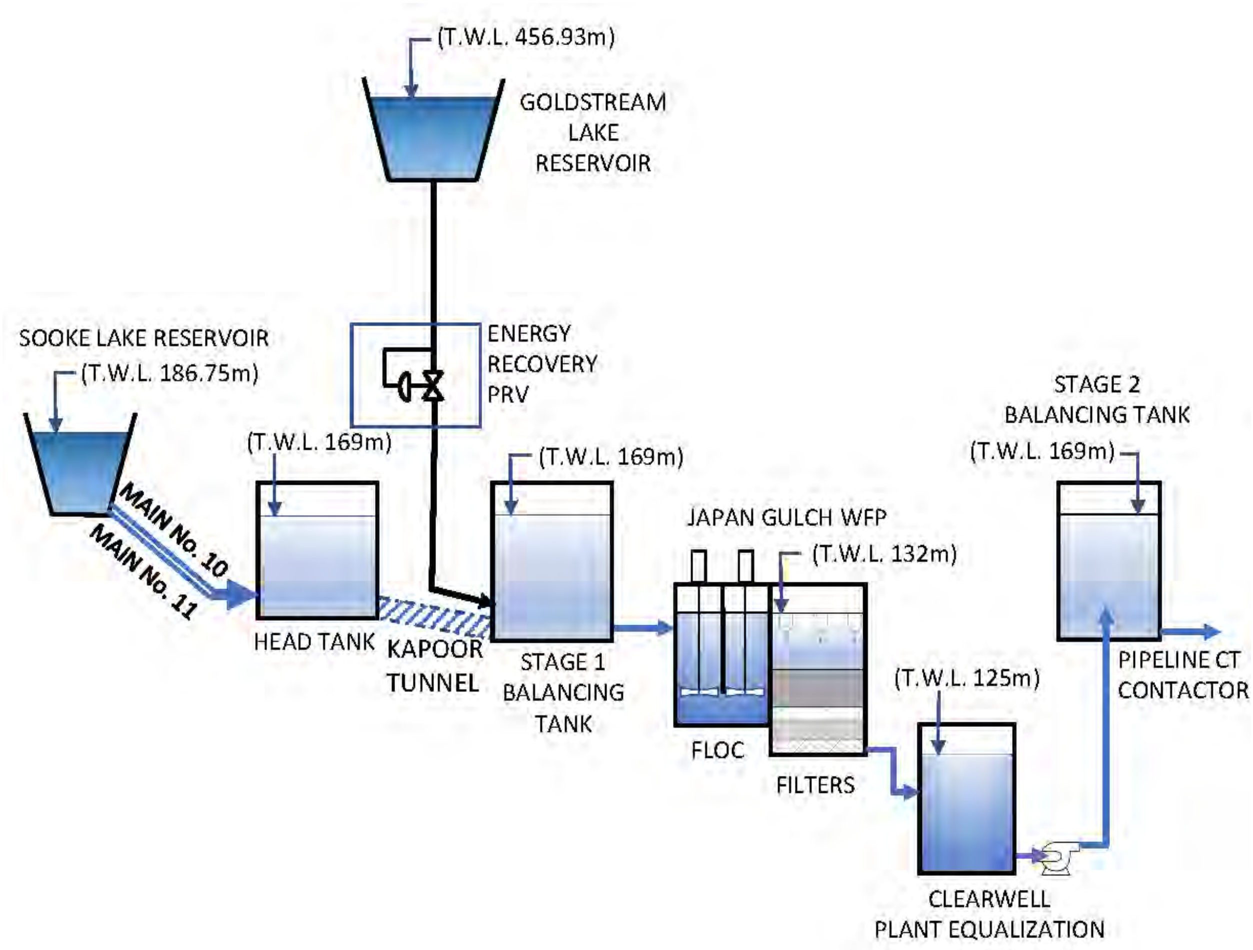


Figure 5.9: WFP & Balancing Storage Hydraulic Grade Line

5.3.9 Filtered Water Clearwell

Filtration facilities are typically designed to process water at a constant rate and satisfy the anticipated maximum day demand for the selected design horizon which typically ranges from 20 to 25 years. Filtered water storage, referred to as a clearwell, provides peak hour flow balancing equalization and reduces filtration flow fluctuations due to instantaneous transmission system demand and also serves as a source of filter backwash water. Such storage may also provide chlorine disinfection contact time. In this case, disinfection will be conducted downstream by existing Goldstream UV and chlorine facilities and the transmission main which serves as contact pipeline to provide residence time for disinfection. The RWS transmission system has a considerable pipeline length prior to first users so adequate contact time can also be achieved in the transmission mains as currently practiced for the Goldstream Disinfection Facility. It is anticipated that 30 to 50 ML of treated water storage will be located at the filtration facility site. A treated water pump station will pump the water to a HGL of 169 m which can be provided by direct pumping into the transmission system or pumping to an elevated Stage 2 head tank close to the plant. The clearwell storage would likely be constructed in 2 cells to facilitate inspection and maintenance activities. Further analysis, including hydraulic modeling of system storage tank sizing, should be conducted to evaluate the final filtered water storage requirements and sizing.

5.3.10 Capital and Operating Costs

The cost of treatment facilities depends on factors including actual maximum day demands, projected capacity requirements, the type of facilities to be constructed, site conditions, and implementation schedule. The following section presents a conceptual level opinion on the probable cost of treatment options for planning purposes.

A planning horizon of 2050, 28 years from the present, has been used to establish the ultimate design capacity of the treatment plant and associated total land requirements for filtration options. However, implementation of additional treatment will most likely be executed in stages of capacity increments based on a design horizon of 20 to 25 years as well as projected water demands to minimize redundant capacity and future inflationary cost increases. Thus, the timing of implementation would impact the cost of treatment. For example, the MDD forecast for 2040 using identical assumptions is 340 MLD, which is 13% less than the MDD of 390 MLD forecast for 2050. For planning level purposes, it is recommended that water treatment planning consider the 2050 design horizon for initial sizing and estimating construction costs.

A feasibility level opinion of probable cost is provided in **Table 5.18** for the three filtration options assessed in this 2022 Master Plan with the understanding that capacity increments for future expansion would be staged and an ultimate site development plan would be provided to plan the site layout for future expansions beyond the initial build. Sufficient site area would also be provided to provide additional pre-treatment such as DAF if required in the future.

Table 5.18: Opinion of Probable Cost for Filtration Plant Options

Treatment Options	Capital Cost (M$)	Operating Cost NPV (M$) *	LCC(M$)
1. Direct Filtration	$570	$205	$780
2. DAF plus Filtration	$660	$235	$900
3. Membranes	$750	$355	$1,200

*NPV calculated using 4% discount rate and Option 3 includes membrane replacement cost at ten-year intervals

A comparison of the capital cost, operating cost, and life-cycle cost suggests direct filtration (Option 1) to be the lowest capital and life cycle cost. These costs will be subject to change depending on market conditions at time of tender and other factors such as the outcome of detailed piloting and preliminary engineering investigations. Note the costs in Table 5.18 above are direct capital costs only and do not include the indirect costs and contingency which are the basis of the estimates included in Section 8.0 of this report.

5.3.11 Energy Consumption

It is generally recognized that the energy requirements for media filtration are less than that of membranes, though a detailed analysis is needed to provide a more accurate comparison.

The head available for granular media filtration may be provided by gravity with Sooke Lake Reservoir located above the treatment facility. In the case of MF/UF membranes, use of a complete or partial siphon to provide the permeate vacuum has been implemented at other sites and may be available for the CRD to offset electrical costs somewhat. A partial siphon was used for the City of Nanaimo's UF system commissioned in 2016 and successfully offsets permeate pumping requirements.

5.3.12 Treatment Options Analysis and Discussion

The three treatment options may be compared on the following basis:

- Log inactivation/removal capabilities for protozoan pathogens
- Area or land requirement
- Capital, O&M, and Life-Cycle Costs
- Ease of integration with existing works
- Energy consumption

The estimated land area requirements for treatment options are displayed in **Table 5.19**.

Table 5.19: Comparison of Treatment Options

Treatment Options		Protozoan Removal with UV (Log)	Land Area (m^2)	Life-Cycle Cost ($M)	Filtration Energy	Chemical Pre-Treatment
1	Direct Filtration	5.5	6,748	780	Low	Critical
2	DAF plus Filtration	6.0	8,320	900	Low	Critical
3	Membranes	7.0	7,850	1,200	High	Non-Critical

With UV incorporated and sized to provide 3 log inactivation in all options more than the required log removal of *Cryptosporidium* and *Giardia* is provided although at the expense of additional operating costs. It is noted however that only direct filtration would require at least 0.5 log of UV inactivation while DAF filtration and membranes would not require UV to meet Provincial requirements. The extent of this is greatest for Option 3 Membranes where the filtration processes achieve better particle removal and hence is given a higher removal credit by regulatory authorities. Total land area required is least for Option 1, Direct Filtration. Life cycle cost for Option 1 is the least, which is 87% of that for Option 2 and about 65% of that for Option 3. Energy requirements are also lowest for Option 1 and highest for Option 3. Staffing levels for all plant technologies are expected to be similar.

A distinct advantage of membrane filtration is the lower importance of chemical pre-treatment to achieve optimal particle and pathogen removal. In membrane filtration applications, chemical pre-treatment using coagulants is applied to reduce the rate of membrane fouling by colloidal and dissolved organic matter, thereby decreasing the frequency of required cleaning operations and prolonging membrane useful life. No ripening occurs and therefore filter-to-waste is not required. The amount of backwash water used is typically 5 to 10% of the water produced compared to 2 to 5% for granular media filtration. Due to the relative unimportance of chemical pre-treatment on low turbidity waters, membrane systems are less sensitive to changes in source water quality that may occur seasonally or due to storm events. The membranes would however still require some form of pre-treatment such as sedimentation or DAF for colour removal if Leech River is used as a source without blending with Sooke Lake water. Treating Leech water without blending would require a pre-treatment process.

All filtration and membrane processes will be capable of removing ash and turbidity. Conventional processes which have a separate solids separation pre-treatment process will be better equipped to treat higher levels of ash and turbidity. More frequent washing of filters may be required if significant ash and sediment due to wildfires impact the raw water quality significantly. The proposed Deep Northern Intake will also provide additional resiliency to raw water quality and treatment impacts from ash or turbidity events in creeks draining into the SLR.

5.3.13 Recommended Indicative Water Treatment Process

Based primarily on cost considerations and review of available water quality information, Stantec considers direct filtration to be an appropriate filtration process for the CRD's Regional Water Supply from Sooke Lake Reservoir with the presumptive site located in the vicinity of the Japan Gulch reservoir upstream of the existing Goldstream Disinfection Facility. This site was selected for ease of access and the ability to easily integrate into the existing transmission system. The continuation of dual primary disinfection using UV, and secondary chlorine and ammonia is recommended with existing facilities replaced or renovated prior to reaching the end of their useful life or new facilities integrated into a filtration plant. The design for new filtration facilities should allow for the addition of dissolved air flotation in the future to deal with differing water quality if Leech River is used as a future source. The final process selection and siting can be finalized once piloting and preliminary designs are completed.

It is also recommended that increased monitoring of water quality be conducted at both the existing SLR intake and the proposed Deep Northern Intake basin to better assess the optimal elevation for extraction of water from the north basin. Other water quality parameters relevant to granular media filtration design and operation include turbidity, TOC, UV absorbance, alkalinity, pH, and temperature. Year-round monitoring should be initiated at a frequency sufficient to capture seasonal variations.

Pilot treatment studies should be initiated, which along with seasonal water quality data from existing and future intake locations, will be used to inform full scale design. During pilot testing it is recommended that a blend of Leech River and Sooke Lake Reservoir water be tested in various proportions to determine the effectiveness of direct filtration and whether a sedimentation process or flotation process will be required to meet treated water objectives.

Pilot studies should also include bench scale evaluation of backwash residuals treatment selection and optimization.

5.4 Transmission and Distribution System Water Quality

Over time, particulate, sediments, inorganic and organic matter will settle an accumulate in the transmission systems. The deterioration of water quality on large transmission systems similar to the CRD is a significant challenge. When initial finished water quality is sufficiently high, the risk of further deterioration is mitigated with the implementation of a filtration facility. The augmentation of treatment to include filtration provides additional benefits beyond health-based protozoan pathogen removal targets, namely by producing a superior finished water quality of greater chemical and biological stability that will improve water aesthetics and facilitate maintenance of transmission system integrity.

5.4.1 Particle Transport, Sedimentation and Accumulation in Transmission System

Despite the very low turbidity and pathogen content of the Regional Water Supply Service source water, over time a considerable amount of particulate matter will be loaded into the transmission and distribution system in the absence of filtration. Such material tends to deposit where flow is lowest, such as transmission mains during low flow periods in the winter, in storage facilities, upstream of closed valves, and dead ends. The presence of such material is associated with several undesirable effects.

This matter thus supports increased rates of bacterial growth, primarily non pathogenic, in transmission and distribution systems. Sediment and particulate accumulations in transmission systems provide nutrients and energy to heterotrophic bacteria, as well as increased surface area for biofilm growth. This material thus supports increased rates of bacterial growth in transmission and distribution. Negative impacts of such material include:

- As organic matter accumulates and decays, anaerobic conditions may result in the development of objectionable taste and odour and a rise in consumer complaints.
- Sudden flow reversals or flow increases and pressure surges may resuspend deposited material causing noticeable turbidity events.
- Greater disinfectant residual demand on disinfectant residual and inability to maintain residual to throughout the system, allowing accelerated bacterial growth and increased risk of nitrification.
- Biofilms may harbour and amplify opportunistic pathogens and act as a source of seed material to colonize building premise plumbing and microbial induced corrosion.
- Biological activity may increase rate of corrosion in areas with ferrous pipe materials.
- Interference with the routine bacteriological sampling of sanitary significance, such as total coliform bacteria. Regrowth of total coliform bacteria may mask coliform intrusion through breaches of integrity, thus making detection integrity losses more difficult. Elevated heterotrophic bacteria levels can suppress the detection of total coliforms and other indicator, increasing the rate of false negative total coliform results.
- Increased flushing requirements to remove accumulated deposits and consequent non-revenue water production. Increased frequency of storage facility cleaning requirements.
- Periodic taste and odour events.
- Greater formation potential for regulated and non-regulated disinfection by-products due to greater amount of precursor material.
- Infestations of invertebrate animals in the distribution system may rise to levels noticeable to consumers.

Such conditions are greatly minimized when particulate removal is provided by effective filtration.

5.4.2 Corrosion Control

The chemical stability of finished water reduces the potential for corrosion in the transmission and distribution system, as well as within the plumbing of home and building water systems. The CRD source water is of low alkalinity, and thus, has low buffering capacity.

The recently completed Greater Victoria pH and Corrosion Control Study (KWL) confirms that very few of the sampled buildings had elevated lead concentrations above the action or health limits of GCDWQ. Based on these results and in accordance with action threshold concentrations set by Health Canada, the Province and the USEPA, it appears that corrosion is not a major issue in the RWS and Greater Victoria area. However, it was noted in the consultant's report that provision for alkalinity and pH adjustment should be considered in the design of any future water filtration facilities. This approach would enable RWS to respond to future regulatory changes, provide pH and alkalinity adjustment to respond to operational requirements and compensate for consumed alkalinity as the result of coagulation chemical addition. Refer to the recently completed KWL Study Conclusions/Recommendations for additional information.

An important consideration in planning filtration treatment is the impact such treatment would have on the corrosivity of finished water. The proper selection of pre-treatment chemicals should be included in pilot evaluations to address this issue. The addition of common coagulants will depress pH and alkalinity. At other plants with low alkalinity raw water similar to RWS sources a variety of chemicals have been used to reduce corrosivity including lime, caustic soda, carbon dioxide and soda ash. For example, Metro Vancouver's Seymour Capilano Filtration Plant (similar raw water quality to CRD sources) uses hydrated lime and carbon dioxide post filtration to increase pH and alkalinity prior to transmission.

5.4.3 Cross Connection Control

International experience has demonstrated that contamination of the system by uncontrolled cross-connections is one of the greatest risks to finished water quality and public health. In compliance with provincial regulation, the CRD has developed and implemented a comprehensive cross connection control program, as described in Bylaw No. 3516 (as amended by Bylaw 4037).

5.5 Water Treatment Implementation Strategy

5.5.1 Treatment Recommendations, Staging and Next Steps

In previous sections of this report, it has been determined that a treatment plant with a gross treatment capacity of 410 MLD will meet the projected 2050 maximum day demand of 390 MLD. The additional finished water capacity is provided for internal plant water use such as filter backwashing. Experience in North America has seen most water treatment plants constructed for a design horizon of anywhere from 20 to 30 years. At the same time that conceptual designs are prepared, an ultimate site development master plan for future expansion of treatment facilities should be prepared. With such a plan and hydraulic considerations through future added processes, future plant expansions can be easily accommodated, and individual projects coordinated. There are a number of investigations and studies that should be completed to finalize the selected water treatment process, and these are summarized below:

- Complete a pilot study to assess the performance of different filtration options and develop design criteria for design of future filtration facilities. The pilot program should consider treatment of SLR water, Goldstream water, Leech River water and a blend of SLR and Leech River water. Because of the significant cost of a membrane plant, the pilot program should be focused on direct filtration and DAF filtration using medium depth and deep bed filter designs. The pilot program should be operated through summer and winter conditions to determine if there are any impacts from season raw water quality changes.
- Undertake a treatment plant site selection study to finalize the plant siting.
- Complete a geotechnical investigation of the selected plant location.
- Complete an indicative design of filtration facility and undertake a siting study to finalize the location of the filtration plant. The indicative design should be comprehensive and should include consideration of flow control through the plant for SLR and Goldstream sources, hydraulic gradeline through the plant unit processes, treated water pumping, clearwell equalization storage, and primary and secondary disinfection. The design should assess the geotechnical considerations, seismic design, and protection from

flood inundation. The Opinion of Probable Construction Cost should be updated once the indicative design is complete.

- Complete hydraulic modeling to finalize the size of balancing storage sizing at the water treatment plant site in combination with the proposed Smith Hill Transmission balancing storage reservoir.

5.5.2 Power Supply

The provision of three-phase electrical power is required for the filtration facility. Capacity upgrade and extension of available power to the proposed filtration facility is required, including consideration of relocation of power lines to below ground surface to improve resiliency. Once an indicative design for the filtration plant is completed, initial discussions should be held with BC Hydro regarding power supply extension to the selected treated plant site.

Most major treatment plants will also have standby power generation so it would be prudent to plan for standby power installation at the water filtration plant to provide the desired reliability and resiliency for these critical infrastructure facilities.

5.5.3 Energy Recovery

Energy recovery of water from a pumped pipeline system via Jack Lake is an option that was investigated in the 1994 Plan. If this option is considered in the future or if a pipeline from Goldstream Reservoir is constructed, it may be possible to incorporate energy recovery into the final design. This option would involve the construction of small piped micro hydro systems that would have a generator installed. While these are potential options, the energy recovered is unlikely to offset the capital cost of such facilities.

5.5.4 Facility Security

Facility security is an important consideration at most water treatment plant sites. Given the remoteness of potential sites, fencing and controlled access is recommended as is currently practiced for the Goldstream Disinfection Facility. Additional monitoring facilities such as cameras, alarm systems, and door/access hatch switches are recommended.

5.5.5 SCADA

The CRD is currently updating their SCADA system and establishing a SCADA Master Plan for future upgrades. The proposed treatment plant would be integrated into the overall SCADA system to enable monitoring from defined locations within the CRD system. The proposed water treatment plant would have a main control room which could serve as the central control hub for monitoring RWS offsite and other facilities.

6.0 TRANSMISSION SYSTEM

6.1 Existing Transmission System

The existing RWS was described in Section 2 of this 2022 Master Plan. For the purposes of the transmission system assessment the following is highlighted:

- Sooke Lake Reservoir is the primary source of supply with a spillway crest elevation of 186.75 m
- Water flows from SLR to the Head Tank which maintains a HGL of 169 m to the RWS system
- A connection upstream of the Head Tank for Main No. 15 supplies the Sooke River Road Disinfection Facility
- Water is conveyed by gravity through the Kapoor Tunnel to the Goldstream Disinfection Facility
- Supply can be augmented to Japan Gulch Reservoir from Goldstream River. (This is a secondary source used by RWS when Kapoor Tunnel is out of service and has been modeled by GeoAdvice in the following sections and noted as “Kapoor Tunnel Out of Service” in hydraulic model runs.)

Figure 6.1 provides a simplified schematic of the RWS supply system for reference and context on supply system operation.

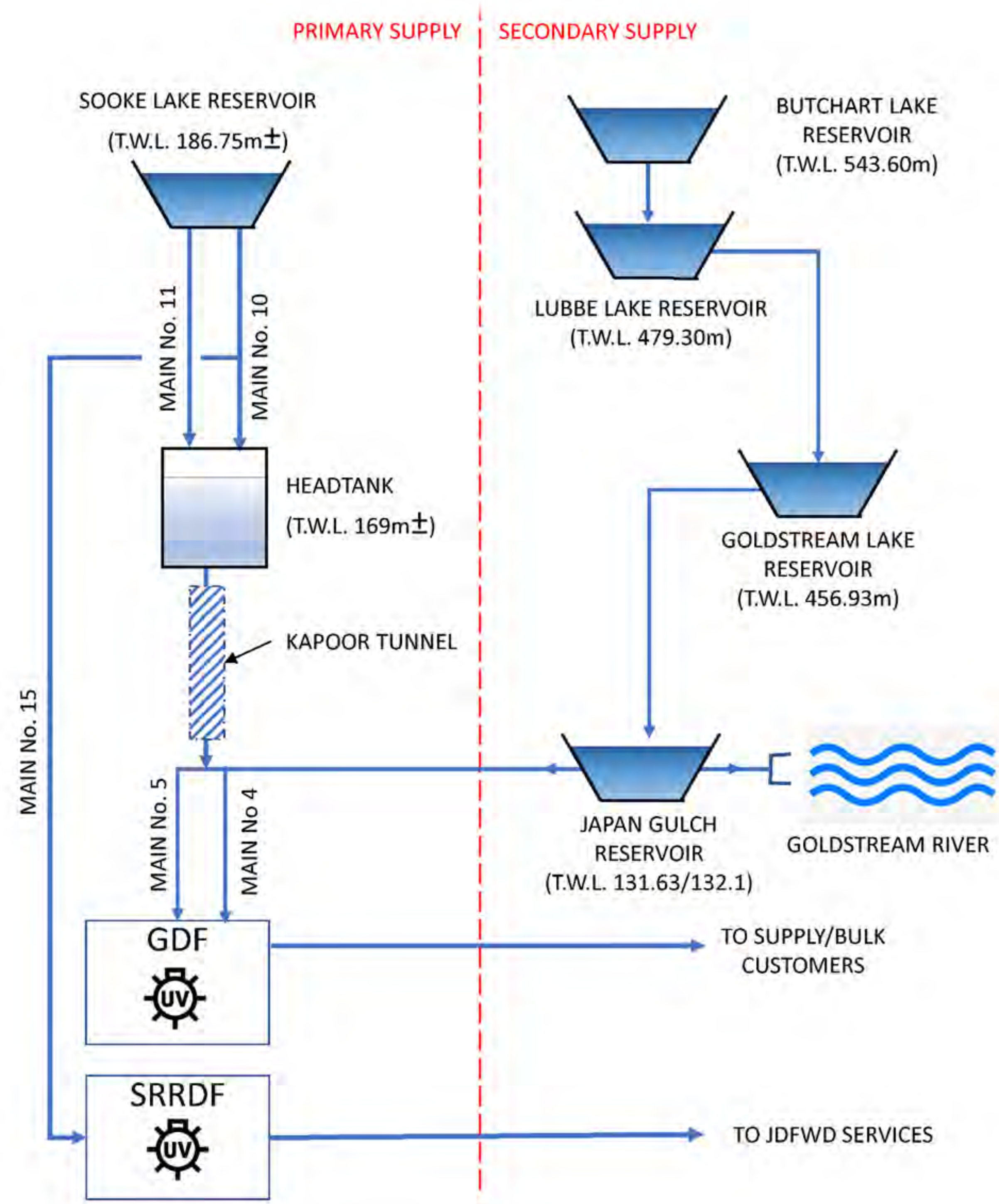


Figure 6.1: RWS Simplified Supply Schematic

6.1.1 Level of Service

The RWS 2017 Strategic Plan[1] recommended that the strategic priorities and actions in the RWS be established for the 2050 planning horizon. For this 2022 Master Plan, the 2025, 2038 and 2050 planning horizons are also considered.

Although the existing RWS system performs well, currently most local municipalities that operate their own distribution system, except for JDFWDS, generally do not have storage for their distribution networks and rely on the hydraulic capacity of the CRD transmission mains and CRD-owned storage tanks to meet maximum day, peak hour, and emergency fire demands. This approach requires that transmission system be oversized to meet these high demands which is not cost effective in the long term and requires continual unnecessary upgrading of the transmission system to meet these high demands. In most jurisdictions where regional water transmission facilities are operated to supply bulk water to customers, emergency flows, fire flows and peak hour flows within the municipal pressure zones are typically provided by the municipal tanks, pump stations and distribution systems. The regional bulk water provider's transmission system supplies up to the maximum day demand at transfer points to the municipal system.

Long term RWS planning would benefit by having level of service agreements between the CRD and individual municipalities, which clearly outline water supply parameters for each municipality at the boundary limits. Typically, the LoS is defined as flow and Hydraulic Grade line (HGL) for Average Day Demand (ADD) and Maximum Day Demand (MDD), at transfer points between the RWS system and the local municipal distribution system. The flow requirements change over time and are estimated by the local municipalities and communicated to the CRD. The HGL LoS do not typically change with time. Peak hour and emergency fire demands are typically provided from storage within the municipal systems because in the long term it is not cost effective to provide them directly from the bulk water providers transmission system. The LoS agreements could include provisions for short term changes in supply pressure to enable operational flexibility of the RWS transmission system.

Establishing flow and HGL metrics would provide all municipal customers with set boundary conditions to design downstream infrastructure. The CRD would then be able to optimize its long-term capital improvement planning process.

Potential contents for drafting a LoS agreement for the RWS would include the following :

- The CRD will maintain water quality to the transfer points within the requirements established by IHA under the Drinking Water Protection Act and Drinking Water Protection Regulation.
- Each municipality would review their specific flow requirements every 5 years and advise CRD of any changes.
- Provision of an established maximum day demand flow and HGL (pressure) at the transfer points to each municipality. The flows would be established based on historical water use and allowances for future demands calculated by IWS based on assessment of planned community growth. The costs for upgrade of the CRD transmission system

[1] Capital Regional District RWS Strategic Plan, 2017

and the growth component of the filtration plant could be covered by future Development Cost Charges for growth related capital improvements or rate structure tariffs to recover costs to pay for improvements to the RWS.

- Municipalities would actively participate in demand management initiatives including efforts to reduce long-term water consumption within their respective municipalities.
- The municipalities would be responsible for providing peak hour balancing storage, fire storage, emergency storage, distribution, and any required pumping within their municipal boundaries.
- The final water service criteria would be documented in a signed LoS agreement with each municipality.

6.1.2 Sooke Lake Reservoir Intake

6.1.2.1 History

The Sooke Lake Intake Tower was constructed in 1970 when the Sooke Lake Dam was constructed. The height of the Intake Tower was increased in 1991 by an extension of 6.2m to the concrete tower and a new mechanical room was constructed on top of the tower. In 1991, the existing generator/electrical room was equipped with a rotary-phase generator.

In 2002, the dam was enlarged and raised, and the Sooke Lake Reservoir top water level was raised by approximately 6m. The access bridge to the tower was reconstructed in 2002 using part of the bridge structure (span closest to the tower) from the original 1970 construction.

6.1.2.2 2016 Intake Tower Assessment

Stantec performed a structural condition assessment of the Sooke Lake Intake Tower in 2017. The structure was determined to be in good condition. The steel stairs and concrete walls in the drywell require annual inspection and minor repairs.

The Intake Tower structure was analyzed against the British Columbia Building Code (BCBC 2012) and the National Building Code (NBC 2015). It was determined that the Intake Tower did not meet the post-disaster requirements specified in the NBC 2015. Stantec concluded that the Intake Tower has a higher seismic capacity than typical structures built in the 1970's and was found to have a capacity of approximately 85% of the NBC 2015 "normal" importance seismic load. Based on the (relatively) high seismic capacity, Stantec did not recommend prioritizing the Intake Tower structure for a seismic retrofit.

The intake tower was upgraded with new travelling screens and other improvements in 2021.

6.1.2.3 Water Supply Reservoirs

The RWS is fed from the Sooke Lake Reservoir. Water from the SLR flows to a nearby downstream Head Tank through Main No. 10, a 1,200 mm diameter steel pipe and Main No.11, a 1,200 mm diameter concrete pipe, which parallel one another. The pipe bridge across the existing spillway channel that supports these mains underwent a seismic retrofit in 1999.

Mains No. 10 and No. 11 also serve to supply water to Main No. 15, a 600 mm diameter PVC and ductile iron pipe constructed in 2009, which is the only main servicing the Sooke River Road Disinfection Facility (SRRDF), also constructed in 2009. The SRRDF provides disinfected water for the CRD's JDFWD system.

The Head Tank is the entry point to the Kapoor Tunnel, the principal transmission conduit for the RWS excluding the JDFWD system which is supplied by a separate Main No.15. The 8.8 km long Kapoor Tunnel is 2.3m diameter and conveys water to an outlet point upstream of the Japan Gulch Reservoir (JGR), where it connects to Main No. 4 and Main No. 5. The hydraulic capacity of this tunnel is estimated to be 682 MLD based on headloss and velocity considerations and could serve the CRD well beyond the 2050 planning horizon to approximately the year 2100 MDD, provided additional source water is developed from Leech and demand conservation continues to lower water consumption. When the tunnel is out of service, the CRD uses the JGR system to supply the RWS, but the JDFWD system is uninterrupted.

The following is a list of source water reservoirs within the RWS:

- Sooke Lake Reservoir – Top Water Level of 186.75 m (controlled by a spillway weir crest) and a storage volume of 92.7 Mm^3. This reservoir is the primary source of water for the RWS.
- Secondary Source Reservoirs include:
  - Butchart Lake Reservoir – Top Water Level of 543.60 m and a storage volume of 3.3 Mm^3. This reservoir feeds into the Lubbe Reservoir.
  - Lubbe Lake Reservoir – Top Water Level of 479.30m and a storage volume of 3.0 Mm^3. This reservoir feeds into the Goldstream Reservoir. The Lubbe Dam No. 4 underwent remediation works in 2020.
  - Goldstream Lake Reservoir – Top Water Level of 456.93 m and a storage volume of 3.6 Mm^3. This reservoir feeds into the Japan Gulch Reservoir.
  - Japan Gulch Reservoir – Top Water Level of 132.1 m with flashboards it has a storage volume of 81 ML. It has a Top Water Level of 131.63 m without flashboards and a storage volume of 80ML. This reservoir feeds into Main No. 4. The JGR is operated without flashboards 98% of the time. Japan Gulch Reservoir TWL controls the hydraulic gradient to the RWS when Kapoor tunnel is out of service for inspection and maintenance. When the RWS system is operating on Japan Gulch the HGL is reduced by 37m (169-132m).

All four Goldstream reservoir volumes combined account for 10 Mm^3 or approximately 10.5% of the SLR's available storage volume (92.7 Mm^3). This storage is a good secondary source and provides supply during maintenance of Kapoor Tunnel as well as short-term emergency use.

6.1.2.4 Flow and Hydraulic Grade Line Calculations

As part of this 2022 Master Plan population and demand forecasting for long-term planning of the water supply to the year 2100 has been completed, including demands for the 2050 planning horizon established for this study. GeoAdvice was retained by CRD in December 2020, to undertake a hydraulic capacity assessment of the RWS transmission system. The GeoAdvice study also assessed the capacity of the RWS transmission system to meet water supply requirements through the 2050 planning horizon, consistent with this study. Since this study was recently completed, it serves as useful information and input into development of transmission system upgrades for this 2022 Master Plan. Stantec has not completed any hydraulic modeling as part of this study since this was not part of the terms of reference for this study due to the recently completed GeoAdvice study. Stantec have reviewed the GeoAdvice report and find it to be consistent with modeling reports for water system hydraulic evaluation. The findings and recommendations of the GeoAdvice report have been used to develop the transmission system capital improvements for this 2022 Master Plan.

As part of the population and demand projections for this 2022 Master Plan, Stantec recommends using a mid-range annual growth rate of 1.25% to estimate future demand growth (see Section 3). GeoAdvice used 1.00% annual growth rate in their hydraulic assessments. The 1% growth rate for the GeoAdvice projections was obtained from a CRD commissioned BC Stats report. For consistency, the population and flow projections used by GeoAdvice are used only for the transmission system hydraulic assessment in this study because modeling results are available for this growth rate scenario. Should the population increase of 1.25%, as used for long term projections in this 2022 Master Plan, be realized, the implication is that capital works improvements associated with transmission improvements would be required sooner. Regular review of water demands will determine if any of the recommended works in this 2022 Master Plan need to be completed earlier.

GeoAdvice calculated the Maximum Day Demand using a peaking factor of 2.0. The Average Day Demand per capita rates for each municipality were taken from the *Population and Per Capita Demand Projections for Hydraulic Capacity Study*[2], for 2019-2038. For hydraulic assessment, Maximum Day Demand calculated by GeoAdvice to assess the transmission system as outlined in **Table 6.1.**

Table 6.1: Maximum Day Demand Projections

Flow Demand	2020	2025	2038	2050
Maximum Day Demand (L/s)	2,590 L/s	2,721 L/s	3,065 L/s	3,469 L/s

Table A-6.2 (Appendix A) summarizes the estimated minimum, maximum and average HGLs at the service connection points (modeling nodes) to the RWS. Model runs were also completed to assess the performance of the transmission system when Kapoor Tunnel is taken out of service. Table A-6.2 also summarizes the existing transmission system performance from the GeoAdvice report for 2018 demands. The Kapoor Tunnel – Out of Service scenario provides HGL performance when the Kapoor Tunnel is out of service and the system driving head is reduce to the 132m TWL of the Japan Gulch Reservoir.

[2] Capital Regional District, 2020

6.1.3 Transmission Main Recommended Upgrades

6.1.3.1 Recommended Upgrades

The Hydraulic Capacity Assessment report by GeoAdvice included a hydraulic analysis of the transmission mains to estimate the existing level of service defined by the 2018 MDD (Table A6.2 – Appendix A) as well as demand and hydraulic gradeline to the 2050 planning horizon. The Kapoor Tunnel "out of service" hydraulic operating scenario is an infrequent event and only occurs during inspection of the tunnel when the transmission is supplied by the Goldstream Watershed via Japan Gulch Reservoir. It is useful for assessing the sensitivity of system hydraulics when operating at a lower hydraulic gradeline driven by the top water level of 132m in Japan Gulch Reservoir.

Table 6.3 lists the recommended improvments. Deficient mains were generally indicated as mains having significant headloss greater than 2.5 m/km. **Figure 6.2** illustrates the deficieint segments of the transmission mains identified in the GeoAdvice report that have excessive headloss.

To maintain the flow capacity and HGL in the RWS transmission mains to the 2050 design horizon, various improvement options were identified by GeoAdvice to mitigate identified deficiencies including:

- Replacing deficient sections of transmission mains with larger diameter mains. Deficient mains were generally indicated as mains having significant headloss greater than 2.5 m/km.
- Twinning deficient sections of transmission mains to provide redundancy to critical mains and increase hydraulic capacity.
- Increasing operating pressure.
- Installing new transmission mains or introduce interconnections to improve redundancy and looping.
- Providing additional storage for system balancing and maintaining HGL during emergencies and out-of-service scenarios.

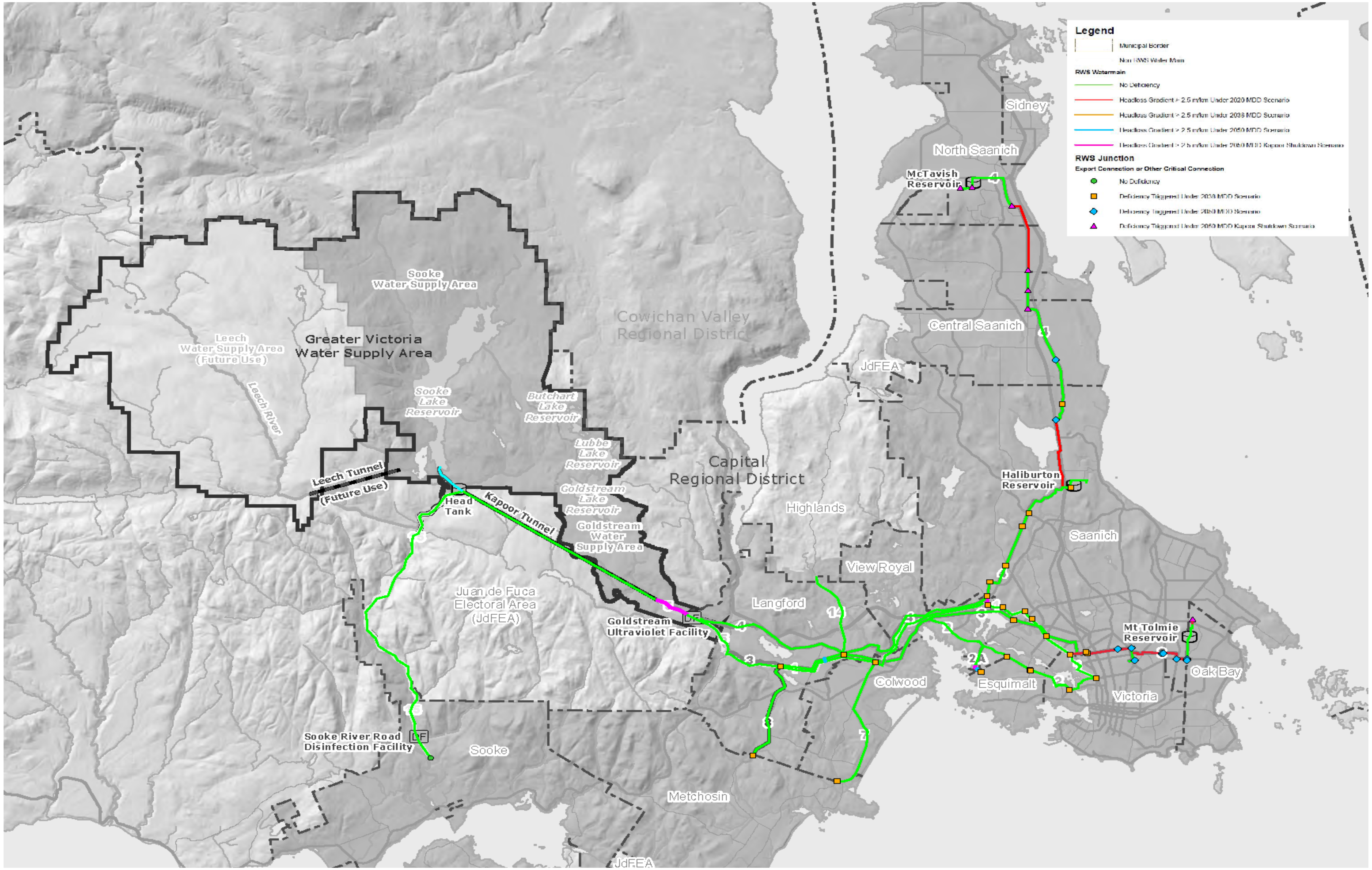


Figure 6.2: RWS Transmission Mains Hydraulic Capacity Deficiency Summary

The upgrades listed in **Table 6.3** were recommended by GeoAdvice to mitigate identified hydraulic capacity deficiencies and have not been independently confirmed by Stantec because GeoAdvice work was current and completed in 2020. The GeoAdvice work is consistent with good engineering practice for similar studies. A four-phase program of transmission system improvements starting in 2025 and completion by 2050 was recommended. **Figure 6.3** provides a location map of the proposed improvements listed in **Table A-6.2 (Appendix A)**.

Table 6.3: Recommended RWS Transmission Improvements

Option	Phase 1 - Implementation Recommended by 2025	
M7	Watkiss PCS Upgrade	Upsize inlet to 1,050 mm ø and outlet piping to 1,200 mm ø for both No. 1 and No. 4 Mains.
		Decommission existing Watkiss PCS lead PRV and replace with two 600 mm diameter lead PRVs.
		Revise downstream HGL settings for lead Watkiss PRVs to 105.5 m.
	Increase HGL of Main No. 1 from 116m to 169m	Implement valving changes along the length of Main No. 1, from Humpback PCS to Watkiss PCS.
		Install five (5) new PCSs to provide redundancy to Main No. 3 and to maintain existing connections with the JDFWD. • Irwin Road & Creekside Trail, connecting Main No. 1 to JDFWD 116 m pressure zone • Glen Lake Road, connecting Main No. 1 to Main No. 8 • Rex Road & Jacklin Road, connecting Main No. 1 to Main No. 3 and JDFWD 116 m pressure zone • Goldstream Avenue & Whitehead Place, connecting Main No. 1 to Main No. 7 • Atkins Road & Traverse Terrace, connecting Main No. 1 to JDFWD 116 m pressure zone
		Revise setpoint of the Millstream PCS lead PRV to achieve downstream HGL of 114 m.
Option	**Phase 2 - Implementation recommended between 2025 and 2038, recommended by 2030**	
M8	Implement part 1 Main No.4 Upgrades	Upsize 4.6 km of pipe to 1,350 mm ø from Goldstream Avenue at Veterans Memorial Parkway to the Watkiss PCS Inlet. Transmission mains upsize should consider longer term planning horizon of at least 75 years.
	Add 3rd Main from Sooke Lake to Head Tank	Install 1,200 mm ø main from Sooke Lake Reservoir to Head Tank to provide increased capacity and redundancy.

Option	Phase 3 - Implementation recommended between 2038 and 2050	
M9	Implement part 2 of Main No.4 Upgrades	Upsize 6.3 km of pipe to 1,500 mm ø from Niagara Main (near Goldstream Disinfection Facility) to Goldstream Avenue at Veterans Memorial Parkway. Transmission main size should consider longer term planning horizon of at least 75 years.
Option	**Phase 4 - Implementation recommended by 2050 planning horizon**	
M10	Twin Critical Main No. 3	Twin 4.6 km of Main No.3 (813/991mm diameter) from Dupplin Road at Tolmie Lane to Lansdowne Road at Foul Bay Road to address capacity.
M11	Twin Critical Main No. 4	Twin 2.6 km of Main No. 4 (743mm diameter) from the old connection with Haliburton Tank to Patricia Bay Highway at Hamsterly Road.
		Twin 3.1 km of Main No. 4 (610/762mm diameter) from Central Saanich Rd at Mount Newton Cross Road to Aldous Terrace at Lowe Rd.
		Twin 0.6 km of Main No. 4 (1,219/1,321mm diameter) for redundancy from the connection with Goldstream Supply Area to the Goldstream Disinfection Facility inlet or add a connection from Goldstream Supply Area directly to Main No. 5, which would remain normally closed except under emergency situations.

Table A-6.4 (Appendix A) shows a comparison of the expected HGL at connection points at the projected 2050 Maximum Day Demand flows before and after the recommended RWS transmission system improvements.

If the proposed transmission main from Goldstream Lake Reservoir to Japan Gulch, as identified in the 1994 Plan, were installed to maintain 169.0 HGL when Kapoor Tunnel is out of service, approximately 20% (9 of 50) deficiencies would be resolved. The majority of the HGL service level deficiencies at the connection nodes are caused by excessive headloss in the transmission mains.

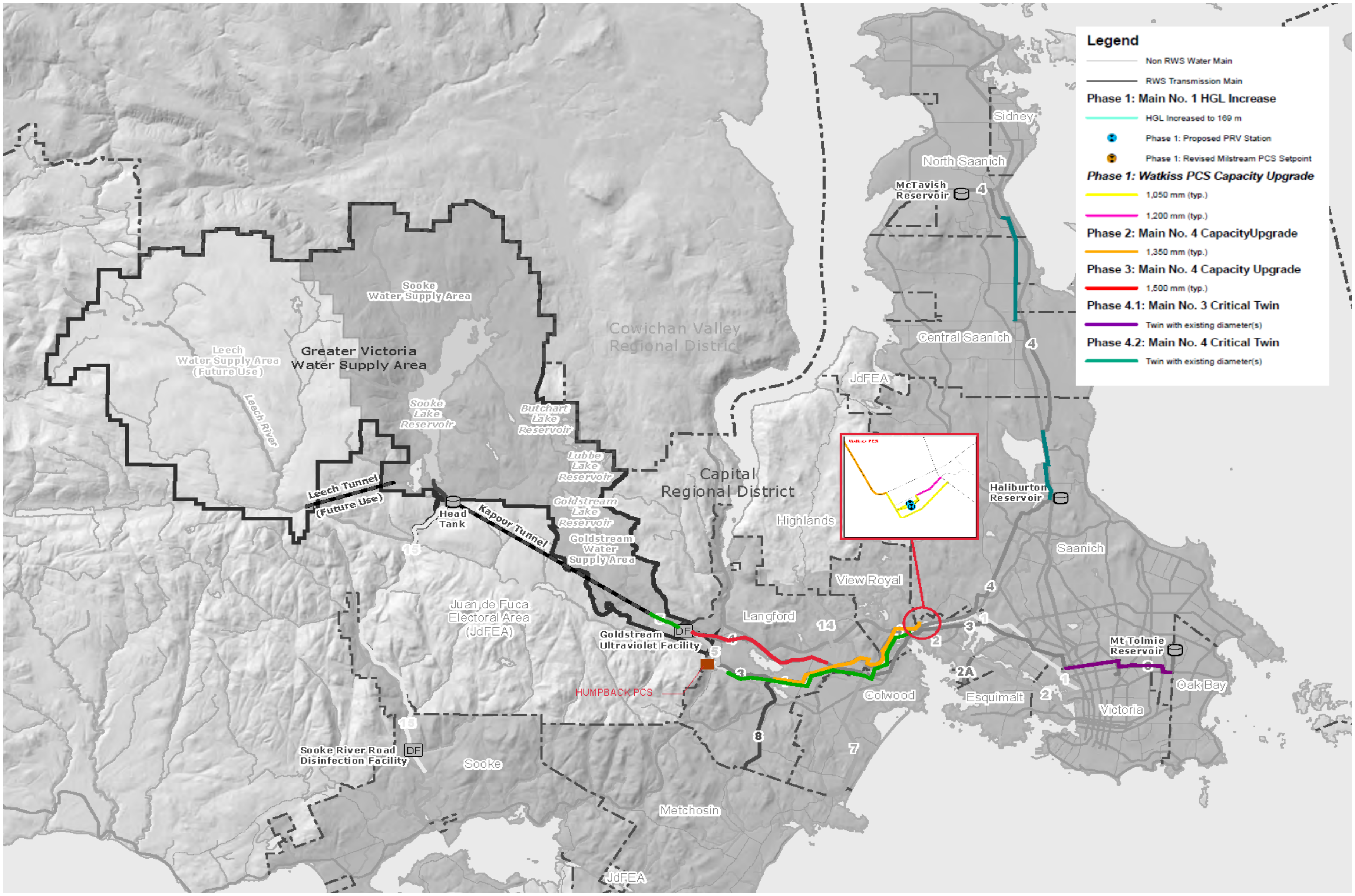


Figure 6.3: RWS Transmission Mains Recommended Improvements

Table 6.5 shows the number of nodes (at customer transfer points) with deficient HGL before and after the recommended transmission main improvements. There are 50 transfer points to the RWS. Without the improvements, 42 connection points will have deficient HGL by 2050. The recommended improvements will reduce the number of deficient connections to three and the level of deficiency is minor.

Table 6.5: HGL Deficiencies at Export Locations Before and After Recommended Upgrades Under MDD

Criteria	2020	2025	2038	2050	2050*
	Number of Deficient Nodes				
At export connection to customers – before recommended upgrades	0	0	31	42	49
At export connection to customers – after recommended upgrades	0	0	2**	3**	1**

*System operating at Japan Gulch HGL

**Assumes 1.0% annual demand growth rate

**Extremely minor head loss variations (< 1m) occur at connections with JDFWD at Mains No. 8 and 14. Open connections to JDFWD maintain in excess of 40 psi.

6.2 TRANSMISSION SYSTEMS DEVELOPMENT

6.2.1 Redundant Supply Options

6.2.1.1 Proposed Deep Northern Intake

Stantec has undertaken a feasibility assessment (see Section 4.5.1 and 5.2.2) of a proposed Deep Northern Intake location at Sooke Lake Reservoir to access the deeper zones of the north basin as well as assessment of a redundant conveyance system for Kapoor Tunnel. This option was identified in the 1994 Plan. Several options were identified for the intake location as part of this 2022 Master Plan. The assessment of raw water transmission system options from the proposed intake requires evaluation of alternative conveyance alignments to the site of the proposed water filtration plant at Japan Gulch Reservoir.

The proposed intake could be constructed using a micro tunneled lake tap where a pressurized face micro-tunnel boring machine (MTBM) would be launched from a shaft on land and mined into the lake at the necessary elevation. The pumps would be installed at the shore with the tunnel shaft used as the wetwell. The proposed intake could be connected to CRD's existing transmission system via a proposed redundant transmission pipeline or tunnel or via connection to the existing Kapoor Tunnel at the Head Tank.

A second option that was investigated uses a floating pumping station. The floating pump station would be constructed on a barge platform with a pedestrian/utility bridge to shore, similar to the Sooke Lake intake tower. Pump suctions or cans with fixed screens would have to be used or an adjustable intake system would be required to enable withdrawal from lower depths of the reservoir. The system would be more cost effective if a lower level of hydraulic service capacity is provided because pumps and transmission pipeline would be smaller. The estimated cost of this option is $55.8M based on the recently constructed Seattle Public Utilities Morse Lake Floating Pump Station project which has similar capacity to the required pumping capacity for the Deep Northern Intake pump station.

6.2.2 Sooke Lake Reservoir Raw Water Transmission Options

As part of the *Deep Northern Intake, Transmission and Treatment Study* (Stantec 2021), five (5) options were assessed to convey water from a second intake in Sooke Lake Reservoir to a proposed Water Filtration Plant (WFP) near the Japan Gulch Reservoir (JGR). The options include gravity options similar to the Kapoor Tunnel, a combination of pumped and gravity options and entirely pumped options. For the pumped options, 3 phase power will have to be extended to all pumping station sites. Ideally, these power lines should be located underground in duct banks to provide better resiliency and reduce potential damage from falling trees or wildfires. The tunnel and pipeline routes are conceptual level options and detailed route assessments would be required as part of any preliminary design and would include geotechnical evaluation, seismic performance assessment and the location of active fault lines. A description of each option is provided below.

For transmission options from SLR to the proposed water filtration plant a planning horizon to the year 2100 is considered because of the design life of transmission mains and tunnels are in the 75 to 100 year range.

6.2.2.1 Option A: Proposed Gravity Tunnel

A proposed tunnel from the proposed Deep Northern Intake, similar to the Kapoor Tunnel, is an option for conveying water from the proposed Deep Northern Intake to a potential water filtration plant site at Japan Gulch. Option A consists of a 2,900 mm diameter tunnel to convey raw water at year 2100 Maximum Day Demand by gravity to the proposed water treatment plant location at Japan Gulch. The proposed tunnel length would be approximately 13 km as is shown in **Figure 6.4.**

While construction methods may vary, construction using a tunnel boring machine (TBM) appears feasible. A tunnel portal could be developed at the downstream end with mining proceeding towards the intake shaft adjacent to SLR. The tunnel would be constructed at a uniform slope. The tunnel launch portal would be located to minimize or eliminate the need for intermediate shaft construction and allow for efficient access for construction materials and handling of spoils from the tunnel excavation.

The tunnel is expected to be constructed entirely in rock based on the installation depths and available geologic mapping. Subsurface exploration would be needed to characterize subsurface rock and groundwater parameters to be used for design. Seismic issues as discussed in Section 5.3.2.6 would also need to be considered during detailed design. If a sufficient length of the tunnel proceeds through sound rock with low permeability, the tunnel may be left unlined. If geologic exploration indicates high permeabilities or materials that are not sound, lining may be needed. The determination of the lengths of lined and unlined sections will be determined during detailed design. The cost estimate for this option for this study was based on a fully lined tunnel for the entire 13 km.

Flow through the tunnel would be controlled by a flow control valve(s) located near Japan Gulch at the headworks to the treatment plant. Redundancy for the control valve(s) would be required as well as isolation valves so that flow can be stopped in the event of an issue with the control valves. Valves would modulate to maintain a setpoint flow through the plant. This type of flow control has been used at other locations including the Tolt Water Treatment Plant in Seattle and Metro Vancouver's Seymour Capilano Filtration Plant.

One of the concerns with a tunnel is that the effort required for access for inspections is significant, the tunnel must be drained, and stringent safety protocols are required for worker safety.

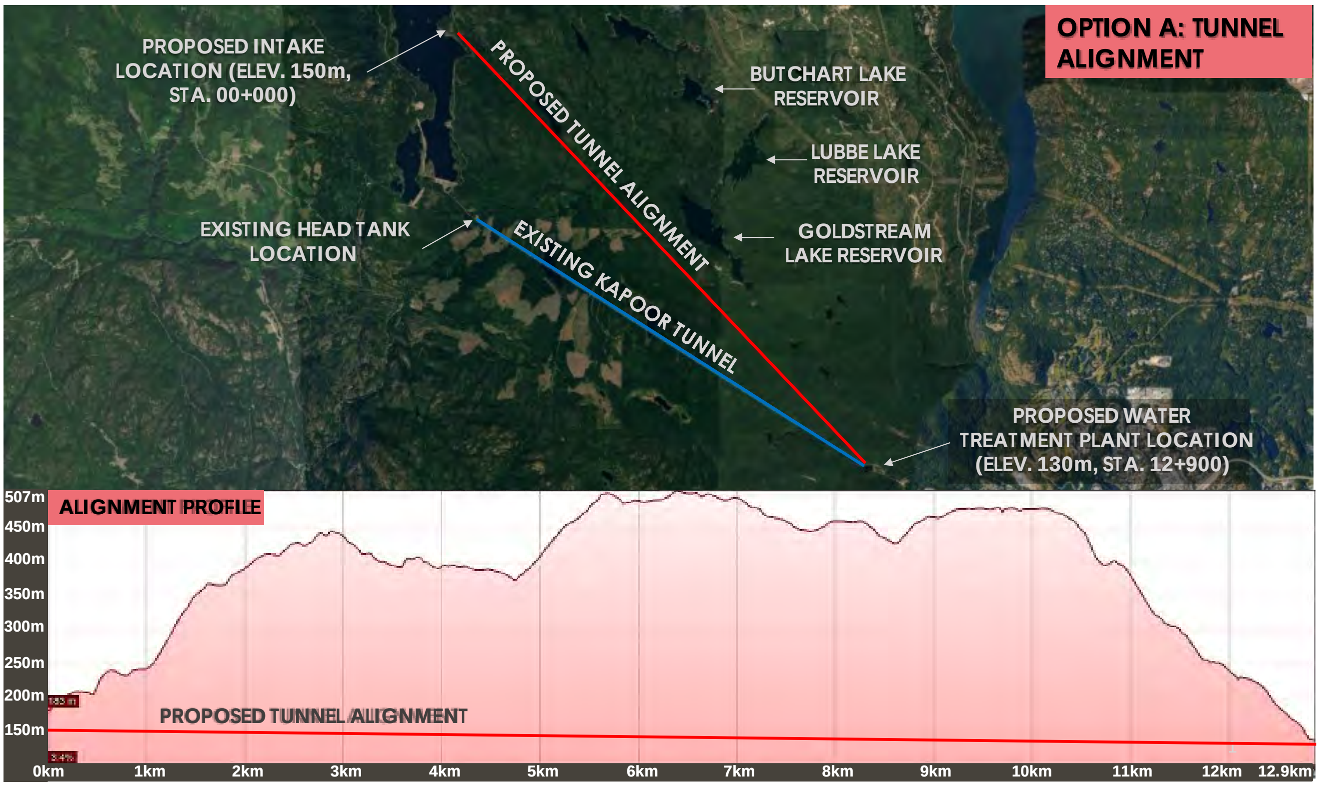


Figure 6.4: Option A – Proposed Intake and Gravity Transmission Tunnel

6.2.2.2 Option B: Proposed Overland Transmission Main Route Through Leechtown and Jack Lake

Option B consists of a 20 km, 2,400 mm diameter, open cut, buried transmission main and a series of pump stations following an overland route from the proposed Deep Northern Intake to the proposed water filtration plant at Japan Gulch. This option requires high combined horsepower pumping and has high annual operating costs due the static head on the pumps. This option was previously investigated in the 1994 Plan (Alternative A). Potential for some energy recovery would exist with this option but the recovered energy would be insufficient to pay for the operating costs of the pump stations. A sub option of this option B is to size a transmission main and pump system for emergency use only with capacity to service average day demand (377MLD) for the year 2100. The emergency use only option would require a smaller transmission main diameter of 2000 mm diameter for the 2100 ADD and would only be operated during planned outages of the Kapoor Tunnel or emergencies, thereby saving significant power costs.

Proposed Alignment

The proposed alignment follows existing service roads where possible as they are currently used to access the Sooke Lake Dam and SLR. This approach reduces the number of cut and fill areas required minimizing the cost associated with clearing, grubbing, and construction of new access roads. The roadways would be improved to a higher standard to allow improved access during inclement weather conditions. **Figure 6.5** shows the proposed alignment.

Starting from the proposed deep northern intake, the alignment parallels the eastern edge of Sooke Lake Reservoir, passes adjacent to the existing Head Tank, then turns south towards Leechtown before veering east and starting a steep incline that peaks at an elevation of 427 m. From there, the overland route follows a ravine between two access roads west of Jack Lake and continues along an access road on the northern shores of Jack Lake. The alignment follows a steep gully which brings the alignment from an approximate elevation of 290 m down to the final elevation of the proposed Japan Gulch water filtration plant at approximate elevation 130 m. There may be land ownership issues with this alignment that will need to be considered during the detailed design of this option.

The proposed alignment would allow for construction in a phased approach and allows for connection of a third main from the existing Sooke Lake Intake Tower to the Head Tank and provides and strengthens redundancy of the existing water supply system. The second phase would involve extension of the transmission main from the Head Tank to Japan Gulch. By establishing the proposed transmission main alignment adjacent to the existing Head Tank, a connection could be introduced to provide the option of conveying water from the proposed Deep Northern Intake to the entrance to Kapoor Tunnel. Another option for consideration is to bring the transmission main to Cabin Pond and then run the transmission main along the alignment of the previous power house penstock which followed an alignment to Japan Gulch.

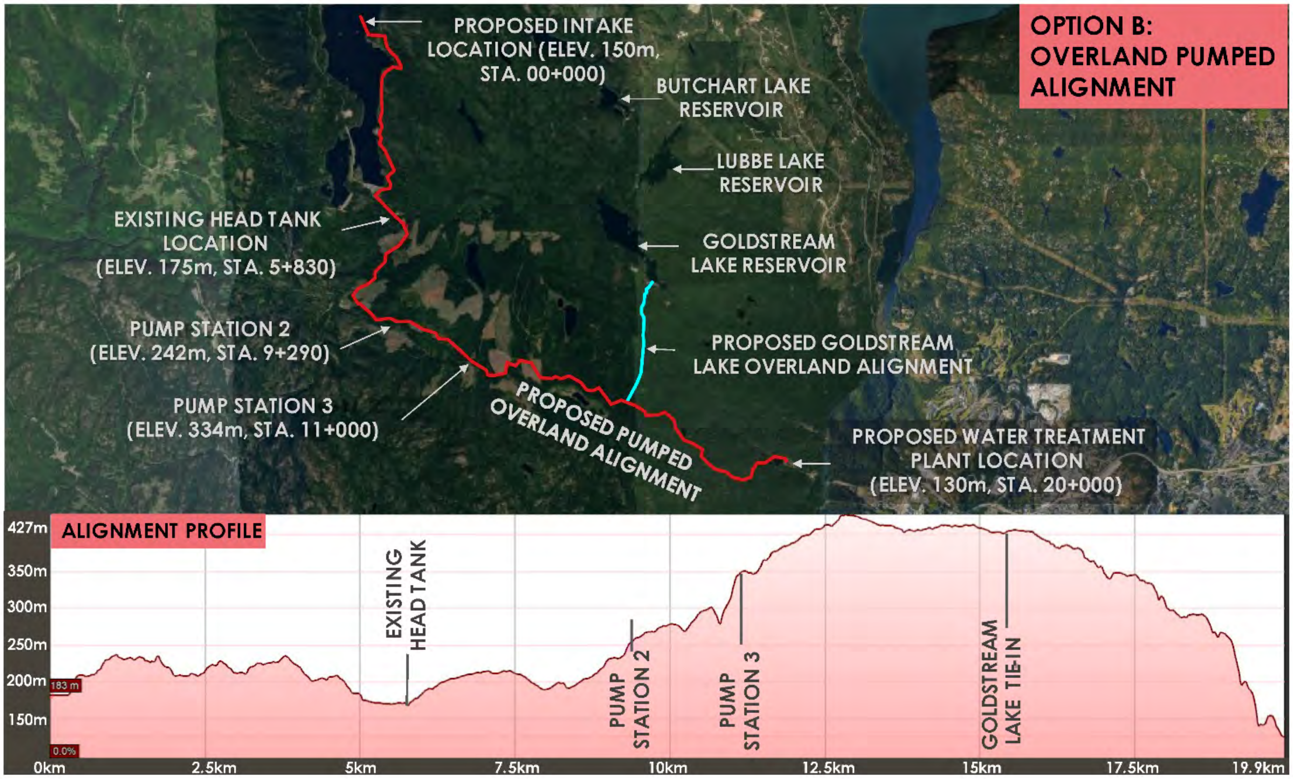


Figure 6.5: Option B – Overland Pumped Route – Jack Lake

Proposed Pump Stations

A 2,400 mm pipe diameter is required to convey the 2100 MDD using a roughness coefficient of 130. This main size can be reduced if the CRD wants to reduce the level of service with reduced flow capacity.

When analyzing the hydraulic profile of this alignment, net elevation rise between the proposed intake elevation (150m) and the highest anticipated point along the alignment (427m) was determined to be 277m. This static head (277m) is generally too great for a single pump station unless specialized high head pumping equipment, thicker wall steel pipe and high pressure valves are used, which is costly. One or more intermediate pump stations are recommended. Pumping head and total horsepower would be similar for a single or multi series pump system.

Stantec recommends that the maximum Total Dynamic Head (TDH) for a water pump station be limited to 100 m. Three pump stations are required to maintain the TDH below 100 m. **Table 6.6** summarizes the hydraulic characteristics of the three pumps stations**.** A low water level in SLR has been assumed at 160 m for preliminary sizing. **Figure 6.5** shows the proposed locations for the pump stations.

Table 6.6: Option B Pump Station Hydraulics

Node	Elevation (m)	Station (m)	Total Dynamic Head (m)	Required Shaft Horsepower (HP)
Sooke Lake Reservoir Intake PS1 (Floating Pump Station or land based fixed Pump Station)	160	00+000	91	13,134
Pump Station 2 on Figure 6.5	242	09+300	94.0	13,540
Pump Station 3 on Figure 6.5	334	11+000	95.0	13,726
WFP Headworks	130	20+000		

High Voltage power (14.4 kVA) will be required for each pump station. The existing power supply to Sooke Lake Reservoir is not adequate for the high horsepower pumping electrical demands. Based on the estimated horsepower requirements for the three (3) proposed pump stations, a separate power supply and substations would be required. The new power supply to the Sooke Lake Reservoir intake could be underground to ensure reliability depending on cost. Underground power supply would be in a concrete encased duct bank due to the high voltage. Overhead could also be considered but the power supply lines would be more vulnerable in the event of trees falling during storms or during a wildfire.

A sub-option of Option B, referenced as Option B1 is to provide a lower level of service and supply the 2100 ADD using a single pump station rather than multiple pump stations. This option would provide an adequate level of service during emergency condition should there be an issue with the Kapoor Tunnel. This option results in a shaft horsepower requirement of 23,733 HP.

6.2.3 Goldstream Reservoir Connector (1994 Plan, Alt A, a2)

The 1994 Plan explored an option of connecting the Goldstream Lake Reservoir system to Japan Gulch Reservoir. This option has a initial intake from the the existing high level overflow channel in Goldstream Lake Reservoir and also connects the Lubbe Lake Reservoir, and Butchart Lake Reservoir system to the proposed pumped Jack Lake overland transmission main alignment.

Figure 6.6 shows the alignment of an overland pipe from Goldstream Lake Reservoir to overland Jack Lake alignment. This option requires an intake into Goldstream Lake Reservoir and reduces water quality issues because the transmission main will bypass the unstable sections of the Goldstream Canyon where turbidity has been an issue in wet weather. Geotechnical and terrain assessment will be required to select the optimal route for the Goldstream Reservoir Connector.

In the existing configuration, this reservoir system flows by gravity to JGR. As shown in Figure 6.6, a 2.7 km overland gravity fed piped system could be introduced from the Goldstream Lake Reservoir at an approximate elevation 456 m down to a proposed tie in point along the proposed pumped overland route at approximate elevation of 402 m. This connection would provide additional redundancy by conveying waters from this reservoir system directly to the WTP. Another option for consideration is to bring the transmission main to Cabin Pond and then run the transmission main along the alignment of the previous power house penstock which followed an alignment to Japan Gulch. The final route selection can be determined at preliminary design.

The proposed Goldstream Connector also has other benefits for the RWS including :

- The transmission main could be operated at the 169m HGL by installation of PRVs or a Head Tank. There would be no need to operate at lower Japan Gulch Reservoir HGL (132m) when Kapoor Tunnel is out of service and other improvements or adjustments to the existing system to operate at lower HGL would not be required. This would benefit the CRD and some bulk water municipal customers (avoids operational/system changes).

- The transmission main would serve as the lower end of Jack Lake transmission main from the Deep Northern Intake.

- Once the entire Jack Alignment is constructed the pipeline could be used to reverse feed SLR to provide quicker replenishment of water levels during drought conditions.

- Once the water treatment plant is constructed, previous off catchment sources could be introduced into this pipeline to provide additional water supply.

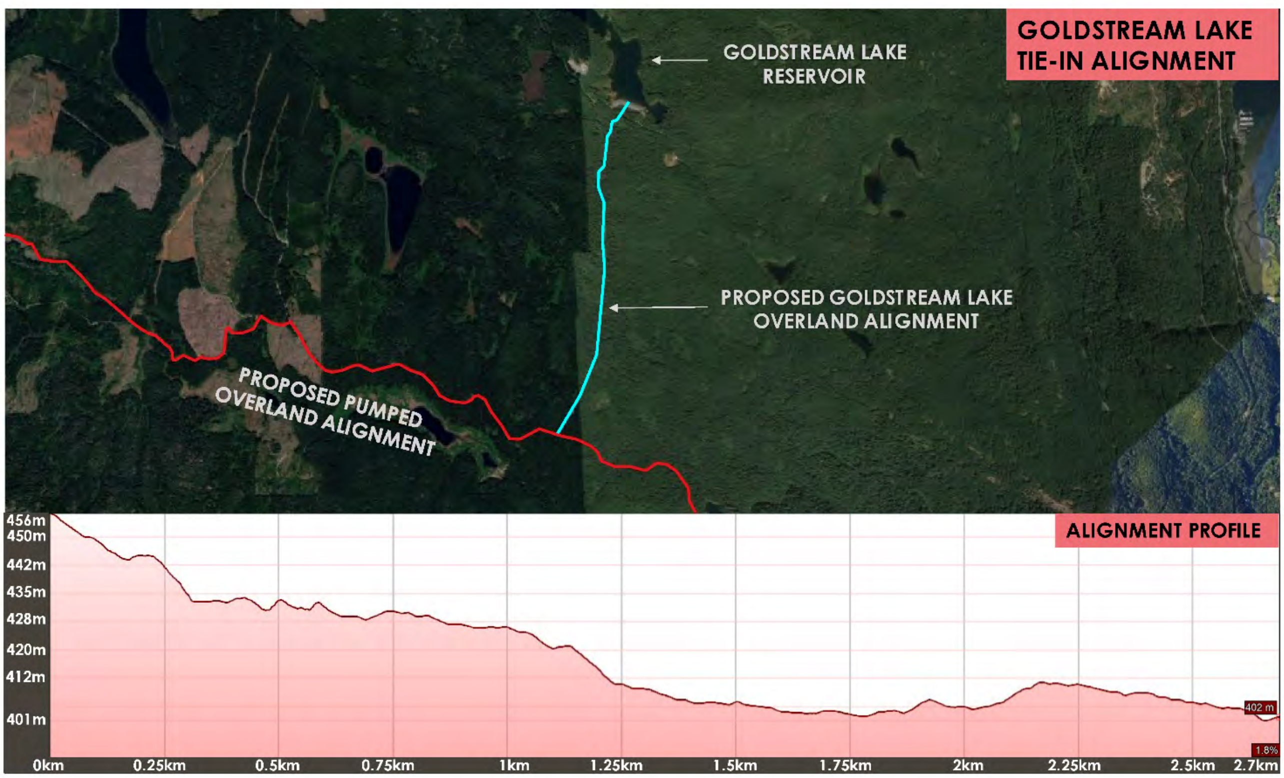


Figure 6.6: Goldstream Connector Option

6.2.3.1 Option C: Proposed Hybrid Overland Pumped Route/Tunnel

A hybrid version of Options A and B has been assessed where the proposed Sooke Lake Reservoir Deep Northern Intake pump station would be the only pump station. **Figure 6.7** shows an alignment consisting of 8.5 km of open cut, buried pipe connecting into a 9.7 km tunnel at elevation 200 m. The total length of the transmission main and tunnel is 18.2 km. This option avoids the need to pump an additional 227 m in elevation and significantly reduces the pumping horsepower.

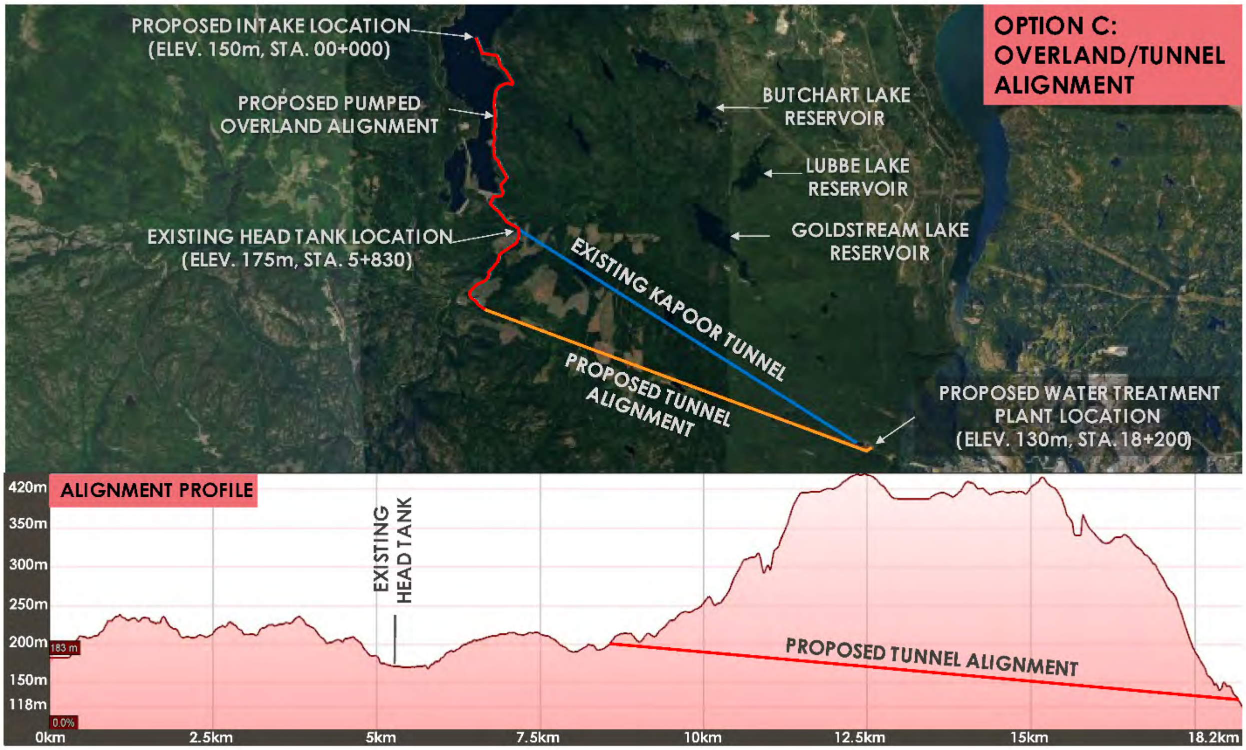


Figure 6.7: Option C – Overland/Tunnel Alignment

Table 6.7 provides additional data for this option.

This option allows for:

- A connection to the existing Head Tank from an overland conveyance pump providing additional redundancy for the existing system
- Significantly reduced pumping head, horsepower requirements and operating costs and would only require a single pumping station at the intake
- A phased construction approach with first stage consisting of connecting the proposed northern intake and transmission main to the existing Head Tank.

Table 6.7: Option C Pump Station Hydraulics

Node	Elevation (m)	Station (m)	Total Dynamic Head (m)	Required Shaft Horsepower (HP)
Sooke Lake Reservoir Intake PS	160	00+000	88	13,032
Tunnel	200	08+500	-	-
WFP Headworks	130	18+200	-	-

6.2.3.2 Option D: Proposed Overland Council Lake Alignment

Option D consists of a variation of Option B where a 17.5 km – 2,400 mm diameter open cut buried transmission main and a series of pump stations following a route from the proposed Deep Northern Intake to the Japan Gulch WTP. This option requires high horsepower pumping and has high annual operating costs. Potential for some energy recovery would exist with this option but the recovered energy would be insufficient to pay for the operating costs of the pumping stations. Another complexity of this option is land ownership along the transmission main alignment, as a significant portion of the alignment crosses land owned by private forestry companies.

The proposed alignment for this option follows existing service roads, where possible, minimizing the cost associated with clearing, grubbing, and construction of new access roads. The roadways would be improved to a higher standard to allow year-round access during inclement weather conditions. **Figure 6.8** shows the 17.5 km proposed alignment.

Starting from the proposed Sooke Lake Reservoir deep northern intake, the alignment follows an access road towards Council Lake. Approximately 2.5 km of new road construction would be required to bridge existing access roads as the alignment progresses past Council Lake. The alignment would then continue south along an existing access road toward the western shores of Jack Lake where the maximum elevation is estimated at 430m. This option mirrors the Option B alignment from Jack Lake to the proposed WTP. The proposed alignment provides no opportunity to utilize the existing Head Tank to provide redundancy to the existing water supply system via the Kapoor Tunnel.

Figure 6.8: Option D – Overland Council Lake Alignment

Goldstream Lake Reservoir Connection

The proposed Goldstream Lake Reservoir connection as outlined in Option B would be applicable for this option as this section of the proposed alignment is synonymous with that of Option B.

It was determined that 2,400mm is the optimal pipe diameter to convey the year 2100 MDD flow and maintain self-scouring velocities using a pipe roughness coefficient of 130 this pipe.

The net elevation rise between the proposed intake elevation (150 m) and the highest anticipated point along the alignment (430 m) was determined to be 280 m (static head).

CRD has requested one pump station be explored to provide the required pumping capacity to convey the 2100 MDD flow. **Table 6.8** summarizes the hydraulic characteristics of the single pump station option.

Table 6.8: Option D Pump Station Hydraulics Single Pump Station

Node	Elevation (m)	Station (m)	Total Dynamic Head (m)	Required Shaft Horsepower (HP)
Sooke Lake Intake	160	00+000	279	41,366
WFP Headworks	130	17+500	-	-

An elevation of 160 m has been selected as lowest level for pump selection condition only. Stantec recommends to not pump the SLR below elevation 177m so that it fills to full supply level during winter rains. The power supply to Sooke Lake is not adequate for the high horsepower pumping electrical demands. Based on the estimated horsepower requirements for the proposed pump station, a new separate high voltage power supply will be required. The new power supply to the Sooke Lake intake could be underground to ensure reliability. Overhead could also be considered but it would be subject to tree fall and wildfire damage.

Another variation on this option is to consider multiple pump stations versus a single pump station.

6.2.3.3 Option E: Proposed Overland Highway 1 Alignment

The proposed alignment for this option consists of a 21 km – 2,400 mm diameter open cut buried transmission main and a series of pump stations following a route from the proposed Deep Northern Intake located on the north end of SLR and over the Malahat (Highway 1) to the proposed Japan Gulch WFP. This option requires high horsepower pumping and has high annual operating costs. Potential for some energy recovery would exist with this option but the recovered energy would be insufficient to pay for the operating costs of the pumping stations. This option would also necessitate the analysis of a new intake location. A review of the bathymetry resulted in an approximate location for the new intake. This alternative location is shown in **Figure 6.9.**

The proposed alignment for this option follows existing forest service roads where possible minimizing the cost associated with clearing, grubbing, and construction of new access roads. The alignment would follow a mixture of existing access roads and trails to make this route feasible. The roadways and trails would be improved to a higher standard to allow year-round access during inclement weather conditions. **Figure 6.9** shows the 21 km proposed alignment.

Starting from the proposed Deep Northern Intake at the North end of SLR, the alignment follows an access road east towards the Saanich Inlet before turning south along the Malahat Highway. The alignment continues south passing along the eastern edge of Devereux Lake before following existing roads to the new WTP.

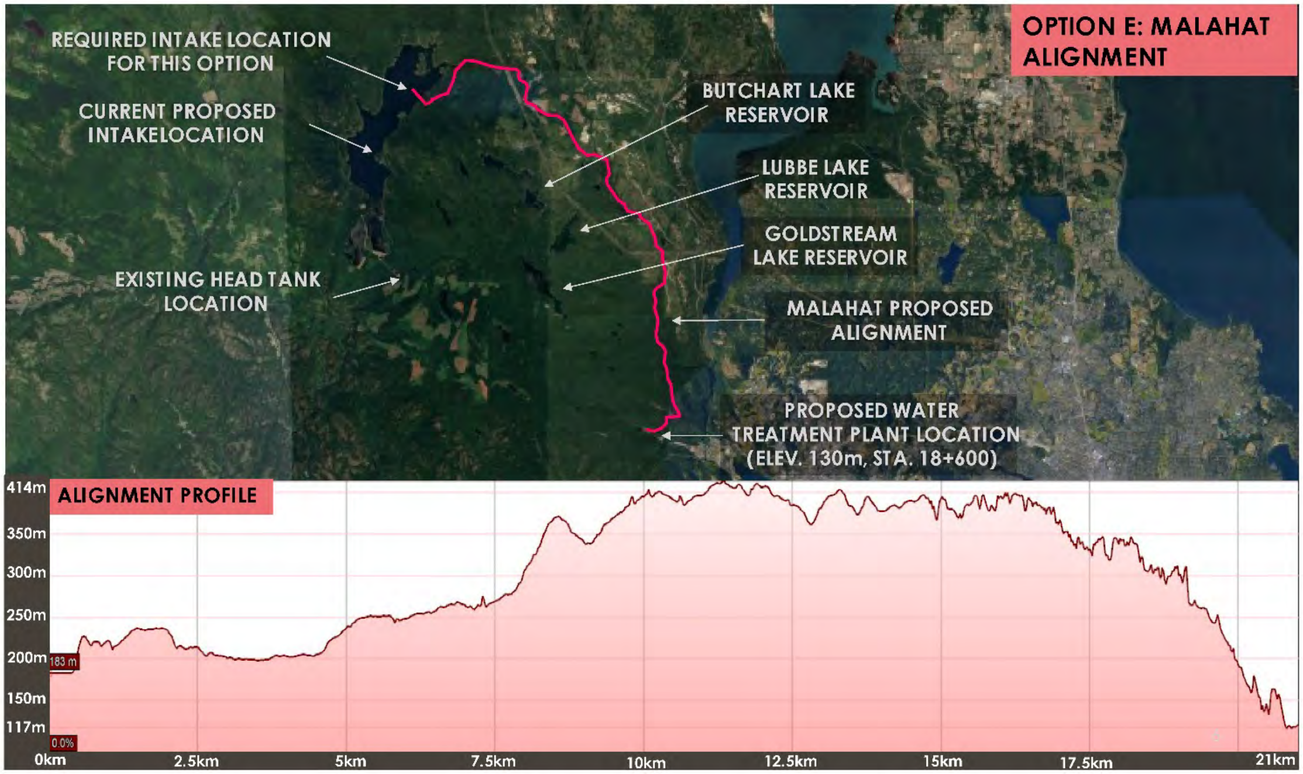


Figure 6.9: Option E – Overland Highway 1 Alignment

The estimated horsepower for this option is shown in **Table 6.9**.

Table 6.9: Option D Pump Station Hydraulics Single Pump Station

Node	Elevation (m)	Station (m)	Total Dynamic Head (m)	Required Shaft Horsepower (HP)
Sooke Lake Intake	160	00+000	279	41,366
WTP Headworks	130	21+000	-	-

6.2.4 Proposed East-West Connector

The RWS currently has two disinfection facilities in operation, the SRRDF which serves only the Sooke area, and the Goldstream Disinfection Facility (located immediately downstream of JGR) which serves the remainder of the RWS system. If a single water filtration plant is constructed at Japan Gulch, a new east – west transmission main to Sooke would be required to supply filtered water. The Sooke area would benefit from improved filtered water quality and also have redundant emergency supply access from the Goldstream supply once connected to the proposed filtration plant.

A 500 mm diameter transmission main is suitable for the 2050 JDFWDS demand only. It is recommended that the transmission main be sized at 1000 mm for a longer design horizon associated with the design life of transmission mains. Final sizing can be determined at preliminary design stage. The transmission main would convey filtered water to the Metchosin/District of Sooke municipal boundary. This main could also be used as an emergency supply main to feed (chlorinated water) water from SLR in the event there was an issue with the Kapoor Tunnel. This emergency supply option would also require twinning of Main No. 15 capacity. Although the water would be unfiltered, it could be chlorinated for emergency use if necessary.

Various alignment Options have been considered for a proposed Juan De Fuca Water District (JDFWD) transmission main:

1. Option 1 alignment follows Humpback Road starting at an elevation of 110m, continuing west along Sooke Road (Highway 14), and terminating at Sooke River Road where it would connect into the existing distribution system. This alignment is estimated to be 17.3 km and has an approximate high point of 170 m before continuing a steady descent to an approximate elevation of 16m. **Figure 6.10** shows the profile for this alignment. Booster pumping or raising of the HGL with the treatment plant low lift pumps will likely be required.

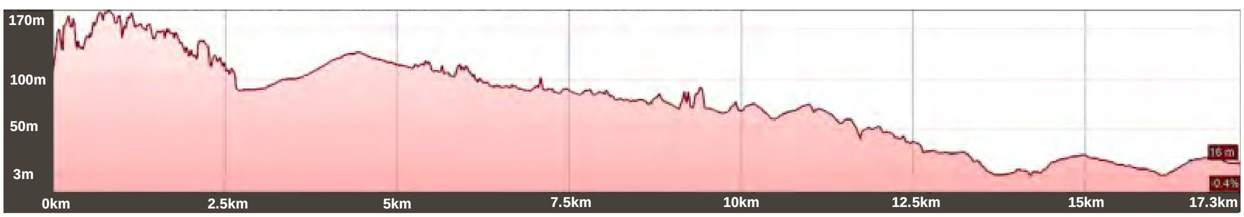


Figure 6.10: East-West Connector Transmission Main Alignment Profile – Option 1

2. Option 2 alignment follows Westshore Parkway starting at an elevation of 89 m, continuing west along Sooke Road and terminating at Sooke River Road where it would connect into the existing distribution sysem. This alignment is estimated to be 18.3 km and rises to an approximate high point of 136 m before terminating at an approximate elevation of 16 m. **Figure 6.11** shows the profile for this alignment. Booster pumping will be required on this alignment.

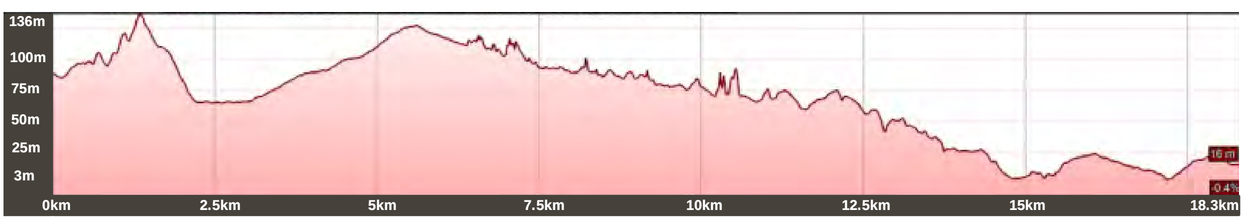


Figure 6.11: East-West Connector Transmission Main Alignment Profile – Option 2

3. The Option 3 alignment would replace Main No. 8 with a larger main and continue along Glenn Lake Road to south along Happy Valley Road, south along Rocky Point Road, west along Kangaroo Road and west along Sooke Road where this line could terminate at the Sooke River Road where it could connect into the existing distribution system. This alignment is estimated to be 23.4 km and rise to an approximate high point of 164 m before terminating at an approximate elevation of 16 m. **Figure 6.12** shows the profile for this alignment.

Figure 6.12: East-West Connector Transmission Main Alignment Profile – Option 3

Figure 6.13 shows the proposed alignment for all three options. All of these options are feasible but further studies are needed to determine to select the preferred option. For the purposes of preparing an Opinion of Probable Cost, Option 2 has been selected because the hydraulic profile will result in lower pumping costs.

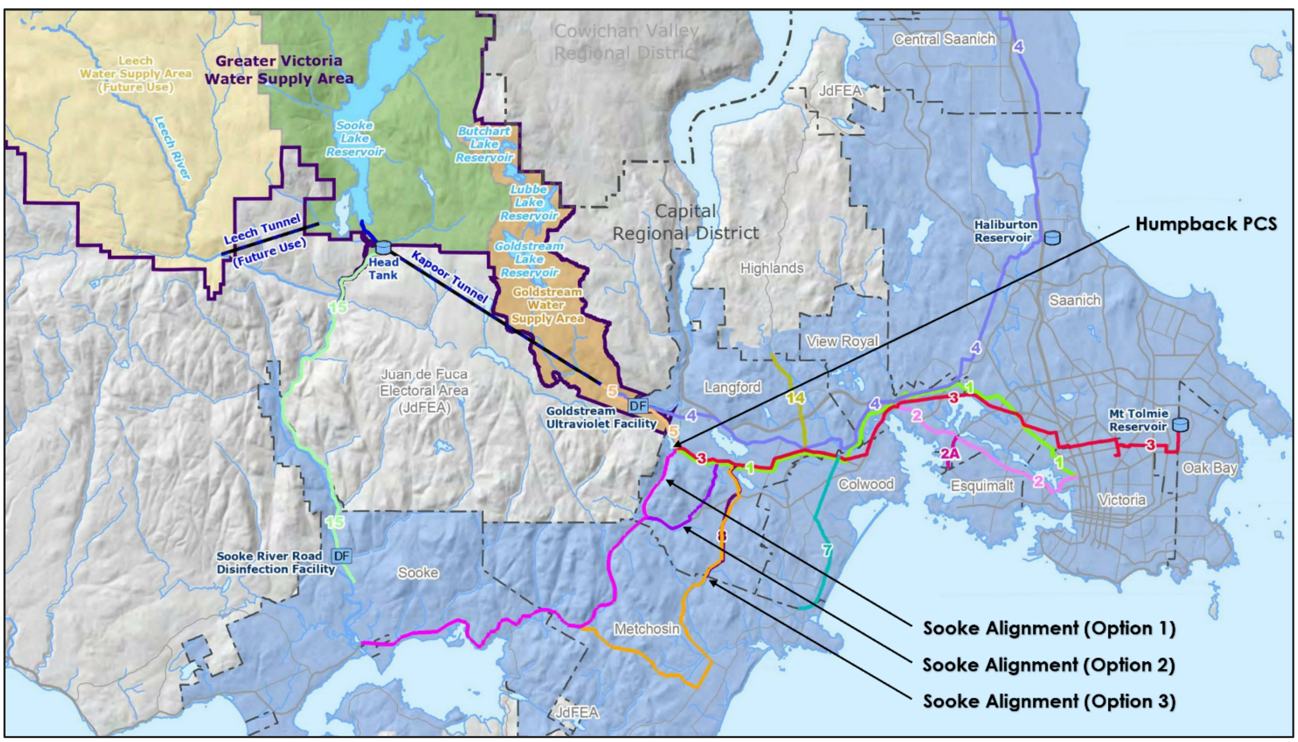


Figure 6.13: East-West Connector – Transmission Main Alignments

6.3 TRANSMISSION SYSTEM STORAGE

Further to the earlier references to water storage, Section 6.3 provides a supplementary discussion related to the transmission system storage including purpose, conclusions from the 1994 Plan, existing storage facilities, relationship with distribution storage, history, and limitations with the existing RWS system.

6.3.1 Water System Storage

Water system storage is typically provided for a variety of reasons and levels-of-service and transmission system storage is commonly included with large water utilities for one or more of the following beneficial purposes:

1. Lessens the effect of peak water demands (i.e. peak hour or instantaneous)
2. Reduces water velocity in the transmission mains and therefore less head-loss (energy or pressure loss)
3. Reduces the potential for transient pressure surges and potential system material failure (e.g. water-hammer)
4. Provides for a discretionary volume of emergency storage
5. Reduction in the design capacity of related works such as water treatment processes, transmission mains, valves, etc.
6. Beneficial for logistics related to capital improvement such as transmission main replacement or renewal, system maintenance (planned and unplanned)

Conversely, negative implications for providing storage include the capital and operating costs and the issue of managing the quality of any stored water during low demand periods where residence time is increased ("water age").

Large water systems such as the RWS, commonly include transmission storage independent from distribution system storage (discussed further on) and although water flows through a transmission system to service a distribution system, the reasons for and how transmission storage is operated are slightly different. Transmission systems in general deliver large volumes of water to many customers, ideally at a moderate pace and in turn delivers water to municipal distribution systems for more specific purposes within a community

An excerpt from the 1994 Plan stated the following:

> *"Thirdly, the appropriate balance between the size of the conveyance works (pipeline and booster pumps) and the size of the equalization [balancing] storage reservoirs [tanks] also has the ability to create cost effectiveness in a system such as that of the GVWD. With the long distances of conveyance facing the GVWD it becomes attractive financially and for reasons of the security of supply to equalize the instantaneous peak demands down by use of local reservoirs, not only to the maximum day levels but in some areas down to two-to-four-day maximum demands."* (reference Page 5-8)

Section 5.3.5, System Reservoirs, of the 1994 Plan also stated the following:

> *"The sizing of a reservoir [storage tank] is principally dependent on the pattern of water demands in the areas which the supply main balanced by the reservoir is serving as well as the cost of the supply main. Once costly water treatment is introduced, reservoir sizing is also affected by the cost of water production.*

> *In the District service area the need for large balancing reservoirs in the next century at Smith Hill and at Haliburton is created by growth exceeding the existing storage capacity in the Lower Mount Tolmie [CRD versus the District of Saanich's Mount Tolmie tank] and Haliburton Reservoirs, by relatively large distance from the Sooke Lake Reservoir source to the areas of water use, the high cost of water treatment and the predicted lower peak hydrographs associated with more intensive land use."* (Reference Page 5-13)

The general conclusions from the 1994 Plan remain valid and it should be noted that for example the RWS service has realized the effect of limited storage especially in the communities of Victoria, Esquimalt and Oak Bay through monitoring observations of peak or instantaneous high flows during events such as fire incidents, distribution main failures and even significant televised sporting events.

Further to transmission system storage, good engineering practice for distribution system design typically includes storage for balancing, fire protection and emergencies. The balancing storage volume is often a portion of the maximum day demand (e.g. Master Municipal Contract Documents, municipal bylaws, etc.), fire protection volume is generally a volume related to a minimum fire flow for a specified duration (typically determined by the Fire Underwriters Survey of Canada) and the emergency storage volume is often expressed as a portion of the sum of the balancing and fire storge with the intent of providing a reasonable amount of storage to maintain continuity of service during an emergency (i.e. failure of water supply or a water main, planned or unplanned interruptions, etc.).

6.3.2 Existing Transmission Storage Summary

The existing RWS storage details are provided in Table 2.4 Storage Tanks and Figure 2.5 and include storage directly from the lake reservoirs (i.e., Sooke Lake Reservoir and the Goldstream Reservoirs), the Head Tank, McTavish Tank and Mount Tolmie Tank. There are two other storage facilities, both of which are out-of-service, those being Smith Hill Reservoir (open reservoir) and Haliburton Tank all of which are described further.

6.3.2.1 Head Tank

The Head Tank is appropriately named as its primary function is to maintain constant head or pressure for the downstream system (e.g., Kapoor Tunnel, transmission mains, etc.). With a limited volume, it has little benefit for balancing of peak demands and the operating philosophy is to keep this tank full to maintain the head (top water level) by modulating inlet control valves.

6.3.2.2 McTavish Tank

The McTavish Tank is located at the terminus of RWS Main #4 in North Saanich, serves as a terminal transmission system storage tank and it works in conjunction with the storage tanks within the CRD's Saanich Peninsula water service (i.e., Bear Hill Tank, Dawson Tank, Dean Park Tanks, Cloake Hill Tank, etc.).

6.3.2.3 Mount Tolmie Tank

The Mount Tolmie Tank is located in the City of Victoria on the border with the District of Oak Bay. This storage tank primarily provides service to the water distribution systems for the City of

Victoria, District of Oak Bay and District of Saanich. The District of Saanich actually operates two pump stations at this location (drawing from the RWS Mount Tolmie Tank) to pump water to its Mount Tolmie Tank at a higher elevation servicing its distribution system.

6.3.2.4 Haliburton Tank (out-of-service)

The Haliburton Tank is out-of-service. The Haliburton Tank was commissioned as a level of service issue between the CRD and the GVWD prior to the GVWD joining the CRD. Once the HGL of Main #4 was raised this tank was no longer required but had remained in service for emergency use until a recent feeder main failure in 2021, at which time the connection was terminated, and the tank was drained. Long-term options for the tank include status quo, demolition or decommissioning or to reintroduce the tank to service to align with the 2017 Strategic Plan for emergency use, but only after completing improvements.

6.3.2.5 Smith Hill Reservoir (out—of-service)

Smith Hill Reservoir has been out-of-service for decades, being at the terminus of the original Main #1 and its operation predating the installation of Main #3 and the Mount Tolmie Tank. Although the site has not been decommissioned the existing system would not be acceptable to recommission without improvements, particularly since it is an open reservoir and the HGL (~67m) does not compliment the HGL of Main #3 or the local distribution systems.

The 1994 Plan stated:

> *“The reactivation of the Smith Hill Reservoir becomes necessary to balance Zone 1 draws in Victoria, Oak Bay, Southeast Saanich and Esquimalt from the GVWD sources.”*

and

> *“…This is cost effective and hydraulically advantageous to provide and the reservoir will be able to balance more than just the peak day demands until growth in demands again catches up with the capacity.”* (Reference Page 5-12)

Although this is an issue for utilizing the site for transmission storage, there is an option of servicing much of Victoria and Oak Bay from a HGL set by Smith Hill, less some localized topography serviced by the City of Victoria's distribution network. Another option is to install a water tower to compliment the Main #3 HGL, but this would result in an elevated structure.

A further option would be to install storage to the benefit of both the transmission system and the customer’s distribution systems. This would require the replication of the existing HGL by use of pumps as identified in the 1994 Plan (Reference 1994 Plan Section 5.3.5 System Reservoirs). This 2022 Master Plan includes this option and identified a storage tank of 25,000m^3 volume at a HGL of 116m with a pump station to replicate the existing distribution system HGL. Until such time that details for storage are concluded and implemented the CRD plans to continue to own and manage the Smith Hill site property.

6.3.3 Existing Distribution Systems Storage

6.3.3.1 Saanich Peninsula Water Service (CRD)

For the Saanich Peninsula there are three levels of water service, the RWS (regional), SPW (sub-regional) and the municipal or distribution services. Although none of the municipal/distribution water systems have water storage facilities, the CRD provides water storage via the RWS and SPW services for the Peninsula.

6.3.3.2 Juan De Fuca Water Distribution Service (CRD)

The JDFWDS consists of numerous pressure zones and related distribution storage tanks. The RWS and the JDFWD services work well even though there is no transmission storage. It is recommended that a comprehensive evaluation of storage be completed as there may be a need for transmission storage in the future as demand on the RWS transmission increases. The potential need for storage may be lessened should the east-west connector main be installed and as well as balancing storage near Japan Gulch.

6.3.3.3 Westhills Development, Langford

The Westhills development/community located within the City of Langford, opted to construct and operate a water distribution system independent of the CRD's JDFWD water service. The Westhill's water system obtains water directly from the RWS service via Transmission Mains #1 and #3 and operates at the HGL provided by those mains. The system includes a supplementary fire pump system in absence of having water storage for fire suppression.

Until recently, this water system did not have distribution system storage and the utility operator recognized the vulnerability including limited fire protection especially as commercial and institutional developments occurred beyond the initial residential development (hence increased required fire demands), and the need for balancing and emergency storage. The utility has recently invested in two tanks (bolted steel) with a total volume of 8,600 m^3 which were commissioned in 2022.

6.3.3.4 District of Saanich

The District of Saanich has invested in its distribution system storage including Rithet Tank which obtains water from the RWS Main #4 and Mount Tolmie Tank which if supplied with water from the RWS Mount Tolmie Tank.

6.3.3.5 Other Distribution Water Services

The District of Oak Bay and the City of Victoria (including the Township of Esquimalt) have not invested in distribution storage, and they rely on the RWS system.

6.3.4 2022 Master Plan Storage Improvements and Next Steps

The conclusions related to transmission storage as identified in the 1994 Plan generally remain valid and the conceptual WFP site works have evolved to included balancing storage relative to the proposed WFP project. In particular, transmission storage at the Smith Hill site and proposed Japan Gulch site would result in many immediate and future benefits for the system. As noted in

Section 5.5.1 a hydraulic modelling study is recommended to finalize the size of balancing storage at the proposed water filtration plant site in combination with the proposed Smith Hill transmission balancing storage. It is recommended that a dynamic simulation model be developed to assess the balancing storage requirements at the proposed Japan Gulch Reservoir treatment plant site and the Smith Hill Reservoir site under diurnal patterns experienced during peak summer demand conditions. For cost estimating purposes a volume of 25,000m3 has been assumed for the Smith Hill tank storage, size to be confirmed based on the outcome of further hydraulic modeling.

Coordination with the municipalities/distribution system water providers should continue in order to develop a comprehensive and optimized plan for system storage regardless of system ownership.

The 2022 Master Plan has included the following proposed improvements related to transmission storage:

1. Japan Gulch Water Filtration Plant – Stage 2 Balancing Tank
2. Smith Hill Storage Tank and Pump Station

7.0 2022 MASTER PLAN OPTIONS & ALTERNATIVES

The 1994 Plan evaluated six Alternatives, based on assessments of water supply requirements. The Alternatives involved either raising Sooke Lake Reservoir or pumping from the northern basin of Sooke Lake Reservoir and secondly, three emergency supply provisions as follows:

1. Restoration of the three Upper Goldstream River dams and reservoirs
2. A pumped Jack Lake supply system from Sooke Lake Reservoir
3. A Northern Supply line (transmission main) to the Saanich Peninsula

The combinations resulted in six Alternatives identified as follows:

Table 7.1: 1994 Long-Term Water Supply Plan Alternatives

Alternative A	Raise Sooke Lake Reservoir/Restore Goldstream dams
Alternative B	Lower Sooke Lake Reservoir/Restore Goldstream dams
Alternative C	Raise Sooke Lake Reservoir/Jack Lake supply system
Alternative D	Lower Sooke Lake Reservoir/Jack Lake supply system
Alternative E	Raise Sooke Lake Reservoir/Northern Supply line
Alternative F	Lower Sooke Lake Reservoir/Northern Supply line

"Alternative A", which included 21 capital projects, was ultimately selected for implementation. Since 1994, IWS has made substantial progress in its implementation as discussed in Section1, Table 1.1 of this 2022 Master Plan.

The principal considerations in the 1994 Alternatives involved:

1. Whether to raise the Sooke Lake Reservoir water level by raising the Sooke Lake Dam or pump from the deep northern basin of the SLR to increase the usable reservoir storage volume
2. Whether or not to restore the Goldstream Reservoir Dams
3. Redundancy of raw water transmission for the Kapoor Tunnel

For consideration 3, the 1994 Plan included evaluation of emergency water supply options in the event of a loss of the Kapoor Tunnel. The emergency design flows provided a lower level of service and was initially established to be 113 MLD or 337 L/c/d and in the future at 180 MLD or 272 L/c/d.

The development of Alternatives for this 2022 Master Plan will use similar methodology from the 1994 Plan described above. For this 2022 Master Plan, the principal considerations are:

1. Security of supply (Now and in the future)
2. Conveyance of water between Sooke Lake Reservoir and Japan Gulch
3. Siting of the proposed filtration treatment plant

7.1 Gap Analysis

7.1.1 Supply

As noted in Section 3.0, the projected 2050 annual demand assuming a 1.25% population increase is estimated at 74 Mm^3Y. This demand is greater than the recommended 1:50 year safe yield capacity of 67Mm^3Y. Additional water sources such as augmentation with flows from Leech watershed, further demand reduction or other potential sources should be planned for development within the next 25 years to ensure that future demands can be met. Continued water conservation efforts and achieving a modest demand reduction to 300 L/c/d would allow the Sooke watershed supply to be adequate until the year 2060.

The development of Alternatives should consider how the security of water supply can be strengthened during the next 25 years.

7.1.2 Raw Water Conveyance from Sooke Lake Reservoir to Japan Gulch

Kapoor Tunnel is the principal raw water transmission conduit for the RWS excluding the JDFWD which is served by Main No.15. This 8.8 km long, 2.3 m diameter tunnel conveys water to an outlet point upstream of the Japan Gulch Reservoir (JGR). The hydraulic capacity of this tunnel is estimated to be 682 MLD and could serve the CRD beyond the planning horizon of 2050 to approximately 2100 provided additional source water is developed from the Leech watershed and demand management continues to maintain current or lower water consumption levels. When the tunnel is out of service, the CRD uses the Goldstream watershed system to supply the RWS.

The lack of redundancy of the critical Kapoor Tunnel supply conduit is a vulnerability to the security of the RWS supply. Consideration of a secondary conveyance main between SLR and Japan Gulch Reservoir, even if at an emergency Level of Service (2100 ADD), is prudent planning.

7.1.3 Treatment

Multiple risks and risk scenarios exist that would present a greater challenge to an unfiltered water supply than one which includes filtration. These typically involve a greater probability of impairment in water quality. Risks to future watershed health and its water quality may be greatly diminished by proactive and preventative measures that provide multiple barriers to microbial pathogens and other hazards. The addition of filtration, in combination with UV and chlorine, would provide a robust multiple-barrier system and be able to better mitigate potential source water quality impairment and protect public health. The addition of filtration would increase the reliability of finished water quality despite adverse watershed conditions, future climate change and reduce the vulnerability of the RWS unfiltered system.

The CRD understands the risk of having an unfiltered water supply and recognizes a filtration plant will be required in the future to improve resiliency. This options analysis will consider filtration technologies and siting options for the treatment plant and technologies.

7.1.4 Treated Water Transmission Mains and Storage

A program of improvements for the transmission mains and storage tank has been developed for the CRD through a series of engineering studies including the 1994 Plan and the recent GeoAdvice report. These transmission main improvements are described in Section 6, Table 6.3. The improvements are considered constant to all the developed Alternatives and will not be further evaluated in this section.

7.2 2022 Master Plan Options

Table 7.2 shows the hierarchy of the high-level options for 3 categories of infrastructure improvements to the RWS.

Table 7.2: 2022 Master Plan Categories Options

Category	Component	
Supply	Sooke Lake Reservoir (Deep Northern Intake)	Leech River (Future Intake)
Raw Water Transmission Mains	Leech River to Sooke Lake Reservoir	Sooke Lake Reservoir to Japan Gulch
Filtration	Siting	Filtration Technologies

Within the high-level Options presented in **Table 7.2**, there are additional considerations that make the evaluation of options more challenging and complex. There are potentially 18 options as outlined in **Table 7.3** that require evaluation compared to the 2017 Strategic Plan objectives.

Table 7.3: 2022 Master Plan – 18 Options for Evaluation

Category	Component	Option	Description
Supply	Sooke Lake Reservoir (Intake)	S1	Deep Northern Intake
		S2	Lake Bottom Marine Intake
		S3	Floating Pump Station Intake
	Leech River (Intake)	S4	Leech River Diversion Intake to Leech Tunnel
		S5	Leech River Dam / Storage
Raw Water Transmission	Leech River to Sooke Lake Reservoir	RWT1	Leech Tunnel to Deception Gulch Reservoir
		RWT2	Leech Tunnel to Sooke Lake Reservoir deep basin
	Sooke Lake Reservoir to Japan Gulch	RWT3	Sooke Lake Reservoir to Japan Gulch tunnel
		RWT4	Hybrid pumping/tunnel alternative
		RWT5	Overland route through Leechtown and Jack Lake – 3 PS
		RWT6	Overland Council Lake Alignment – 3 PS & 1 PS
		RWT7	Overland Hwy 1 Malahat Alignment - 3 PS & 1PS
Filtration	Filtration Plant Sites	T1	Sooke Lake Reservoir site
		T2	Japan Gulch site
		T3	Japan Gulch site + Sooke River Road site
	Filtration Technology	T4	Direct Filtration
		T5	Dissolved Air Flotation (DAF) with granular media filtration
		T6	Membrane Filtration

Most of these 18 options are described in more detail in Sections 5 and 6 of this 2022 Master Plan. The advantages and disadvantages for the Options are listed in **Tables 7.4** to **7.9**.

Table 7.4: Sooke Lake Reservoir Intake Options

Supply: Sooke Lake Reservoir (Intake)	Advantages	Disadvantages
Deep Northern Intake (S1)	• Provides access to high quality water • Facilitates deeper drawdown for emergency condition or extreme seismic event • Ability to select best depth for water withdrawal pending outcome of further sampling/study • Provides redundancy for the existing Intake Tower • Improves resiliency of water extraction from SLR and provides and enables water extraction from lower levels of North Basin of SLR.	• High CAPEX • Complex pumping/intake installation. • Marine construction required • Difficult for O&M staff to access intake screen if there is a problem. • Hydrology studies recommend to not lower SLR below elevation 177m.
Lake Bottom Marine Intake (S2)	• Gravity flow from SLR deep basin to existing Intake Tower • Less complex construction • Provides redundancy to the existing intake • Screens can be cleaned from shore by air bursting system	• Alignment selection needs to reduce high points or dredging required • Marine construction required • Difficult for O&M staff to access intake screen if there is a problem • Divers required for screen inspection
Floating Pump Station (S3)	• Water quality addressed through an adjustable deep intake. • Expandability/modular • Can easily be built for lower capacity or level of service. • Provides redundancy to the existing Intake Tower	• Concept is pioneering but there are examples such as Seattle Public Utilities. • High voltage power supply to offshore pump station will require detailed engineering assessment and may have high CAPEX. • Marine construction required • Maintenance access to floating platform will be a challenge for transportation of tools and equipment. • Operator access to the pump station will require nonstandard safety procedures. • Capacity of the pump station will be limited to the number/capacity of discharge watermains from the pump station to the existing intake tower at Sooke Lake Dam.

Table 7.5: Leech River Intake Supply Options

Supply: Leech River (Intake)	Advantages	Disadvantages
Leech River Diversion intake to Leech Tunnel (S4)	• Leech River diversion tunnel capacity is increased by surcharging its inlet but could operate as a gravity conduit for direct diversion. • Could provide additional storage in the Leech Watershed. • Relatively low-cost solution to increasing the recharge capacity of the Sooke Lake Reservoir but reservoir balancing model required to confirm feasibility. • Direct diversion without dam can be completed using gravity flow through tunnel at a relatively low cost. • Can be used to augment SLR conservation flows.	• Available yield from this watershed in summer months is affected by limited local storage in DGR to store the runoff and diversions from Leech River. • Fishery compensation requirements in the lower reaches of the Sooke River to which Leech River is discharging (BC Environmental Flow Needs (EFN) policy. • Diversion of Leech River to SLR limited to wet weather months. • Leech watershed water quality could impact the blended water quality of the Sooke Lake Reservoir supply.
Leech River Dam (S5)	• A high dam could provide additional storage. • Leech watershed has significant additional catchment area (greater than Sooke watershed) to meet long term water demands of RWS beyond planning horizon.	• A high dam would be expensive to construct. • Leech watershed water quality could impact the blended water quality of the Sooke Lake Reservoir supply. • Steep unstable slopes in watershed. Further geotechnical assessment will be required. • Low return on investment for storage volume/dam height due to steep geometry of Leech River Valley. • Dam safety requirements. • The environmental impact of constructing this size dam and reservoir may not satisfy current environmental regulatory standards and would require a long permitting period.

Table 7.6: Leech River to Sooke Lake Reservoir Transmission Options

Raw Water Transmission Leech River to Sooke Lake Reservoir	Advantages	Disadvantages
Leech Tunnel to Deception Gulch Reservoir (RWT1)	• DGR can be used with upgrade to the Saddle Dam and diversion structure to transfer flows directly to SLR. • Removal of organic material from bottom sediments would help with water quality • Low cost to implement	• If dredging is required, disposal of significant volumes of dredge spoils would be difficult. • Rehabilitation of Deception Gulch Dam and Sooke Lake Saddle Dam would be required.
Leech Tunnel to Sooke Lake Reservoir deep basin (RWT2)	• Discharge directly to Sooke Lake Reservoir and bypassing Deception Gulch Reservoir • Potential lower cost to install a Leech River Bypass in comparison to Sooke Lake Reservoir Saddle Dam upgrade. • Isolates the Deception Gulch Reservoir from the Sooke Lake Reservoir.	• Transmission main construction adjacent could encounter wet conditions since it would be adjacent to Deception Gulch Reservoir. • Requires that the Leech River diversion dam be concurrently constructed to provide sufficient hydraulic head for conveyance of the flow. • Could end up being a higher cost because of geotechnical conditions and high water table.

Table 7.7: Sooke Lake Reservoir to Japan Gulch Transmission Options

Raw Water Transmission Sooke Lake Reservoir to Japan Gulch	Advantages	Disadvantages
Sooke Lake Reservoir to Japan Gulch tunnel (RWT3)	• Provides full redundancy to the Kapoor Tunnel. • Pumping not required to convey source water from SLR to Japan Gulch. • Supply not interrupted during extended periods of power outages.	• Most expensive option • Provides fully redundant capacity years in advance of system demands. • More difficult to access for inspection/maintenance
Hybrid pumping/tunnel (RWT4)	• Open cut /buried construction transmission main from Sooke Lake Reservoir connecting into a tunnel. • Reduces the cost of tunnelling. • Allows for staged construction of pumped transmission mains to match demand requirements. • Pumped portion can be sized for emergency supply only.	• More expensive than pumping options. • High head pumps required for pumped portion of the transmission system. • High operations and maintenance costs. • Large standby power generators required for pump station.
Overland route through Leechtown and Jack Lake – 3 PS (RWT5)	• Redundancy for the Kapoor Tunnel • Bi-directional flow to convey the Upper Goldstream watershed peak runoff to the Sooke Lake Reservoir for equalizing storage if necessary. • Potential power generation to offset the pumping power requirements. • Can be sized for a lower level of service average day demand (ADD) instead of maximum day demand. Results in smaller transmission main size and lower pumping costs. • Addresses redundancy requirements. • If system is used as an emergency supply only the pumping costs can be reduced because Kapoor Tunnel will continue as the primary gravity supply. • Potential to utilize existing head tank. • Facilitates the incorporation of the Goldstream Reservoir piped connection to Japan Gulch.	• This option requires high horsepower pumping and high annual operating costs depending on Level of Service. • Substantial improvements to road access required. • Based on the estimated horsepower requirements, a separate power supply and substation will be required for the three (3) proposed pump stations. • BC Hydro power supply to the 3 pumping stations will be expensive. • Large capacity standby power generators may be required at each pumping station depending on Level of Service.

Raw Water Transmission Sooke Lake Reservoir to Japan Gulch	Advantages	Disadvantages
Overland Council Lake Alignment – 3 PS (RWT6)	• Redundancy for the Kapoor Tunnel during peak flow periods and/or emergency conditions. • Slightly shorter route compared to Jack Lake Option. • Potential energy recovery to offset the District power requirements. • Facilitates the incorporation of the Goldstream Reservoir piped connection to Japan Gulch	• This Option may require high horsepower pumping and high annual operating costs depending on the Level of Service. • Single pump station option would have high discharge pressure which is not common for a municipal water system. • Substantial improvements to road access required. • Based on the estimated horsepower requirements, a separate 14.4 kVA power supply and substation will be required for the three (3) proposed pump stations. • BC Hydro power supply to the 3 pumping stations will be expensive. • Large capacity standby power generators may be required at each pumping station depending on Level of Service.
Overland Hwy 1 Malahat Alignment - 3 &1 PS (RWT7)	• Redundancy for the Kapoor Tunnel during peak flow periods and/or emergency conditions. • Potential energy recovery to offset the power requirements. • The alignment proposed for this option follows existing forest service roads where possible minimizing the cost associated with clearing, grubbing, and construction of new access roads. This alternative would follow a mixture of existing access roads and trails to make this alignment feasible. The roadways and trails would be improved to a higher standard to allow year-round access and during inclement weather conditions.	• The proposed alignment provides no opportunity to utilize the existing Head Tank. • This option requires high horsepower pumping and high annual operating costs. • Substantial improvements to road access required. • Based on the estimated horsepower requirements, a separate power supply and substation will be required for the proposed pump stations. • BC Hydro power supply to the pumping stations will be expensive. • Large capacity standby power generators may be required at each pumping station depending on the Level of Service. • Does not facilitate the Goldstream Reservoir piped connection to Japan Gulch.

Table 7.8: Filtration Siting Options

Filtration Siting Options	Advantages	Disadvantages
Sooke Lake Reservoir Site (T1)	• SLR site provides the ability to supply Main No.15 from a single facility, eliminating the need for enhanced treatment at the Sooke River Road Disinfection Facility. • Water supply to Kapoor Tunnel and Main No. 15 can be fed by gravity or east-west JDF connector.	• Significantly reduced access, requiring substantial improvements to road access and electrical power supply • 3 phase power extension to site will be expensive. • Higher operating costs for residual waste disposal. • SLR location cannot treat water from the Goldstream watershed using existing means of conveyance. • Long drive to site for operators is inefficient and difficult in winter conditions.
Japan Gulch Site (T2)	• Japan Gulch site has the ability to treat water from the Goldstream watershed, Sooke Watershed, and future Leech supply. • Improved access for transportation of personnel, equipment, and chemical deliveries. • Goldstream secondary source can serve as an emergency supply and secondary source. It can be used year-round with filtration. • Filtration facility would be in close proximity to existing UV disinfection facility and would not require operators to work at 2 locations. • BC Hydro power is available nearby at the Goldstream Disinfection Facility. • Residual waste disposal easier to manage.	• This location will require high capacity, low lift pumping to 169 m HGL as the head must be broken to accommodate granular media or membrane filtration (T4, T5 and T6). • Accommodating supply from a centralized Japan Gulch WTP to the JDFWD may be achieved by east – west connector main. • Flood protection of site required.
Japan Gulch + Sooke River Road Sites (T3)	• Water quality improvements for the Juan de Fuca communities may be achieved by augmenting existing treatment at SRR with a small membrane plant, which likely would cost less than the construction of a transmission main between Langford and Sooke.	• Two treatment facilities will require additional operators and have higher operations and maintenance costs • Membrane filtration likely required at SRR due to site constraints. • No redundancy of supply for Main No. 15.

Table 7.9: Filtration Options

Treatment Filtration Options	Advantages	Disadvantages
Direct Filtration (T4)	• Direct filtration is considered most suitable for relatively stable sources that consistently demonstrate low turbidity and low organic matter. • Table B.1 from the Guidelines for Canadian Drinking Water Quality: Guideline Technical Document shows that direct filtration will receive 2.5-log removal credit for cryptosporidium oocysts but 0.5 log must be provided by UV to achieve 3.0 log IHA requirement for protozoa. • 1.0-log credit is provided to direct filtration for virus removal • Higher filtration rates for direct filtration may result in smaller plant size and associated CAPEX cost savings. • Modular design could facilitate phased construction of the treatment facility. • Generally recognized that the energy requirements for media filtration are less than that of membrane filtration. • The amount of backwash water used is typically 2 to 5% for granular media filtration.	• Achieving consistent low turbidity filter effluent is highly dependent on proper chemical pre-treatment and usually requires use of filter aid polymers. • Residual waste streams must be processed. Equalization storage of liquid residuals streams is usually required. • Due to the low alkalinity of Sooke Lake Reservoir and other sources, common metal coagulants such as alum are unreliable without prior alkalinity addition. pH adjustment may be required. • Future raw water quality conditions with addition of Leech River may change sufficiently to challenge the performance of direct filtration. • Filtration technology is not as robust to perform well during raw water quality excursions that may occur following a wildfire. • May need to have additional space provision for pre-treatment process such as DAF to deal with future Leech River Water Quality (to be confirmed by piloting).
Dissolved Air Flotation (DAF) and Filtration (T5)	• DAF is the most appropriate form of clarification to provide more consistent and reliable treatment performance for colour and algae removal. • DAF may be included in the initial design or provided as a subsequent retrofit • The flocculation time is short and comparable to that of direct filtration.	• The overall increase in treatment facility footprint is related to the DAF footprint. • The recycle stream may amount to 10% of the influent flow to the DAF. • Higher capital and operating costs than Direct Filtration option (T4). • DAF filtration is more costly than direct filtration.

Treatment Filtration Options	Advantages	Disadvantages
	• Can deal with future Leech River colour levels as well as algae from all sources. • DAF clarification is recognized as having protozoan pathogen removing capabilities and enhancing the performance of filtration overall.	
Membrane Filtration (T6)	• Membrane filtration, which includes microfiltration (MF) and ultrafiltration (UF), are an increasingly competitive alternative to granular media filtration. • Removes particles having nominal sizes of 0.1 µm for MF and 0.01 µm for UF by physical sieving at the interface of a fiber membrane • MF/UF is an effective method of producing very low turbidity filtrate (< 0.1 NTU). • Provides an absolute barrier to protozoan oocysts. • Direct challenge testing has been found to achieve > 6-log removal of Cryptosporidium oocysts and Giardia cysts. • Membrane systems are less sensitive to changes in source water quality that may occur seasonally or due to storm events	• The rejectate of the secondary stage membrane will contain a much higher concentration of solids and must be processed by a dedicated DAF thickener. • The amount of backflush water used is typically 5 to 10% of the water produced, compared to 2 to 5% for granular media filtration. • Recycle flows treatment more complex than Direct Filtration or Direct Filtration + DAF options. • Membrane life is 8 to 10 years and significant capital cost for replacement. • Highest capital and operating cost of the three treatment technologies. • Pre-treatment still required for colour removal.

7.3 OPTIONS EVALUATION AND ALTERNATIVE PLANS DEVELOPMENT

7.3.1 Evaluation Criteria

The RWS 2017 Strategic Plan provides guidance on the Commitments for the Regional Water Supply. These Commitments are grouped into 3 categories shown below:

- Provide high quality, safe drinking water
- Provide an adequate, long-term supply of drinking water
- Provide a reliable and efficient drinking water transmission system

The 2017 Strategic Plan also identified Areas of Focus, Strategic Priorities, and Actions including:

- CRD Board Priorities - Sustainable and Livable Region
- Climate Change Impacts - Mitigation and Adaptation
- Preparing for Emergency and Post - Disaster Water Supply
- Supply System Infrastructure Investment - Renewing Existing and Preparing for New Infrastructure
- Planning for the Future Use of the Leech Water Supply Area
- Demand Management - Addressing Changing Trends in Water Demand

7.4 Options Evaluation

The 1994 Plan included an options evaluation to ultimately arrive at the preferred Alternative A capital program. Since that time, significant capital works have been completed and several Strategic Plans have been prepared. This 2022 Master Plan compares the options developed as part of this report against the most recent 2017 Strategic Plan objectives.

In **Table 7.11** through to **Table 7.15**, the Options are evaluated for alignment with the 2017 Strategic Plan Commitments and Areas of Focus. Each Option is scored based on meeting the criteria outlined in the 2017 Strategic Plan using the scoring criteria shown in **Table 7.10**.

Table 7.10: Scoring of Options

Very Good (5)	Good (4)	Average (3)	Fair (2)	Poor (1)
The Option is very favorable and far exceeds minimum expectations.	The Option is favorable and clearly exceeds minimum expectations.	The Option is acceptable and meets or somewhat exceeds minimum expectations.	The Option barely meets minimum expectations.	The Option fails to meet minimum expectations.

Table 7.11: Supply Options S1 thru S3

Supply	Criteria Weighting	Sooke Lake Reservoir Intake					
		Option S1 - Deep Northern Intake	Score	Option S2 - Lake Bottom Marine Intake	Score	Option S3 - Floating Pump Station	Score
2017 Strategic Plan Commitments							
Provide high quality, safe drinking water	3	Accessing water from the deep Sooke Lake Reservoir basin will provide high quality water.	5	Accessing water from the deep Sooke Lake Reservoir basin will provide high quality water.	4	Floating Pump Station Intake access to deeper water elevations will be limited to the length of intake boom below the water surface. The floating pump station will access high quality water from the lower elevations when the lake level has been significantly reduced.	4
Provide an adequate, long-term supply of drinking water	3	The intake Options to the deep basin of the Sooke Lake Reservoir will not increase the capacity of this source since the drawdown is limited to approximately 177 m based on hydrology assessment.	4	The intake Options to the deep basin of the Sooke Lake Reservoir will not increase the capacity of this source since the drawdown is limited to approximately 177 m based on hydrology assessment.	3	The intake Options to the deep basin of the Sooke Lake Reservoir will not increase the capacity of this source since the drawdown is limited to approximately 177 m based on hydrology assessment.	4
Provide a reliable and efficient drinking water transmission system	3	Redundancy added for Sooke Lake Reservoir intake.	3	Redundancy added for Sooke Lake Reservoir intake if Lake Bottom Intake is connected directly to Kapoor Tunnel Head Tank.	3	Redundancy added for Sooke Lake Reservoir intake.	3
2017 Strategic Plan Areas of Focus							
CRD Board Priorities - Sustainable and Livable Region	2	Deep Northern Intake will provide access to coldest water and will enable management of the Sooke watershed supply such that the reservoir can be refilled during the annual hydrologic cycle. Deep intake will allow greater drawdown of the reservoir during extreme drought conditions.	4	A gravity Lake Bottom Marine Intake will provide access to coldest water and will enable management of the Sooke watershed supply such that the reservoir can be refilled during the annual hydrologic cycle. Since the additional intake pipe is proposed to be connected to the existing Head Tank the drawdown will be controlled by SLR to Head Tank available head.	3	Floating Pump Station Intake will not always provide access to coldest water but will enable management of the Sooke watershed supply such that the reservoir can be refilled during the annual hydrologic cycle. This intake will allow greater drawdown of the reservoir during extreme drought conditions.	4
Climate Change Impacts - Mitigation and Adaptation	2	Deep Northern Intake will provide access to coldest water when the surface waters may be warmer due to climate change. Deep intake will allow greater drawdown of the reservoir during extreme drought conditions.	5	Lake Bottom Marine Intake will provide access to coldest water when the surface waters may be warmer due to climate change. This intake will not allow greater drawdown of the reservoir during extreme drought conditions.	3	Floating Pump Station Intake access will be limited to the length of intake boom below the water surface when the surface waters may be warmer due to climate change. This intake will allow greater drawdown of the reservoir during extreme drought conditions.	4
Preparing for Emergency and Post - Disaster Water Supply	3	Deep Northern Intake provides full redundancy to the existing Intake Tower and could convey raw water to the Kapoor Tunnel Head Tank or directly to Japan Gulch. Depending on Transmission Option selected, this option could be a gravity supply which would continue to provide water during an extended power outage.	5	Lake Bottom Intake provides redundancy to the existing Intake Tower since it connects from the Sooke Lake Reservoir deep basin to the Intake Tower. If the Intake Tower or Kapoor Tunnel are out-of-service, this option has no benefit.	5	Floating Pump Station Intake does provide redundancy to the existing Intake Tower since it connects from the Sooke Lake Reservoir to the Intake Tower. If the Intake Tower or Kapoor Tunnel are affected by a natural disaster, this option has no benefit. The system could be connected to a secondary transmission system to Japan Gulch.	3
Supply System Infrastructure Investment - Renewing Existing and Preparing for New Infrastructure	1	The Deep Northern Intake could be connected to the existing Kapoor Tunnel Head Tank or to a new redundant Transmission Main from Sooke Lake Reservoir to Japan Gulch.	4	The Lake Bottom Intake is connected to the existing Intake Tower and is marginally beneficial to preparing for new infrastructure.	3	The Floating Pump Station Intake is connected to the existing Head Tank and is beneficial to preparing for proposed future Jack Lake infrastructure as well as allowing for pumping to Kapoor Tunnel.	4
Planning for the Future Use of the Leech Water Supply Area	1	Several Leech Water Supply Options will direct water from the Leech Watershed to the Sooke Lake Reservoir or Deception Gulch Reservoir.	4	Several Leech Water Supply Options will direct water from the Leech Watershed to the Sooke Lake Reservoir or Deception Gulch Reservoir.	4	Several Leech Water Supply Options will direct water from the Leech Watershed to the Sooke Lake Reservoir or Deception Gulch Reservoir.	4
Demand Management - Addressing Changing Trends in Water Demand	1	All of the supply Options have a neutral impact on the Demand Management Initiatives.	3	All of the supply Options have a neutral impact on the Demand Management Initiatives.	3	All of the supply Options have a neutral impact on the Demand Management Initiatives.	3
Total- Meeting Strategic Plan Objectives - Total Raw Score		37		31		33	
Total- Meeting Strategic Plan Objectives - Total Weighted Score		80		67		69	

Table 7.12: Supply Options S4 thru S5

Supply	Criteria Weighting	Leech River (Intake)			
		Option S4 - Leech River Diversion Intake to Leech Tunnel	Score	Option S5 - Leech River Dam	Score
2017 Strategic Plan Commitments					
Provide high quality, safe drinking water	3	Leech watershed water appears to be lower quality than Sooke Lake Reservoir.	3	Leech watershed water may be lower quality than Sooke Lake Reservoir.	3
Provide an adequate, long-term supply of drinking water	3	The yield of the Leech watershed is estimated to be greater than that of the Sooke and Goldstream watersheds combined. Seasonal flows require the development of storage impoundment dams for which options are limited and would involve significant capital investment for construction of a new dam. A dam at the inlet of the Leech tunnel will provide additional storage. CRD already has a water license for drinking water use on Leech River. May only be used to replenish Sooke Lake Reservoir in winter months to meet Environmental Flow Needs (EFN) policy in summer months (to be confirmed with Province through discussions).	3	The yield of the Leech watershed is estimated to be greater than that of the Sooke and Goldstream watersheds combined. Seasonal flows require the development of storage impoundment dams for which options are limited and would involve significant capital investment for construction of a new dam. A dam at the inlet of the Leech tunnel will provide additional storage. Could supply Sooke Lake Reservoir in summer months. CRD already has a water license on Leech River.	4
Provide a reliable and efficient drinking water transmission system	3	Redundancy added for water supply.	3	Redundancy added for water supply and additional storage created.	3
2017 Strategic Plan Areas of Focus					
CRD Board Priorities - Sustainable and Livable Region	2	A review of limited water quality from Leech watershed indicates that turbidity is low, but there are times when colour levels are elevated. Filtration facility would likely be required concurrently or prior to the development of this water supply.	3	A review of limited water quality from Leech watershed indicates that turbidity is low, but there are times when colour levels are elevated. Filtration facility would likely be required concurrently with the development of this water supply.	3
Climate Change Impacts - Mitigation and Adaptation	2	Additional yield to refill Sooke Lake Reservoir will be limited to winter months only	3	Additional Leech watershed storage will benefit the replenish of Sooke Lake Reservoir in winter months.	4
Preparing for Emergency and Post - Disaster Water Supply	3	Seasonal supply only to meet Environmental Flow Needs (EFN) requirements in summer months.	3	Year-round supplementary supply to Sooke Lake Reservoir.	4
Supply System Infrastructure Investment - Renewing Existing and Preparing for New Infrastructure	1	First investment towards integration of Sooke and Leech watersheds.	3	Provides for ultimate integration of Sooke and Leech watershed supplies.	4
Planning for the Future Use of the Leech Water Supply Area	1	Provides for seasonal access to the Leech watershed supply.	3	Provides for ultimate integration of Sooke and Leech watershed supplies.	4
Demand Management- Addressing Changing Trends in Water Demand	1	All of the supply Options have a neutral impact on the Demand Management Initiatives.	3	All of the supply Options have a neutral impact on the Demand Management Initiatives.	3
Total- Meeting Strategic Plan Objectives - Total Raw Score		**27**		**32**	
Total- Meeting Strategic Plan Objectives - Total Weighted Score		**57**		**67**	

Table 7.13: Raw Water Transmission Options RWT1 thru RWT4

Raw Water Transmission	Criteria Weighting	Leech River to Sooke Lake Reservoir				Sooke Lake Reservoir to Japan Gulch			
		Option RWT1 - Leech Tunnel to Deception Gulch Reservoir	Score	Option RWT2 - Leech Tunnel to SLR Deep Basin	Score	Option RWT3 - Tunnel	Score	Option RWT4 - Hybrid Pumping/Tunnel	Score
2017 Strategic Plan Commitments									
Provide high quality, safe drinking water	3	Leech River water may be lower quality than Sooke Lake Reservoir. This option has Deception Gulch Reservoir as a transfer point between Leech River intake and Sooke Lake Reservoir. Deception River water is also lower water quality and bottom sediments in Deception Gulch Reservoir are a concern.	3	Leech River water may be lower quality than Sooke Lake Reservoir. This option avoids transferring to Deception Gulch Reservoir.	4	Transmission alignment and conveyance method (gravity vs. pumped) does not impact water quality.	3	Transmission alignment and conveyance method (gravity vs. pumped) does not impact water quality.	3
Provide an adequate, long-term supply of drinking water	3	Excavating Deception Gulch Reservoir would provide an additional storage volume, but excavation and disposal would be costly.	3	A dam at the inlet of the Leech tunnel would provide additional storage. Could supply Sooke Lake Reservoir in winter months.	4	Increases the transmission capacity between Sooke Lake Reservoir and Japan Gulch and provide redundancy.	4	Increases the transmission capacity between Sooke Lake Reservoir and Japan Gulch and provides redundancy	4
Provide a reliable and efficient drinking water transmission system	3	Additional supply but does not impact the lack of transmission redundancy between Sooke Lake Reservoir and Japan Gulch.	3	Additional supply but does not impact the lack of transmission redundancy between Sooke Lake Reservoir and Japan Gulch.	3	Provides full redundancy to the Kapoor Tunnel, SLR intake and Mains 10 &11 required to convey source water from Sooke Lake Reservoir to Japan Gulch. Supply not interrupted during extended periods of power outages. Gravity conveyance is preferred to pumping since it increases the reliability of supply during emergency conditions. Does not allow the connection of the Goldstream Reservoir emergency connection.	4	Provides full redundancy to the Kapoor Tunnel, SLR intake and Mains 10 &11 required to convey source water from Sooke Lake Reservoir to Japan Gulch. Pumping is less reliable than gravity connection. Does not allow the connection of the Goldstream Reservoir emergency connection.	3
2017 Strategic Plan Areas of Focus									
CRD Board Priorities - Sustainable and Livable Region	2	Deception Gulch Reservoir is a shallow reservoir with reported poorer water quality and located adjacent to Sooke Lake Reservoir. Filtration facility would likely be required concurrently with the development of this water supply.	3	A review of limited water quality from Leech watershed indicates that turbidity is low, but there are times when colour levels are elevated. Filtration facility would likely be required concurrently with the development of this water supply.	3	Potential energy recovery at the discharge end of tunnel. Greenhouse gas (GHG) lower than pumped options.	4	Higher GHG impacts due to pumping requirements Lower potential energy recovery at the discharge end of tunnel.	3
Climate Change Impacts - Mitigation and Adaptation	2	Seasonal availability only.	4	Seasonal availability only.	4	Lowest GHG impact of all the Raw Water Transmission Options.	5	Pumping will increase the GHG emissions and impact the carbon footprint for the conveyance system.	4

Raw Water Transmission	Criteria Weighting	Leech River to Sooke Lake Reservoir				Sooke Lake Reservoir to Japan Gulch			
		Option RWT1 - Leech Tunnel to Deception Gulch Reservoir	Score	Option RWT2 - Leech Tunnel to SLR Deep Basin	Score	Option RWT3 - Tunnel	Score	Option RWT4 - Hybrid Pumping/Tunnel	Score
Preparing for Emergency and Post - Disaster Water Supply	3	Emergency backup storage to Sooke Lake Reservoir but has limited storage.	3	Emergency backup storage to Sooke Lake Reservoir.	3	Redundant connection from Sooke Lake Reservoir to Japan Gulch provides security of supply following a natural disaster. Supply not interrupted during extended periods of power outages Gravity conveyance is preferred to pumping since it increases the reliability of supply during emergency conditions Does not allow the connection of the Goldstream Reservoir emergency connection.	5	Redundant connection from Sooke Lake Reservoir to Japan Gulch provides security of supply following a natural disaster. Pump station is a vulnerability since requires continuous power supply. Does not allow the connection of the Goldstream Reservoir emergency connection.	4
Supply System Infrastructure Investment - Renewing Existing and Preparing for New Infrastructure	1	This Deception Gulch Reservoir could serve as a receiving reservoir for water diverted from Leech River, which could then be transferred to Sooke Lake Reservoir via the existing gate and culvert system.	3	No redundancy to the existing Intake Tower. Seasonal access to Leech watershed supply.	3	This connection is the foundation for many other system improvements contemplated in this 2022 Master Plan.	5	This connection is the foundation for many other system improvements contemplated in this 2022 Master Plan.	4
Planning for the Future Use of the Leech Water Supply Area	1	Provides for ultimate integration of Sooke and Leech watershed supplies. May trigger the need for filtration plant.	4	Provides for ultimate integration of Sooke and Leech watershed supplies. May trigger the need for filtration plant.	4	Will accommodate future Leech watershed diversions to Sooke Lake Reservoir.	4	Will accommodate future Leech watershed diversions to Sooke Lake Reservoir.	4
Demand Management - Addressing Changing Trends in Water Demand	1	All the supply Options have a neutral impact on the Demand Management Initiatives.	3	All the supply alternatives have a neutral impact on the Demand Management Initiatives.	3	All of the transmission Options have a neutral impact on the Demand Management Initiatives.	3	All of the transmission Options have a neutral impact on the Demand Management Initiatives.	3
Total- Meeting Strategic Plan Objectives - Total Raw Score		**29**		**31**		**37**		**32**	
Total- Meeting Strategic Plan Objectives - Total Weighted Score		**60**		**66**		**78**		**67**	

Table 7.14: Raw Water Transmission Options RWT5 Thru RWT7

Raw Water Transmission	Criteria Weighting	Sooke Lake Reservoir to Japan Gulch					
		Option RWT5 - Overland route through Leechtown and Jack Lake - 3 PS	Score	Option RWT6 - Overland Council Lake Alignment - 3 & 1 PS	Score	Option RWT7 - Overland Malahat Alignment – 3 & 1 PS	Score
2017 Strategic Plan Commitments							
Provide high quality, safe drinking water	3	Transmission alignment and conveyance method (gravity vs. pumped) does not impact water quality.	3	Transmission alignment and conveyance method (gravity vs. pumped) does not impact water quality.	3	Transmission alignment and conveyance method (gravity vs. pumped) does not impact water quality.	3
Provide an adequate, long-term supply of drinking water	3	Increases the transmission capacity between Sooke Lake Reservoir and Japan Gulch and provides redundancy.	3	Increases the transmission capacity between Sooke Lake Reservoir and Japan Gulch and provides redundancy.	3	Increases the transmission capacity between Sooke Lake Reservoir and Japan Gulch and provides redundancy.	3
Provide a reliable and efficient drinking water transmission system	3	Provides full redundancy to the Kapoor Tunnel, SLR intake and Mains 10 &11 required to convey source water from Sooke Lake Reservoir to Japan Gulch. Pumping is less reliable than gravity connection. Allows the connection of the Goldstream Reservoir Connector.	3	Provides full redundancy to the Kapoor Tunnel, SLR intake and Mains 10 &11 required to convey source water from Sooke Lake Reservoir to Japan Gulch. Pumping is less reliable than gravity connection. Allows the connection of the Goldstream Reservoir Connector.	3	Provides full redundancy to the Kapoor Tunnel, SLR intake and Mains 10 &11 required to convey source water from Sooke Lake Reservoir to Japan Gulch. Pumping is less reliable than gravity connection. Does not allow the connection of the Goldstream Reservoir Connector.	2
2017 Strategic Plan Areas of Focus							
CRD Board Priorities - Sustainable and Livable Region	2	GHG calculations for pumped options score lower than gravity transmission options. Potential energy recovery.	3	GHG calculations for pumped options score lower than gravity transmission options. Potential energy recovery.	3	GHG calculations for pumped options score lower than gravity transmission options. Potential energy recovery.	3
Climate Change Impacts - Mitigation and Adaptation	2	Pumped conveyance of raw water to the treatment facilities is not impacted by climate change.	3	Pumped conveyance of raw water to the treatment facilities is not impacted by climate change.	3	Pumped conveyance of raw water to the treatment facilities is not impacted by climate change.	3
Preparing for Emergency and Post - Disaster Water Supply	3	This alignment would facilitate the connection of the Goldstream Reservoir to Japan Gulch using a shared pipe. Goldstream connection is a gravity supply.	4	This alignment would facilitate the connection of the Goldstream Reservoir to Japan Gulch using a shared pipe. Goldstream connection is a gravity supply.	4	This alignment would not allow the connection of the Goldstream Reservoir to Japan Gulch using a shared pipe. Goldstream connection is a gravity supply. Pumping is less reliable during emergency conditions. Reliability of supply is less secure.	3
Supply System Infrastructure Investment - Renewing Existing and Preparing for New Infrastructure	1	This connection is the foundation for many other system improvements contemplated in this 2022 Master Plan.	4	This connection is the foundation for many other system improvements contemplated in this 2022 Master Plan.	4	This connection is the foundation for many other system improvements contemplated in this 2022 Master Plan.	4
Planning for the Future Use of the Leech Water Supply Area	1	Will accommodate future Leech watershed diversions to Sooke Lake Reservoir.	4	Will accommodate future Leech watershed diversions to Sooke Lake Reservoir.	4	Will accommodate future Leech watershed diversions to Sooke Lake Reservoir.	4
Demand Management - Addressing Changing Trends in Water Demand	1	All of the transmission Options have a neutral impact on the Demand Management Initiatives.	3	All of the transmission Options have a neutral impact on the Demand Management Initiatives.	3	All of the transmission Options have a neutral impact on the Demand Management Initiatives.	3
Total- Meeting Strategic Plan Objectives - Total Raw Score		**30**		**30**		**28**	
Total- Meeting Strategic Plan Objectives - Total Weighted Score		**62**		**62**		**56**	

Table 7.15: Treatment Options T1 thru T3

Treatment Options	Criteria Weighting	Treatment Plant Siting					
		Option T1 - Sooke Lake Reservoir	Score	Option T2 - Japan Gulch	Score	Option T3 - Japan Gulch & Sooke River Road	Score
2017 Strategic Plan Commitments							
Provide high quality, safe drinking water	3	Sooke Lake Reservoir site is an additional 10+km from Japan Gulch and may result in some water quality degradation during transmission.	4	The shorter transmission distance from Japan Gulch to end users will ensure that there is minimal water quality degradation in the transmission pipes.	5	Having 2 treatment facilities to operate and maintain could result in different water quality from the 2 facilities.	4
Provide an adequate, long-term supply of drinking water	3	Sooke Lake Reservoir location cannot treat water from the Goldstream watershed using existing means of conveyance.	3	Japan Gulch location can treat water from the Goldstream watershed using existing means of conveyance.	4	Japan Gulch location can treat water from the Goldstream watershed using existing means of conveyance. Sooke River Road location cannot treat Goldstream Reservoir supply.	4
Provide a reliable and efficient drinking water transmission system	3	Location provides the ability to supply the JDFWD service area from a single facility, eliminating the need for filtration treatment at the Sooke River Road disinfection facility or a costly Langford/JDFWD transmission main. Does not require repumping after treatment.	5	Japan Gulch site will require additional transmission mains and pump stations to Sooke. This location will require low lift pumping as the head must be broken to accommodate gravity granular media or membrane filtration.	4	2 treatment facilities to operate and maintain.	3
2017 Strategic Plan Areas of Focus							
CRD Board Priorities - Sustainable and Livable Region	2	All the location alternatives support the Sustainable and Living Region priorities.	3	All the location alternatives support the Sustainable and Living Region priorities. This Option requires the decommissioning of the Japan Gulch dam.	3	All the location alternatives support the Sustainable and Living Region priorities. This Option requires the decommissioning of the Japan Gulch dam.	
Climate Change Impacts - Mitigation and Adaptation	2	Carbon footprint for plant site is largest of 3 alternatives due to longer travel distance. Significant impacts on natural habitat to construct new access road and extend BC Hydro power supply.	4	Carbon footprint for plant site smallest of 3 alternatives due to shorter travel distance for construction traffic and ongoing operations traffic. Loss of natural habitat is minimal.	5	Carbon footprint for 2 plant site is greater than Japan Gulch centralized site.	
Preparing for Emergency and Post - Disaster Water Supply	3	Poor access to site during emergencies and natural disasters. Gravity supply will not be affected by power outages.	3	More accessible site during emergencies and natural disasters. Pumping required which could be impacted during extended power failures.	4	More accessible site during emergencies and natural disasters. Pumping required which could be impacted during extended power failures.	
Supply System Infrastructure Investment - Renewing Existing and Preparing for New Infrastructure	1	Site will likely require multiple operations groups at filtration plant and UV/chloramination facility.	3	Site is adjacent to existing IWS treatment processes and control center.	5	Sooke River Road would likely be operated as unattended site with remote monitoring from JG or Sooke Lake Reservoir site.	
Planning for the Future Use of the Leech Water Supply Area	1	No differences between siting Alternatives.	3	No differences between siting Alternatives.	3	No differences between siting Alternatives.	
Demand Management - Addressing Changing Trends in Water Demand	1	Neutral impact on the Demand Management Initiatives.	3	Neutral impact on the Demand Management Initiatives.	3	Neutral impact on the Demand Management Initiatives.	
Total- Meeting Strategic Plan Objectives - Total Raw Score		**31**		**36**		**30**	
Total- Meeting Strategic Plan Objectives - Total Weighted Score		**68**		**78**		**66**	

Table 7.16: Treatment Options T4 thru T6

Treatment Options	Criteria Weighting	Filtration Plant Technology					
		Option T4 - Direct Filtration	Score	Option T4 - Dissolved Air Floatation	Score	Option T4 - Membrane Filtration	Score
2017 Strategic Plan Commitments							
Provide high quality, safe drinking water	3	Direct filtration is considered most suitable for relatively stable sources that consistently demonstrate low turbidity and low organic matter.	3	DAF is the most appropriate form of clarification to provide more consistent and reliable treatment performance. Can deal with future Leech River colour levels as well as algae.	4	Removes particles having nominal sizes of 0.1 µm for MF and 0.01 µm for UF by physical sieving at the interface of a fiber membrane MF/UF is an effective method of producing very low turbidity filtrate (< 0.1 NTU). Provides an absolute barrier to protozoan oocysts.	5
Provide an adequate, long-term supply of drinking water	3	Cost effective filtration at large scale has most commonly been achieved using gravity based granular media filtration. Direct filtration may receive 2.5-log removal credit for oocysts. This would lower the inactivation requirements of subsequent UV disinfection, but 0.5 log inactivation is still required through use of UV to meet guidelines. Virus inactivation would be obtained chiefly by using free chlorine, though 1.0-log credit is provided to direct filtration for virus removal.	3	Potential future augmentation of source supply capacity using the Leech watershed may impose more challenging treatment conditions depending on the timing of water draws from the Leech system and how it is incorporated into the Sooke supply. DAF will be used in combination with filtration to provide a more robust treatment train for varying raw water conditions.	4	MF/UF is an effective method of producing very low turbidity filtrate (< 0.1 NTU), effectively providing an absolute barrier to protozoan cysts and oocysts. Multiple skids or cassettes assembled into trains yields a large surface area for filtration which occupies a small footprint, providing significant benefit when space is limited.	4
Provide a reliable and efficient drinking water transmission system	3	Filtration technologies options have a neutral impact on the water transmission system.	3	Filtration technologies options have a neutral impact on the water transmission system.	3	Filtration technologies options have a neutral impact on the water transmission system.	3
2017 Strategic Plan Areas of Focus							
CRD Board Priorities - Sustainable and Livable Region	2	Carbon footprint for plant construction is smallest of 3 alternatives. Lowest power consumption.	5	Carbon footprint for plant construction is largest of 3 alternatives. Middle power consumption.	3	Carbon footprint for plant construction is middle of 3 alternatives. Highest power consumption.	4
Climate Change Impacts - Mitigation and Adaptation	2	Direct filtration will provide good water treatment for treatment raw water quality that may have been degraded by climate change. Carbon footprint for plant construction is smallest of 3 alternatives. Lowest power consumption.	5	Treatment technology is more robust for treatment raw water quality that may have been degraded by climate change. Carbon footprint for plant construction is largest of 3 alternatives. Middle power consumption.	3	Treatment technology is most robust for treatment raw water quality that may have been degraded by climate change, but pre-treatment will still be required for colour removal. Carbon footprint for plant construction is middle of 3 alternatives. Highest power consumption.	4
Preparing for Emergency and Post - Disaster Water Supply	3	Will provide high quality water post-disaster and during emergency conditions.	4	Will provide high quality water post-disaster and during emergency conditions.	4	Will provide high quality water post-disaster and during emergency conditions	4
Supply System Infrastructure Investment - Renewing Existing and Preparing for New Infrastructure	1	Supplemental pre-treatment processes may be required once other water sources are blended with Sooke Lake Reservoir raw water. Modular design will allow for phased construction to match demand growth.	3	DAF technology combined with granular media filtration will provide high quality treatment for future Leech watershed raw water. Modular design will allow for phased construction to match demand growth.	4	UF/MF technology will provide high quality treatment. Modular design will allow for phased construction to match demand growth.	3
Planning for the Future Use of the Leech Water Supply Area	1	Suitable for treatment of lower quality Leech watershed water. Will not remove colour.	3	Suitable for treatment of lower quality Leech watershed water. Will remove colour.	4	Suitable for treatment of lower quality Leech watershed water. Will not remove colour.	3
Demand Management - Addressing Changing Trends in Water Demand	1	All the treatment alternatives have a neutral impact on the Demand Management Initiatives	3	All the treatment alternatives have a neutral impact on the Demand Management Initiatives	3	All of the treatment alternatives have a neutral impact on the Demand Management Initiatives.	3
Total- Meeting Strategic Plan Objectives - Total Raw Score		32		32		33	
Total- Meeting Strategic Plan Objectives - Total Weighted Score		68		68		70	

7.5 Summary of Options Evaluation and Development of Alternative Plans

Table 7.17, on the following page, summarizes the raw and weighted scoring of the 18 Options for future improvements for the Regional Water Supply. These are relative scorings and show how well the Options align with the 2017 Strategic Plan objectives. Cost estimates for the 18 Options are included in **Table 7.17**.

There are numerous other projects related to Treated Water Transmission and Storage that were not included in Section 8.2 Options Evaluation. **Table 7.18** shows these additional projects that have been concluded in previous engineering studies and considered essential to maintaining the Level of Service to the local municipal customers. These projects are common to the Alternative Plans that will be developed and evaluated in the following section.

In addition to the transmission projects listed in Table 7.18, there are other projects discussed in Section 6 of this report that require further study and should be included in the recommended program of improvements. These other projects include:

- Goldstream Reservoir Connector
- Goldstream Connector Head Tank
- Balancing Head Tank at Japan Gulch Filtration Plant
- Smith Hill Storage Tank and Pump Station
- East -West Connector Transmission Main

Table 7.17: Scoring Summary and Cost Estimates

Category	Component	Options	Option	Raw Score	Weighted	Cost M$2022
Supply	Sooke Lake Reservoir (Intake)	S1	Deep Northern Intake	37	80	$46.90
		S2	Lake Bottom Marine Intake	31	67	$16.20
		S3	Floating Pump Station Intake	33	69	$65.2*
	Leech Watershed (Intake)	S4	Leech River Diversion Intake to Leech Tunnel	27	57	$16.7**
		S5	Leech River Dam	32	67	$115**
Raw Water Transmission	Leech River to Sooke Lake Reservoir	RWT1	Leech Tunnel to Deception Gulch Reservoir	29	60	$105.60
		RWT2	Leech Tunnel to Sooke Lake Reservoir deep basin	31	66	$32.40
	Sooke Lake Reservoir to Japan Gulch	RWT3	Sooke Lake Reservoir to Japan Gulch tunnel	36	75	$390
		RWT4	Hybrid pumping/tunnel	31	64	$540
		RWT5	Overland route through Leechtown and Jack Lake – 3 PS	30	62	$486
		RWT6	Overland Council Lake Alignment – 3 &1 PS	30	62	$454 - $699
		RWT7	Overland HWY 1 Malahat Alignment - 3 &1 PS	28	56	$508 - $809
Filtration	Siting	T1	Sooke Lake Reservoir	31	68	Base Case + $25M
		T2	Japan Gulch	36	78	Base Case
		T3	Japan Gulch + Sooke River Road	30	66	Base Case + $15M
	Treatment Technologies	T4	Direct Filtration	32	68	$736
		T5	Dissolved Air Flotation with filtration	32	68	$852
		T6	Membrane Filtration	33	70	$969

*Indicative based on SPU Lake Morse project

**From 1994 Plan adjusted by 2.31 multiplier ENR CCI (2022)/ENR CCI (1994) to be confirmed following geotechnical and environmental studies. Indirect costs added.to 1994 estimate.

Table 7.18: Treated Water Transmission Projects

Phase 1 - Implementation Recommended by 2025	
Watkiss PCS Upgrade	Upsize inlet to 1,050 mm ø and outlet piping to 1,200 mm ø for both No. 1 and No. 4 Mains
	Decommission existing Watkiss PCS lead PRV and replace with two 600 mm diameter lead PRVs
	Revise downstream HGL settings for lead Watkiss PRVs to 105.5 m
Increase HGL of Main No. 1 from 116m to 169m	Implement valving changes along the length of Main No. 1, from Humpback PCS to Watkiss PCS.
	Install five (5) new PCSs to provide redundancy to Main No. 3 and to maintain existing connections with the JDFWD. • Irwin Road & Creekside Trail, connecting Main No. 1 to JDFWD 116 m pressure zone. • Glen Lake Road, connecting Main No. 1 to Main No. 8. • Rex Road & Jacklin Road, connecting Main No. 1 to Main No. 3 and JDFWD 116 m pressure zone. • Goldstream Avenue & Whitehead Place, connecting Main No. 1 to Main No. 7. • Atkins Road & Traverse Terrace, connecting Main No. 1 to JDFWD 116 m pressure zone.
	Revise setpoint of the Millstream PCS lead PRV to achieve downstream HGL of 114 m.
Phase 2 - Implementation recommended between 2025 and 2038, recommended by 2030	
Implement part 1 Main No.4 Upgrades	Upsize 4.6 km of pipe to 1,350 mm ø from Goldstream Avenue at Veterans Memorial Parkway to the Watkiss PCS Inlet. Transmission mains upsize should consider longer term planning horizon of at least 75 years.
Add 3rd Main from Sooke Lake to Head Tank	Install 1,200 mm ø main from Sooke Lake Reservoir to Head tank to provide increased capacity and redundancy
Phase 3 - Implementation recommended between 2038 and 2050	
Implement part 2 of Main No.4 Upgrades	Upsize 6.3 km of pipe to 1,500 mm ø from Niagara Main (near Goldstream Disinfection Facility) to Goldstream Avenue at Veterans Memorial Parkway. Transmission main size should consider longer term planning horizon of at least 75 years.
Phase 4 - Implementation recommended by 2050 planning horizon	
Twin Critical Main No. 3	Twin 4.6 km of Main No.3 (813/991mm diameter) from Dupplin Road at Tolmie Lane to Lansdowne Road at Foul Bay Road to address capacity.
Twin Critical Main No. 4	Twin 2.6 km of Main No. 4 (743mm diameter) from the old connection with Haliburton Tank to Patricia Bay Highway at Hamsterly Road.
	Twin 3.1 km of Main No. 4 (610/762mm diameter) from Central Saanich Rd at Mount Newton Cross Road to Aldous Terrace at Lowe Rd.
	Twin 0.6 km of Main No. 4 (1,219/1,321mm diameter) for redundancy from the connection with Goldstream Supply Area to the Goldstream Disinfection Facility inlet or add a connection from Goldstream Supply Area directly to Main No. 5, which would remain normally closed except under emergency situations.

It was decided to preselect preferred Options for the Supply and Treatment Categories to limit the number of Alternatives to evaluate.

7.5.1 Supply

Based on the scoring of Supply Options and the cost estimates provided in Table 7.17, Options S1 – Deep Northern Intake and Option S3 – Floating Pump Station are the preferred Options for improving the security of supply. Although Option S1 has the highest score and the lower cost, there is limited engineering completed on this option and it does not provide flexibility to stage construction for lower level of service. It is recommended that Option S3 – Floating Pump Station be included in the recommended program of improvements at this time and the Deep Northern Intake be further evaluated in the future at preliminary design once geotechnical investigations are completed.

7.5.2 Treatment

There are two issues for consideration–siting and technology for the filtration plant. Based on the detailed evaluation of filtration options presented in Section 5.3 of this report and the financial analysis, it is clear that direct filtration is the most cost-effective filtration technology for the Regional Water Supply. The final process technology will be confirmed through a pilot study.

From the evaluation of siting Options shown in **Table 8.6**, the Japan Gulch location is the highest scored Option.

All Alternatives for further consideration will include a direct filtration treatment plant at the Japan Gulch location.

7.5.3 Raw Water Transmission

There are five Options for Raw Transmission between Sooke Lake Reservoir and Japan Gulch which include:

RWT3	Sooke Lake Reservoir to Japan Gulch tunnel
RWT4	Hybrid pumping/tunnel
RWT5	Overland route through Leechtown and Jack Lake – 3 PS or 1 large high lift pump station
RWT6	Overland Council Lake Alignment – 3 PS
RWT7	Overland Malahat Alignment - 3 PS

These options can be further reduced to 3 options:

1. Gravity tunnel RWT3
2. Hybrid pumping/gravity tunnel RWT4
3. Pumped conveyance RWT5

For the pumped Options, RWT5 (Jack Lake Alignment) is the lowest cost option at $486 M. Options RWT6 and RWT7 were not included in the Alternative Plans since they are more expensive pumping Options. When the project proceeds in the future, the design engineer should re-evaluate all three options based on prevailing conditions at the time of construction

The CRD has requested that Stantec include a Pumped Alternative at a lower level of service flow or 2100 ADD. The size of the transmission main can be reduced from 2.4 m to 1.2 m. The cost of the pump stations and transmission mains for this lower pumping rate reduced from $486 M to $292 M.

Four Alternatives were developed by comparing Options for further evaluation and foundation of the recommended plan of improvements.

Table 7.19: Alternative Plans for Regional Water Supply

Alternatives	Filtration Plant Site	Sooke Lake Reservoir to Japan Gulch Transmission Options	Cost 2022$ Sooke Lake Reservoir to Japan Gulch Transmission Only
Alternative 1	Japan Gulch (T2)	Pumped at 2100 ADD demand (RWT5*)	$292 M
Alternative 2	Japan Gulch (T2)	Pumped at 2100 MDD demand (RWT5)	$486 M
Alternative 3	Japan Gulch (T2)	Tunnel (RWT3)	$390 M
Alternative 4	Japan Gulch (T2)	Hybrid pumping/tunnel (RWT4)	$540 M

RWT5* is the Jack Lake transmission main alignment with the pump stations and transmission sized for 2100 ADD flow (377 MLD)

The four Alternatives are based on a direct filtration treatment plant located at Japan Gulch and 4 different raw water transmission options. The filtration plant and the Sooke Lake Reservoir to Japan Gulch Transmission Options are the two highest capital cost components of this 2022 Master Plan.

For the evaluation of Alternatives, only the three commitments from the Strategic Plan were considered rather than the 3 Commitments and the 6 Areas of Focus. In addition, IWS has identified additional criteria that should be considered when evaluating the Alternatives. These criteria include:

1. Level of Service maintenance/improvement opportunities
2. Resolves needs gap in engineered assets
3. Redundancy and security of supply

The intent of evaluating the Alternative against these additional criteria is to assess how well these Alternatives meet the operational needs of the RWS to provide an adequate long-term supply and safe drinking water.

In addition to the non-financial criteria, the evaluation of Alternatives needs to consider capital and operating cost.

The four Alternatives were evaluated against six non-financial criteria using a 1-10 scoring system. The maximum non-financial score for any Alternative is 60 points.

The costs for the four Alternatives are scored with lowest cost getting 40 points and highest cost getting 0 points and the other Alternatives scored by prorating to the lowest cost Alternative.

7.6 Comparison of Alternatives and Conclusion

Table 7.20 presents a comparison for the four Alternatives with scoring for the six non-financial criteria. The financial scoring is shown on the bottom of the table.

The financial score was calculated based on 40 points to the lowest cost, 0 points to the highest cost and the other two Options costs prorated between low and high cost.

Based on this analysis, the preferred Raw Water Transmission Option is Alternative 1 – Pumping at 2100 ADD Jack Lake Alignment RWT5*.

Table 7.20: Evaluation of Alternatives 1-4

Criteria	Alternative 1 (T2/T4 + RWT5*)		Alternative 2 (T2/T4 + RWT5)		Alternative 3 (T2/T4 + RWT3)		Alternative 4 (T2/T4 + RWT4)	
	Pumping @ 2100 ADD (Jack Lake alignment)	Score	Pumping @ 2100 MDD (Jack Lake alignment)	Score	Tunnel	Score	Hybrid Pumping/Tunnel	Score
Provide high quality, safe drinking water	High level of treatment will ensure that there is minimal water quality degradation in the transmission pipes.	9	High level of treatment will ensure that there is minimal water quality degradation in the transmission pipes.	9	High level of treatment will ensure that there is minimal water quality degradation in the transmission pipes.	9	High level of treatment will ensure that there is minimal water quality degradation in the transmission pipes.	9
Provide an adequate, long-term supply of drinking water	Pumping sized for reduced level of service only (2100 ADD)	7	Pumping sized for full redundancy of Kapoor Tunnel. (2100 MDD)	8	Gravity supply at 2100 MDD.	10	Pumping sized for full redundancy of Kapoor Tunnel. (2100 MDD)	8
Provide a reliable and efficient drinking water transmission system	Low lift pumping to HGL 169m as the head must be broken to accommodate gravity granular media or membrane filtration. Raw Water Transmission pumping may be sized for reduced level of service only.	7	Low lift pumping to HGL 169m as the head must be broken to accommodate gravity granular media or membrane filtration. Raw Water Transmission pumping may be sized for reduced level of service only.	7	Low lift pumping to HGL 169m as the head must be broken to accommodate gravity granular media or membrane filtration.	8	Low lift pumping to HGL 169m as the head must be broken to accommodate gravity granular media or membrane filtration. Raw Water Transmission pumping could be sized for reduced level of service only.	7
Level of Service maintenance and/or /improvement	RWS currently does not have filtration treatment. Japan Gulch site could accommodate at plant sized for 2050 MDD and expandable to 2100 MDD Site could accommodate additional pre-treatment processes if water quality deteriorates in the future due to climate change or different water supply sources. Site will treat raw water from Sooke, Leech and Goldstream watersheds. Pumped connection is sized for 2100 ADD demand. Reduced LoS.	7	RWS currently does not have filtration treatment. Japan Gulch site could accommodate at plant sized for 2050 MDD and expandable to 2100 MDD. Site could accommodate additional pre-treatment processes if water quality deteriorates in the future due to climate change or different water supply sources. Site will treat raw from Sooke, Leech and Goldstream watersheds. Pumped connection may be sized for emergency flow only. Site is adjacent to existing IWS treatment processes and control center.	6	RWS currently does not have filtration treatment. Japan Gulch site could accommodate at plant sized for 2050 MDD and expandable to 2100 MDD Site could accommodate additional pre-treatment processes if water quality deteriorates in the future due to climate change or different water supply sources. Site will treat raw from Sooke, Leech and Goldstream watersheds. Tunnel connection would be sized for 2100 MDD flows Site is adjacent to existing IWS treatment processes and control center.	9	RWS currently does not have filtration treatment. Japan Gulch site could accommodate at plant sized for 2050 MDD and expandable to 2100 MDD Site could accommodate additional pre-treatment processes if water quality deteriorates in the future due to climate change or different water supply sources. Site will treat raw from Sooke, Leech and Goldstream watersheds Pumped connection may be sized for emergency flow only. Site is adjacent to existing IWS treatment processes and control center.	8
Resolves needs gap deficiency	Provides filtration which does not currently exist and improves connectivity between water supply sources and Japan Gulch. Pumped connections less preferred to gravity connections.	7	Provides filtration which does not currently exist and improves connectivity between water supply sources and Japan Gulch. Pumped connections less preferred to gravity connections.	7	Provides filtration which does not currently exist and improves connectivity between water supply sources and Japan Gulch	9	Provides filtration which does not currently exist and improves connectivity between water supply sources and Japan Gulch. Pumped connections less preferred to gravity connections.	8
Redundancy and security of supply	Provides partial redundancy to the Kapoor Tunnel and Mains 10 &11 required to convey source water from Sooke Lake Reservoir to Japan Gulch. Pumping is less secure than gravity connections. More pump stations with this alternative. Pumped connection sized initially for emergency supply only (2100 ADD).	6	Provides partial redundancy to the Kapoor Tunnel and Mains 10 &11 required to convey source water from Sooke Lake Reservoir to Japan Gulch. Pumping is less secure than gravity connections. More pump stations with this alternative. Pumped connection may be sized for 2100 MDD.	7	Provides full redundancy to the Kapoor Tunnel, SLR intake and Mains 10 &11 required to convey source water from Sooke Lake Reservoir to Japan Gulch.	9	Provides partial redundancy to the Kapoor Tunnel and Mains 10 &11 required to convey source water from Sooke Lake Reservoir to Japan Gulch. Pumping is less secure than gravity connections. Pumped connection may be sized initially for emergency supply only.	8
Total Non-Financial Score	**43**		**44**		**54**		**48**	
Cost ($M)	**$292M**		**$486M**		**$390M**		**$540**	
Financial Score	**40**		**9**		**24**		**0**	
Combined Score	**83**		**53**		**78**		**48**	

7.7 2022 Master Plan Recommended Program of Improvements

Table 7.21 provides a summary of the improvements recommended in this 2022 Master Plan to the year 2050 based on a direct filtration treatment plant located at Japan Gulch and providing emergency redundancy to Kapoor Tunnel with a pumped overland transmission system at 2100 ADD flow. The Sooke Lake Reservoir Floating Pump Station/Intake is recommended as the preferred Option to achieve redundancy to the Intake Tower. A connection from the Goldstream Reservoir to Japan Gulch is included in the recommended program.

Table 7.21: 2022 Master Plan Recommended Program of Improvements

Alternative 1 – Direct Filtration Treatment Plant at Japan Gulch			Cost ($M) (2022)
Supply	S3	Deep Northern Intake/Floating Pump Station	$72.5[A]
	S4/RWT1	Leech River Diversion	$16.7
	M1	Sooke Lake Saddle Dam Hydraulic Improvements	$10.0
Water Treatment	T2/T4	Japan Gulch Dam Decommissioning	$10.3
	T2/T4	Direct Filtration	$736.2
	T2/T4	Clearwell	$24.0
	T2/T4	Treated Water Pump Station	$29.8
	M2	Japan Gulch Water Filtration Plant Stage 2 Balancing Tank	$15.4
Raw Water Transmission Mains	M3	DNI Transmission Main to Head Tank	$38.8
	M4	3rd Main - Sooke Lake Dam to Head Tank	$7.4
	RWT5*	Jack Lake - Head Tank to Japan Gulch + 2 PS @ 2100 ADD	$208.7
Goldstream Reservoir Connector	M5	Goldstream Dam to Japan Gulch	$67.1
	M6	Stage 1 Balancing Tank	$5.5
Treated Water Transmission Mains	M7	Phase 1 Upgrades	$7.5
	M8	Phase 2 Upgrades	$38.2
	M9	Phase 3 Upgrades	$55.3
	M10	Phase 4.1 Upgrades	$47.7
	M11	Phase 4.2 Upgrades	$48.9
East-West Connector	M12	Option 2 Transmission Main	$58.6
Storage Tank	M13	Smith Hill Storage Tank	$12.8
	M14	Smith Hill Tank Pump Station	$17.1
		Total	**$1,528**

[A]Based on SPU Morse Lake Pump Station project
*Jack Lake alignment with Pump Stations and transmission main sized for 2100 ADD Level of Service flow ~375 ML

8.0 OPINION OF PROBABLE COSTS FOR RECOMMENDED IMPROVEMENTS

8.1 Basis of Capital Estimates

The Opinions of Probable Cost were prepared using the parametric estimating method. This approach is beneficial when little or no design information is available and is used at early project stages including Master Planning and Project Definition. The estimate is a Class D indicative estimate and will have an accuracy of +/- 50%. Costs from recent, similar projects provide valuable information, but the historical data must always be reviewed to ensure it aligns with current market conditions at time of tender. Cost estimates should be updated following completion of preliminary design.

The recommended improvements included in this 2022 Master Plan are based on conceptual or planning level of detail without preliminary or detailed design engineering. No new geotechnical investigations were completed as part of this study. Geotechnical information is limited to available investigations completed for previously completed projects in the RWS and may not be applicable to site specific conditions which can only be determined by future investigations on a site specific basis.

The parametric method produces a high-level estimate using various factors (parameters) developed from similar past projects, historical databases, engineering practices, and technologies, such as:

- Cost per metre of watermain
- Cost per m^3 of tank volume
- Cost per MLD of treatment capacity
- Cost per MLD of pumping capacity

This method of estimating is sometimes referred to as Rough Order of Magnitude (ROM) by PMP designated professionals. Further refinement of cost class estimates to a higher level of accuracy requires preliminary design. All cost estimates are in 2022 Canadian dollars.

8.1.1 Estimate Exclusions

The following items have not been considered or included in the preliminary Opinion of Probable Cost estimates.

- Land or right-of-way acquisition
- Subsurface conditions
- Hazardous material removal and disposal
- Foreign exchange fluctuations
- Commodity price excursions
- Risk assessment and mitigation
- Unforeseen excessive inflation increases over historical annual rates
- Any new equipment for plant operations (i.e., forklifts, trucks, etc.)

8.1.2 Direct and Indirect Costs

In preparing planning level budget estimates, the Capital Regional District has used certain direct and indirect costs as described below.

8.1.2.1 Direct Costs

Direct costs are line items that are included in the tender Schedule of Quantities and Prices. The following items are included in the Opinions of Probable Cost estimates for construction costs:

Mobilization/Demobilization	2%
Bonding	1.5%
Insurance	1.5%
General Conditions (Division 1 requirements)	10%
Construction Contingency	35%
Inflation to Mid-point of Construction - (% per annum)	2%

% are applied to Total Construction Costs

Total Construction Costs are the sum of the items in the Schedule of Quantities and Prices excluding Mobilization/Demobilization, Bonding, Insurance, General Conditions, Construction Contingency, and Inflation to mid-point of construction.

Recently annual inflation has been higher than 2% but over the long-term inflation rates have generally been in the 2 to 2.5% range. The CRD should revisit inflation estimates at the time of finalizing costs for projects once schedules are better refined and preliminary engineering and investigations are complete.

8.1.2.2 Indirect Costs

Indirect costs are other soft costs that the CRD include in their Capital Budget estimates. The following items are included in the Opinions of Probable Cost estimates:

Engineering (% of Direct Costs)	15%
Administration & Program Management (% of Direct Costs)	6%
Miscellaneous/Specialty Consultants (% of Direct Costs)	2%

% are applied to Total Direct Costs

Direct Costs include Total Construction Costs plus Mobilization/Demobilization, Bonding, Insurance, General Conditions, Construction Contingency, and Inflation to mid-point of construction.

8.1.2.3 Other Estimate Allowances

The CRD frequently includes the following allowances as a percentage of Direct + Indirect Costs in preparing capital budget estimates:

Interim Financing (% of Subtotal)	0%
Project Contingency (% of Subtotal)	5%

Interim financing accounts for Interest during Construction which typically applies to Alternative Service Delivery procurement projects. Since the procurement model for the Water Master Plan projects has not been determined, there is no allowance for Interim Financing in the Opinions of Probable Cost estimates.

8.1.3 Allowance for Contingency

Contingency includes considerations for errors, omissions, and unknowns which are fully expected to occur, but which cannot be specifically identified at the time of the estimate, and, if not considered, underestimate the final installed cost and result in an overrun. Contingency is not meant to cover functional scope changes, acts of God, unusual economic situations, or gross estimate inaccuracies.

Since these projects are developed only to conceptual level of planning, a construction contingency of 35% has been applied to the estimated construction costs, consistent with industry best practices.

In addition, an overall project contingency of 5% has been applied to the total direct + indirect costs for each project.

8.1.4 Allowance for Inflation to Midpoint of Construction

The construction cost estimates are based on 2022 dollars. The estimated 2022 construction costs have been escalated by 2% per year to the midpoint of construction. Inflation rates could be higher depending on market conditions at time of tender.

8.1.5 Accuracy

Engineers and Geoscientists BC (EGBC) provide the following classification definition and accuracy estimate:

> *Class D estimate (±50%): A preliminary estimate which, due to little or no site information, indicates the approximate magnitude of cost of the proposed project, based on the client's broad requirements. This overall cost estimate may be 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.*

8.2 Proposed Deep Northern Intake Capital Costs

A 2021 study by Stantec concluded that a deep northern intake into Sooke Lake Reservoir would provide benefits in terms of improved raw water quality, emergency water supply, resiliency of supply during drought conditions and improvements in water quality. The final approach to which option is used for the deep northern intake, a micro tunneled intake/fixed shore pump station or a floating pump station can be determined at the preliminary engineering phase. For planning purposes, the most expensive option has been used for cost estimates.

The Deep Northern Intake project is comprised of four (4) primary component projects. The extension of the transmission main to Japan Gulch can be deferred until after the WFP at Japan Gulch is constructed. **Table 8.1** shows the costs and timing of these four (4) projects.

Table 8.1: Deep Northern Intake Projects

Deep Northern Intake	2022 $	Inflated $	Start of Construction	Duration (years)
Floating Pump Station	$72,505,000	$87,929,000	2030	4
DNI Transmission Main DNI Pump Station to Sooke Lake Head Tank	$38,768,000	$47,483,000	2031	2
3rd Main - Sooke Lake Dam to Sooke Lake Head Tank	$7,384,000	$9,134,000	2032	2
Jack Lake Transmission Main from Sooke Lake Head Tank to Japan Gulch	$208,649,000	$284,959,000	2036	3

8.3 Phase 2 Seismic Assessments

In 2021, Stantec completed a high-level *Seismic Assessment of Critical Facilities Study – Phase 1* which serves as a register of all major facilities and includes their importance within the Regional Water Supply, year of construction, foundation type, superstructure type, seismic force resisting system, and seismic code in place at time of design.

Assets requiring a Phase 2 seismic assessment have been identified and categorized in order of importance and risk with approximate costs. The Phase 2 seismic assessments will typically consist of site reconnaissance to determine missing structural element sizes and piping connections to below grade walls and slabs, geotechnical field exploration to determine the latest seismic site class, ground accelerations, and soil bearing capacities, followed by a detailed seismic assessment to the latest National Building Code of Canada. The detailed seismic assessment would include preparation of Issued for Tender detailed drawings and specifications.

The estimated costs to complete Phase 2 assessments for primary, secondary, and tertiary structures are approximately $1,500,000, $745,000, and $700,000, respectively, for total cost of $2,945,000. This cost does not include the potential capital costs to complete the seismic upgrades, if needed.

8.4 Goldstream Reservoir Connector to Japan Gulch

A project (Alternative A, a2) was identified in the 1994 Plan to improve system resiliency and includes construction of a new connection from the Goldstream Lake Reservoir to the proposed water filtration plant location at Japan Gulch and decommissioning the existing Japan Gulch Reservoir. A proposed transmission main could be constructed to bring water to the Japan Gulch site from Goldstream Lake Reservoir. The conceptual design of this transmission main includes a balancing tank upstream of Japan Gulch at a HGL of 169m, the same as the Sooke Lake Head Tank.

Table 8.2: Goldstream Reservoir Connector

Goldstream Connector	2022$	Inflated $	Start of Construction	Duration (years)
Goldstream Dam to Japan Gulch	$67,075,000	$82,971,000	2032	2
Goldstream 169m Head Tank	$5,538,000	$6,850,000	2032	2

8.5 Large Diameter Transmission Main Capacity Improvements

The Hydraulic Capacity Assessment Report by GeoAdvice included a hydraulic analysis of the transmission mains to estimate headloss for various future flow conditions to the 2050 planning horizon. A summary of recommended improvements is described in Section 6.1.3 of this 2022 Master Plan. The upgrades listed in **Table 8.3** were recommended to mitigate identified hydraulic capacity deficiencies. Cost estimates in 2022 dollars and inflated dollars are included in Table 8.3 for the four phases of the improvement program.

In the long term, an East-West connector main to Juan de Fuca Water District is recommended with sufficient capacity to provide treated water to West Shore communities. Three options for route to the new transmission main have been considered in this study. Option 2 was selected as the preferred option for calculation of an opinion of Probable Cost.

The East-West Connector transmission main is shown from 2035 to 2037 in the long-term capital budget to coincide with construction of water filtration facilities. The construction timing of this main should be reviewed and should be coordinated with the construction of the water filtration plant so that filtered water can be provided to Juan de Fuca Water Distribution.

Table 8.3: Large Diameter Treated Water Transmission Main Capacity Improvements

Option	Phase 1 - Implementation Recommended by 2025		2022$	Inflated
M6	Watkiss PCS Upgrade	Upsize inlet to 1,050 mm ø and outlet piping to 1,200 mm ø for both No. 1 and No. 4 Mains	$7,499,000	$7,838,000
		Decommission existing Watkiss PCS lead PRV and replace with two 600 mm diameter lead PRVs		
		Revise downstream HGL settings for lead Watkiss PRVs to 105.5 m		
	Increase HGL of Main No. 1 from 116m to 169m	Implement valving changes along the length of Main No. 1, from Humpback PCS to Watkiss PCS.		
		Install five (5) new PCSs to provide redundancy to Main No. 3 and to maintain existing connections with the JDFWD. • Irwin Road & Creekside Trail, connecting Main No. 1 to JDFWD 116 m pressure zone. • Glen Lake Road, connecting Main No. 1 to Main No. 8. • Rex Road & Jacklin Road, connecting Main No. 1 to Main No. 3 and JDFWD 116 m pressure zone. • Goldstream Avenue & Whitehead Place, connecting Main No. 1 to Main No. 7. • Atkins Road & Traverse Terrace, connecting Main No. 1 to JDFWD 116 m pressure zone.		
		Revise setpoint of the Millstream PCS lead PRV to achieve downstream HGL of 114 m.		
Option	**Phase 2 - Implementation recommended between 2025 and 2038, recommended by 2030**		**2022$**	**Inflated**
M7	Implement part 1 Main No.4 Upgrades	Upsize 4.6 km of pipe to 1,350 mm ø from Goldstream Avenue at Veterans Memorial Parkway to the Watkiss PCS Inlet. Transmission mains upsize should consider longer term planning horizon of at least 75 years.	$38,204,000	$44,085,000

Option	Phase 3 - Implementation recommended between 2038 and 2050		2022$	Inflated
M8	Implement part 2 of Main No.4 Upgrades	Upsize 6.3 km of pipe to 1,500 mm ø from Niagara Main (near Goldstream Disinfection Facility) to Goldstream Avenue at Veterans Memorial Parkway. Transmission main size should consider longer term planning horizon of at least 75 years.	$55,293,000	$77,792,000
Option	**Phase 4 - Implementation recommended by 2050 planning horizon**		**2022$**	**Inflated**
M9	Twin Critical Main No. 3	Twin 4.6 km of Main No.3 (813/991mm diameter) from Dupplin Road at Tolmie Lane to Lansdowne Road at Foul Bay Road to address capacity.	$47,670,000	$81,771,000
M10	Twin Critical Main No. 4	Twin 2.6 km of Main No. 4 (743mm diameter) from the old connection with Haliburton Tank to Patricia Bay Highway at Hamsterly Road.	$48,928,000	$83,930,000
		Twin 3.1 km of Main No. 4 (610/762mm diameter) from Central Saanich Rd at Mount Newton Cross Road to Aldous Terrace at Lowe Rd.		
		Twin 0.6 km of Main No. 4 (1,219/1,321mm diameter) for redundancy from the connection with Goldstream Supply Area to the Goldstream Disinfection Facility inlet or add a connection from Goldstream Supply Area directly to Main No. 5, which would remain normally closed except under emergency situations.		
		Totals	**$197,594,000**	**$295,416,000**

8.6 Storage Tanks

The recommended treated water transmission system storage includes a balancing/head tank at the proposed Japan Gulch Water Filtration Plant and a storage tank at Smith Hill. A balancing/head tank is also proposed for the Goldstream Reservoir Connector. Estimated costs and timing of these projects are shown in **Table 8.4**.

Table 8.4: Storage Tank Projects

Storage Tanks	2022$	Inflated $	Start of Construction	Duration (years)
WFP Clearwell	$23,999,000	$32,134,000	2036	2
Japan Gulch WFP Balancing Storage (Phase 2 Balancing Storage)	$15,384,000	$20,599,000	2036	2
Smith Hill Storage Tank	$12,800,000	$17,859,000	2038	2
Goldstream Reservoir Connector Phase 1 Balancing Tank	$5,538,000	$6,850,000	2032	2

8.7 Pump Stations

Three proposed pump stations will be required for the future development of the RWS. The proposed Deep Northern Intake can be a fixed or floating pump station. Costs presented in **Table 8.5** are the most expensive options, which is a fixed pump station. The water filtration plant requires a pump station to boost HGL from the Japan Gulch site elevation of approximately 130 m to a HGL of 169 m as head through the plant will be broken for gravity filtration.

Table 8.5: Pump Stations

Pump Stations	2022$	Inflated $	Start of Construction	Duration (years)
DNI - Floating Pump Station	$72,505,000	$87,929,000	2030	4
WFP – Treated Water Pump Station	$29,800,000	$39,873,000	2036	2
Smith Hill Tank Pump Station	$17,148,000	$23,888,000	2038	2

8.8 Water Filtration Plant

Based on technical and cost considerations, Stantec considers direct filtration to be the most appropriate treatment selection for the CRD's Regional Water Supply, with the presumptive site located adjacent to the Japan Gulch reservoir upstream of the existing Goldstream Disinfection Facility.

8.8.1 Opinion of Probable Capital and Operating Costs

The cost of the proposed treatment facilities depends on factors including projected capacity requirements, the type of facilities to be constructed, site conditions, and implementation schedule. The following section presents a conceptual level opinion on the probable cost of treatment options for planning purposes.

A planning horizon of 2050, nearly 30 years from the present, has been used to establish the ultimate design capacity of the treatment plant and associated total land requirements for filtration options. However, implementation of additional treatment will most likely be executed in stages of capacity increments based on a design horizon of 20 to 25 years to minimize redundant capacity and cost increases. Thus, the timing of implementation would impact the cost of treatment. For example, the MDD forecast for 2040 using identical assumptions is 340 MLD, which is 13% less than the MDD of 390 MLD forecast for 2050. For planning level purposes, it is recommended that water treatment planning consider the 2050 design horizon.

A feasibility level opinion of probable cost is provided in **Table 8.6** for the three filtration options identified, in this 2022 Master Plan, with the understanding that capacity increments may be staged, and that DAF may involve a future upgrade to a direct filtration plant.

Table 8.6: Opinion of Probable Cost for a 390 MLD Filtration Plant Options

Treatment Options	Capital Cost (M$)	Operating Cost NPF (M$) *	LCC(M$)	Inflated Capital Cost $ 2029
1. Direct Filtration	$570	$205	$780	$996
2. DAF-Filtration	$660	$235	$900	$1,153
3. Membranes	$750	$355	$1,200	$1,300

*NPV calculated using 4% discount rate and Option 3 includes membrane replacement cost at ten-year intervals

A comparison of the capital cost, operating cost, and life-cycle cost suggests Option 1-Direct Filtration to be the lowest capital and life cycle cost.

Applying the additional soft direct and indirect costs plus an allowance for inflation to the midpoint of construction increases the OPC above the direct construction cost shown in Table 8.6. The planning, designing and construction phases of a major capital project such as a Water Filtration Plant is a typically takes 5 to 7 years. It is recommended that CRD undertake pilot and preliminary design engineering in the next few years so design can be complete by 2032 to enable the plant to be constructed by 2037.

8.9 Present and Future Value Estimates

Table 8.7 summarizes the Recommended RWS Capital Improvements Program up to 2050. Present and future inflated values to mid point year of construction are provided for budgeting purposes. Estimates should be updated at preliminary design phase and adjusted for inflation depending on market conditions and timing of construction. **Figure 8.1** is a graphical presentation of this recommended Capital Improvement Program. Detailed cost estimating worksheets for each of the 27 projects are included in **Appendix B**.

Table 8.7: Recommended RWS Capital Improvements Program

	Option	2022$	Mid-Point of Construction	Inflated $
Supply				
Deep Northern Intake/Floating Pump Station	S3	$72,505,000	12/31/2031	$87,929,000
Leech River Diversion	S4/RWT1	$16,700,000	12/31/2044	$26,204,000
Sooke Lake Saddle Dam Hydraulic Improvements	M1	$10,000,000	12/31/2044	$15,691,000
Water Treatment				
Japan Gulch Dam Decommissioning	T2/T4	$10,256,000	12/31/2033	$12,940,000
Direct Filtration	T2/T4	$736,155,000	12/31/2035	$966,353,000
Clearwell	T2/T4	$23,999,000	12/31/2036	$32,134,000
Treated Water Pump Station	T2/T4	$29,780,000	12/31/2036	$39,873,000
Japan Gulch Water Filtration Plant Stage 2 Balancing Tank	M2	$15,384,000	12/31/2036	$20,599,000
Raw Water Transmission Mains				
DNI Transmission Main to Head Tank	M3	$38,768,000	06/30/2032	$47,483,000
3rd Main - Sooke Lake Dam to Head Tank	M4	$7,384,000	12/31/2032	$9,134,000
Jack Lake - Head Tank to Japan Gulch + 2 PS @ 2100 ADD	RWT5*	$208,649,000	12/31/2037	$284,959,000
Goldstream Reservoir Connector				
Goldstream Dam to Japan Gulch	M5	$67,075,000	12/31/2030	$82,971,000
Stage 1 Balancing Tank	M6	$5,538,000	12/31/2030	$6,850,000
Treated Water Transmission Mains				
Phase 1 Upgrades	M7	$7,499,000	6/30/2024	$7,838,000
Phase 2 Upgrades	M8	$38,204,000	6/30/2029	$44,085,000
Phase 3 Upgrades	M9	$55,293,000	6/30/2039	$77,792,000
Phase 4.1 Upgrades	M10	$47,670,000	6/30/2049	$81,771,000
Phase 4.2 Upgrades	M11	$48,928,000	6/30/2049	$83,930,000
East-West Connector				
Option 2 Transmission Main	M12	$58,562,000	6/30/2036	$77,639,000
Storage Tank				
Smith Hill Tank	M13	$12,820,000	12/31/2038	$17,859,000
Smith Hill Tank Pump Station	M14	$17,148,000	12/31/2038	$23,887,800
Total Estimated Cost		**$1,528,000,000**		**$2,048,000,000**

*Jack Lake alignment with Pump Stations and transmission main sized for 2100 ADD Level of Service flow ~375 MLD

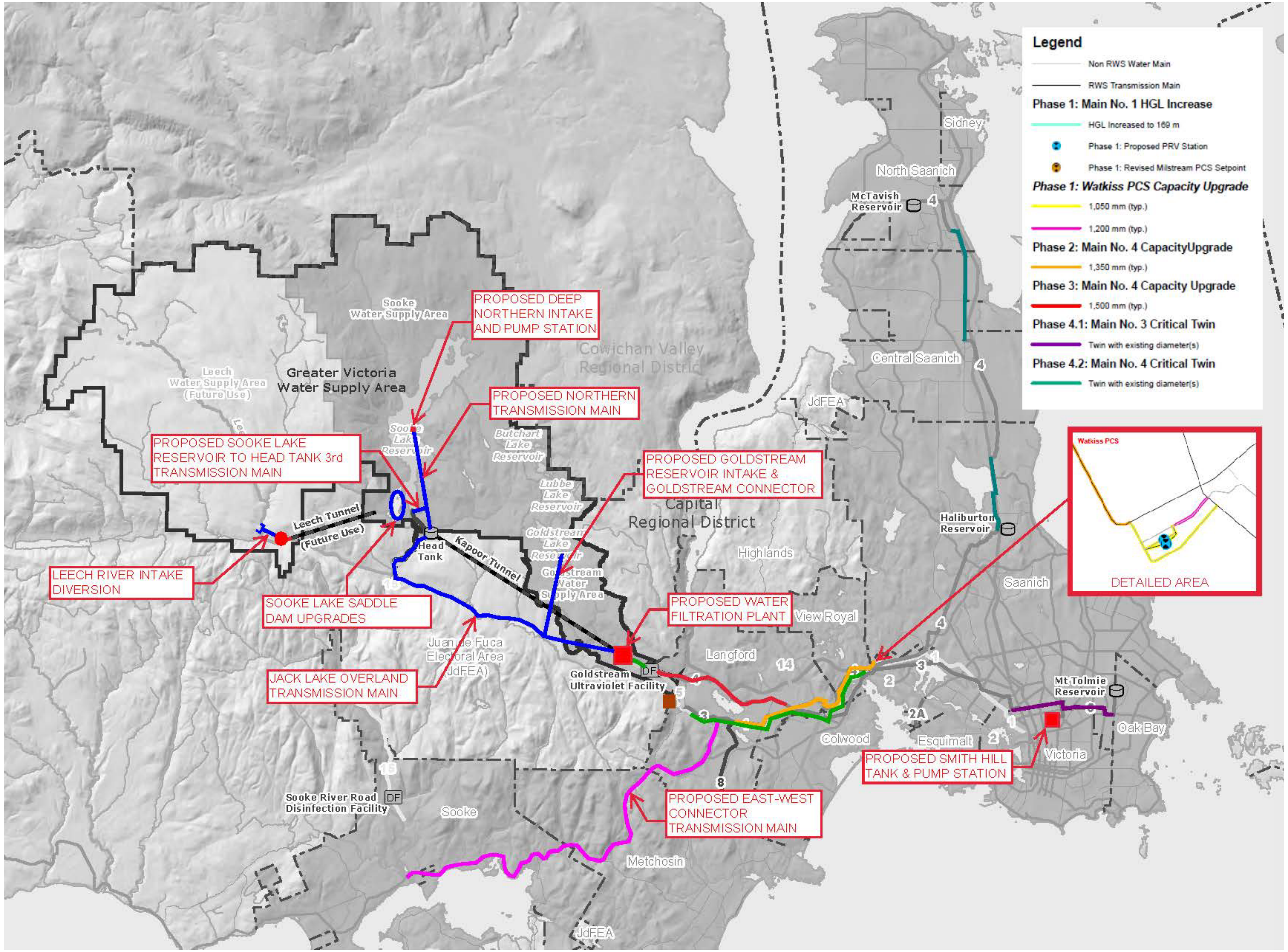


Figure 8.1: Recommended RWS Capital Improvement Program

9.0 CONCLUSIONS

This section of the 2022 Master Plan summarizes conclusions based on the work completed as part of this study and other concurrent studies (Stantec 2021). The CRD should review the 2022Master Plan progress regularly once further investigations are completed and to monitor overall progress on achieving objectives and improving overall resiliency of the Regional Water Supply system. While a Master Plan is a comprehensive overall plan, it must be reviewed on a regular basis to respond to changes in regulatory requirements, climate change, trends in water use, demand management and population growth.

9.1 Water Sources

The Sooke watershed should continue to serve as the primary supply for the RWS. This source will reach its sustainable safe yield capacity limit between 2045 and 2050 depending on demand management initiatives implemented by the CRD. Continued demand management initiatives to reduce the per capita consumption to an achievable 300 L/c/d is recommended. Reducing demand to 300 L/c/d would extend the capacity of this source to the year 2060 at a 1.25% annual population growth rate.

The Leech watershed has the potential to provide significant additional water supply to augment SLR supply in the long term; however, storage will be required as there is little inflow into the watershed during the summer months. Another option to be explored further is a direct intake into the Leech River for diversion of water to Deception Gulch Reservoir (DGR) and ultimately to SLR. One option is to complete improvements to the Sooke Lake Saddle Dam and the Deception Gulch Dam and spillway to enable transfer of water directly to SLR. DGR can also be used to receive water from Leech River in the interim and be used for Sooke River conservation flows thereby conserving water currently released annually for conservation flows. A hydrology study and reservoir balancing model which would look at the operation of SLR and Leech River diversion or storage options to assess the best alternative for optimal use of Leech River water.

The Goldstream reservoirs have served as a secondary source during Kapoor Tunnel maintenance activities. The CRD should consider connecting this system via transmission main to the Japan Gulch Reservoir. The transmission main would alleviate turbidity issues from slides in the Goldstream River Canyon and maintain the Goldstream raw water quality. The transmission main alignment should facilitate the future connection of the Jack Lake overland transmission main alignment and ultimate connection to a filtration plant at Japan Gulch.

The CRD should continue to optimize use of water sources under their ownership and licence rather than investigate sources that are not within their current jurisdiction.

9.2 Water Supply Dams

IWS manages numerous dams with the primary purpose of providing a reliable supply of safe drinking water to the residents of the region. A comprehensive dam safety program is in place to manage the dams within the legislated framework. The IWS should continue to make investment in dam safety to manage these assets and mitigate dam safety issues. Recent dam safety reviews have highlighted the importance of improving existing dam performance monitoring systems to current industry best practices as well as alignment with the 2017 Strategic Plan objectives. In general, the dams have performed well, and more specific conclusions and their alignment with 2017 RWS Strategic plan objectives include:

- [water quantity] - In the near and intermediate terms, the existing dams will provide the primary and secondary water storage requirements to address the seasonal variations in water yield and the annual demand variations of the customers to the year 2050.
- [reliability] -The existing dams are being managed by IWS to identify and mitigate risk "as low as reasonably practical."
- [water quantity] - In the future, off-catchment lands could be considered for additional water supply, recognizing the reasons for which the earlier sources of water and reservoirs were decommissioned from service. Some of these sources could be recommissioned once water filtration facilities are constructed.
- [reliability] - From a reliability perspective, continue to manage and mitigate the dam risks and carry-on with the IWS Dam Safety Program.
- [water quantity and reliability] - Since the Goldstream watershed is needed for a secondary water supply short-term only) the dams will need to be maintained.
- [water quantity] - The existing dams and related storage reservoirs will provide the quantity of water to meet the demands of the system for the planning horizon of this 2022 Master Plan.
- [water quantity and reliability] - Sooke Lake Reservoir is the primary source of water and will continue for years to come.
- [reliability] - Based on the Strategic Plan theme of reliability, the Goldstream watershed, dams and related reservoirs shall be maintained for secondary or redundancy of water supply.
- [water quantity and reliability of supply] - At a certain demand threshold nearing the end of the planning horizon of 2050 additional water supply will be required.
- [water quantity and reliability] - Deception Gulch Dam and Reservoir could be re-commissioned to full pool.

9.3 Water Quantity

Hydrological assessments of the Sooke and Leech watersheds have been completed. Based on this work, it is estimated the Sooke watershed can supply 40% additional annual demand (up to 67Mm^{3}Y) over current demand levels during a 1:50 year drought precipitation condition. Additional water source development will be required around the year 2050 to support population growth but should be in service by 2045. The timing of additional source development will be somewhat dependent on demand management initiatives.

The Leech River watershed has the capability of providing additional water supply but requires development of storage or a direct intake that would enable water to be transferred to Sooke Lake Reservoir during the shoulder seasons. Leech River water can be transferred to DGR via the existing Leech tunnel. Diversion to DGR using a direct intake into Leech River would also enable more resiliency in supply because the SLR could be filled quicker following a drought condition and would provide additional protection should drought conditions extend over a period of several years.

The steep topography of the Leech River watershed will require construction of a high dam to store and utilize Leech River water. A high dam would be costly and further assessment on costs of development of a high dam versus benefit will need to be completed. The feasibility of dam construction in the Leech River valley will have to be evaluated following geotechnical investigation and assessment by dam design specialists. In addition, a Phase 2 Hydrology study and a reservoir water balance and operating model should be developed to optimize and further develop alternatives for concurrent use of Sooke and Leech watershed sources.

9.4 Proposed Deep Northern Intake

A study completed by Stantec (2021) indicated there is potential to access water in the Sooke Lake Reservoir deep northern basin with a proposed intake. This intake would serve as an emergency intake, while at the same time enabling access to better quality water with a more consistent temperature from deep zones of Sooke Lake Reservoir. It is noted that the intake will not allow additional water supply from Sooke Lake Reservoir as the future extraction water level should be limited to 177m to ensure the reservoir is replenished by normal annual precipitation. Hydrological analysis indicates it is possible to withdraw 40% additional water (up to 67.3 Mm^3 annually) from SLR during a 1:50 year drought condition. During emergency drought conditions this intake would make the system more resilient with the diversion of Leech River—one of the main objectives of the 2017 Strategic Plan. The proposed intake will be located at an approximate elevation of 150 m (Floating Pump Station inlet piping would also be designed to reach the 150 m elevation) so that during an emergency or drought condition it could be used to provide additional water for a short duration The CRD understands that it may take several years of precipitation to fill the reservoir following such an event. If Leech River water is diverted to SLR during a drought condition the SLR fill time would be reduced and the likelihood of concurrent back-to-back drought conditions would be reduced, thereby improving overall reliability and resilience of the water supply in extreme drought conditions.

Two options are available for a Deep Northern Intake. The first option is a conventional pump station constructed on shore with a MTBM used to tunnel the intake from shore. The second option is a floating pumping station. The final selection of which style of pump station to construct can be made at preliminary design phase.

9.5 Demand Management

Continued demand management is an integral component of managing the available water supply for the RWS. Demand management initiatives and water efficient fixtures and appliances have significantly reduced RWS demands. Reducing demands further will extend the life of the existing water sources and defer requirement for capital investment in new sources.

9.6 Transmission

9.6.1 Kapoor Tunnel

The Kapoor Tunnel is a critical conveyance infrastructure for the RWS. The CRD has done a good job in managing this asset and completing maintenance repairs. The tunnel has sufficient hydraulic capacity to convey projected demands to near the year 2100. The CRD should continue with condition assessment inspections of the tunnel to manage this critical asset.

There is no redundancy for the Kapoor Tunnel. Based on inspections and maintenance completed by the CRD and others, the tunnel is in good condition; however, due to the tunnel proximity to the Leech River Valley fault, a seismic evaluation of the tunnel should be completed. Further detailed seismic assessment is warranted to identify if there are any significant vulnerabilities. It is noted that the Kapoor Tunnel has the hydraulic capacity to supply demands to the year 2100, so provided it is maintained and seismically stable, additional capital investment on a second conveyance system from SLR can be deferred for many years. Other considerations such as emergency water supply may warrant construction of a second transmission main earlier, but this transmission main can likely be sized for an emergency level of service flow (ADD) to reduce capital costs.

9.6.2 Other Transmission Main Improvements

Several options were investigated to provide transmission redundancy from Sooke Lake Reservoir. These options include a second gravity tunnel similar to Kapoor Tunnel, pumped open cut and buried transmission mains and hybrid pumped transmission main/tunnel options. All options are feasible and have different capital and life cycle costs.

A first stage would involve construction of the Deep Northern Intake pump station with a transmission pipeline extended to the Sooke Lake Head Tank. A third intake pipe from Sooke Lake Dam would be connected to the transmission pipeline. The second stage (Sooke lake Head Tank to Japan Gulch) could be deferred to a later date and could include a transmission main via Jack Lake as previously explored in the 1994 Plan.

Several transmission improvement projects have been identified to increase hydraulic capacity (see Table 9.2 and 9.3) including a transmission main connection to Goldstream Lake Reservoir and an East-West connector main to the District of Sooke, which would provide water from a single water filtration plant located near Japan Gulch Reservoir in the future. This would defer the need to construct a second smaller water treatment plant at the Sooke River Road Disinfection Facility. The other transmission system improvements are related to replacement of old main and additional capacity and level of service requirements identified in the 2018 GeoAdvice hydraulic capacity report.

9.7 Storage Tanks

System storage deficiencies have been identified for peak hour and discretionary emergency storage. Fire storage is not proposed as part of the transmission system but would be provided as part of the municipal water distribution system along with pumping as required. The RWS transmission system would supply up to the 2100 MDD level of service. This would extend the life of the RWS transmission system and defer the requirement for future capacity investments in both transmission and treatment.

An equalization clearwell at the filtration plant would have benefits of balancing filtration plant flows so the plant can be sized for MDD rather than PHD. The costs for the WFP would increase significantly if system peak hour balancing storage is not provided at the filtration plant. This balancing storage tank (Clearwell) could be located with a TWL of 169m to replicate the historic hydraulic supply conditions of the RWS.

A second tank, proposed at the location of the previous Smith Hill open reservoir, will provide balancing and emergency storage for significant service areas in the City of Victoria, District of Oak Bay, and the District of Saanich.

9.8 Water Treatment

The water quality provided by RWS meets current provincial standards as well as Federal Guidelines for Canadian Drinking Water Quality. The water supply is, however, unfiltered, with the only treatment barriers provided being primary disinfection with UV light and chlorine and chloramines for secondary transmission system disinfection. This system has provided acceptable water quality because of the high quality of the Sooke Lake Reservoir source. In the future it is possible that Island Health Authority may require water filtration for major water supplies serving large populations, so CRD should begin planning for water treatment within the next 5 to 10 years. Pilot studies, siting investigations and preliminary designs will be required to enable Project Definition with sufficient detail provided for Provincial and Federal funding applications.

The selected treatment process of direct filtration is suitable for treatment of Sooke Lake Reservoir and Goldstream Reservoir water and likely even a blended Sooke Lake / Leech River water, but this will have to be confirmed by pilot plant studies. Good practice would be to design the plant to enable addition of a pre-treatment process such as dissolved air flotation or conventional sedimentation in the event that raw water quality conditions deteriorate in the future.

9.9 Water Filtration Plant Siting

Three WFP sites have been investigated. The preferred site for a future water filtration plant is adjacent to the Japan Gulch Reservoir. This site is easily accessed for operations and can easily be connected to the RWS transmission system. The site will have to be protected from potential flood inundation from the Goldstream River, but this can be easily accommodated with appropriately designed river training and flood protection works. Following filtration, treated water pumping will be required to maintain the RWS system HGL of 169m.

9.10 Risk and Resiliency

The AWWA J100 process has been used to identify threats and vulnerabilities to the RWS (Stantec 2021). Several risks, threats, and vulnerabilities have been identified in the CRD system including seismic risks, wildfire risks and potential future risks such as climate change. The CRD should continue planning any capital improvements to mitigate the identified risks. The risks and threats identified in the AWWA J100 process should be reviewed every 5 years to monitor progress on mitigating risks as well as identifying any new risks that emerge.

9.11 Future Studies

9.11.1 Seismic Assessments and Upgrades (Phase 2)

The CRD should proceed with Phase 2 seismic assessment for critical water supply facilities as identified in the *Seismic Assessment of Critical Facilities Study – Phase 1 (Stantec 2021)* within the next 5 years.

9.11.2 Deep Northern Intake Options Analysis

As additional water quality data is collected in the area of the proposed Deep Northern Intake, further studies, and analysis of location options for the proposed intake should be conducted. This next phase study could be undertaken in 2030.

9.11.3 Leech Watershed Development

This 2022 Master Plan has identified the Leech watershed as a potential, viable, future water supply for the RWS. Additional studies and assessment of the storage options or direct intake and diversion of the Leech watershed are required. Planning for the Leech diversion works, or storage should commence no later than 2032 as it is required to be online around 2042 as the safe yield of the Sooke watershed will be reached in 2045 at current demand levels.

9.11.4 Transmission Options Study

Several options were investigated to provide a secondary transmission system from Sooke Lake Reservoir to Japan Gulch. These options include another tunnel, transmission mains, and combined tunnel/transmission main options. All options are feasible and have different capital and life cycle costs. The options should be further refined at a conceptual design level which would include field route reconnaissance and detailed cost estimates to determine the best option. The timing of the study will depend on the findings of the Kapoor Tunnel Phase 2 Seismic Assessment. If the Kapoor Tunnel is assessed as being at risk, the CRD may choose to accelerate the construction of a redundant transmission main between Sooke Lake Reservoir and Japan Gulch. Consideration for the Level of Service for the redundant transmission main should be included in future studies.

9.11.5 Water Filtration Pilot Studies

The conclusion of this 2022 Master Plan is that the conversion of the RWS to a filtered water supply is not urgent, although changes in regulatory requirements may accelerate this conversion. It is prudent to start planning for a water filtration plant in the next 10 years. A piloting study to evaluate different treatment process configurations for Sooke Lake Reservoir and blended Sooke Lake Reservoir / Leech River water should be completed. Once the results of the pilot investigation are completed, preliminary designs can be prepared to refine capital cost estimates.

9.11.6 Storage Tanks

The issue of storage requires a more detailed examination. The RWS is supplying the instantaneous PHD and fire flows, which is not typical of transmission mains for large utilities. If this issue is not addressed, it will result in an oversizing of the future water filtration plant and transmission mains. The planned improvements for the transmission mains are based on maintaining a LoS for MDD conditions. If the RWS is supplying PHD, the LoS will not be achieved. This detailed examination of storage should be undertaken within the next 3 years.

10.0 RECOMMENDATIONS

Based on the work completed for this 2022 Master Plan the following specific recommendations are provided below.

	Recommendation	$ 2022 Estimated Cost	Inflated Cost	Timing
Water Sources				
1	Complete Phase 2 hydrology study water balance model and develop reservoir operating rules in consideration of water use and dam safety including optimization for future concurrent use of Leech and Sooke watershed water. Investigate feasibility of direct diversion of Leech River water to SLR via DGR or construction of storage dam on the Leech River. Study the feasibility of direct intake or dam construction on the Leech River. The study should include the assessment of Goldstream watershed as well as the Council watershed to see how the use of water in the WSAs can be optimized.	$1,000,000	$1,020,000	2023
2	Complete one year of water quality monitoring on SLR to identify deep northern basin water quality and seasonal quality fluctuations at various water extraction depths.	$200,000	$204,000	2023
3	Complete one year of water quality monitoring on Deception Gulch Reservoir to obtain baseline water quality data for this source.	$100,000	$102,000	2023
4	Study the upgrade requirements for Sooke Lake Saddle Dam and Deception gulch Dam/spillway to facilitate transfer of Leech River water to SLR. Investigate use of DGR water for fisheries conservation flows to offset conservation flows from SLR.	$300,000	$312,000	2024
5	Continue with Dam Safety Review (obligation), Capex improvements for rehabilitation, renewal, increased performance, and real-time performance monitoring.	As required		As required
6	Continue with Dam Safety Program investigations and improvements for RWS dams.	As required		As required
7	Maintain Goldstream Reservoirs as a secondary source and complete preliminary engineering for intake into Goldstream Reservoir and a transmission main to Japan Gulch.	$500,000	$520,000	2024
8	IWS should continue with demand management program to enable RWS to optimize the use of their available sources. Continued public education, ICI programs and lawn irrigation management will extend the life of the RWS water sources.	As required		2022-2050
9	Once the SLR reaches a demand level of 67.3 Mm^3Y it should not be drawn down below 177m to reduce the impact of the SLR not being able to fill during the winter precipitation period in drought years. The	NA		NA

	Recommendation	$ 2022 Estimated Cost	Inflated Cost	Timing
	reservoir should only be drawn down in an emergency condition.			
10	The SLR demand should be managed so the life of this source can be extended. The annual demand should not be increased beyond 40% of current demand to a maximum of 67.3. Mm^3. The Phase 2 hydrology study (Item #1 above) should assess if future extractions from Leech watershed can assist in increasing water supply yield in combination with SLR.	NA		NA
Kapoor Tunnel				
1	The CRD should completed a detailed seismic assessment of the Kapoor Tunnel to assess its resiliency against the latest seismic design codes as part of the overall management of this asset.	$400,000	$416,000	2024
Deep Northern Intake				
1	Complete a conceptual design of a floating pump station and transmission main connection to the Head Tank. A conceptual design should also be completed for a fixed land pump station along with cost estimates to compare the optimal solution for extraction of water from the deep northern basin. (Option S3)	$1,500,000	$1,940,000	2035
Water Treatment				
1	Complete a water filtration pilot program to select the final filtration process for water filtration. The pilot program should be completed over a period of at least one year to cover seasonal changes in raw water quality from the SLR and Leech River. The pilot should be run with SLR only, Leech River water only and blended water from both sources to determine if raw water conditions significantly impact filtration performance. Spiked turbidity and ash challenge testing should be completed as part of the pilot program to assess the filtration performance under more adverse water quality conditions.	$1,500,000	$1,561,000	2023-2025
2	Complete an indicative preliminary level design for a water filtration plant located at the Japan Gulch site. The layout should be developed for initial build and ultimate build so that the Japan Gulch site can be planned for future plant expansion. A geotechnical investigation should be completed at the Japan Gulch Site. Assess mitigation requirements for seismic design and flood inundation protection as part of the indicative design.	$2,000,000	$2,208,000	2027
3	Complete detailed design of water filtration plant.	Included in Item 4 costs		2029-2031
4	Construct water filtration plant. (T2/T4)	$736,155,000	$836,353,000	2033-2037

Recommendation		$ 2022 Estimated Cost	Inflated Cost	Timing
5	Depending on treatment process selected assess the requirement for continued primary disinfection using UV. If UV is not required decommission the existing GDF and SRRDF following construction of WFP.	Included in WFP costs		
Raw Water Transmission				
1	Construct third 1,219 mm transmission main from SLR to Head Tank. (M4)	$7,384,000	$9,134,000	2032
2	Complete detail design of Goldstream Reservoir Intake and transmission main from Goldstream Reservoir to Japan Gulch.	Included in item 3 costs		
3	Construct Goldstream Reservoir Connector transmission system. (M5)	$67,075,000	$82,971,000	2032
4	Complete design and construction of DNI and pump station + raw water transmission system from SLR to Japan Gulch. (S3 + M3 + RWT5*)	$254,801,000	$341,576,000	2045 to 2050
Treated Water Transmission (see Table 9.3)				
1	Phase 1 Upgrades (M7) • Watkiss PCS Upgrade • Increase Main No. 1 to 169 m HGL	$7,499,000	$7,838,000	2023
2	Phase 2 Upgrades (M8) • Main No.4 Upgrades (Part 1) • Main No. 4 Replace Concrete Pipe Sections	$38,204,000	$44,085,000	2025-2029
3	Phase 3 Upgrades (M9) • Part 2 Main No.4 Upgrade	$55,293,000	$77,792,000	2039
4	Phase 4 Upgrade			
	• Twin Main No.3 (M10)	$47,670,000	$81,771,000	2049
	• Twin Main No.4 (M11)	$48,928,000	$83,930,000	2049
5	East-West Connector – Option 2 (M12)	$58,562,000	$77,639,000	2036
Storage Tanks				
1	Construct Smith Hill Balancing Storage (M13)	$12,820,200	$17,859,000	2038
2	Construct Smith Hill Tank Pump Station (M14)	$17,148,000	$23,888,000	2038

11.0 REFERENCES

Acres International. 1999. Strategic Plan for Water Management Volume 3 Watershed Management, Final Report. Prepared for Capital Regional District Water Department, September 13.

Ahmed, A. 2017. "Inventory of Streamflow in the South Coast and West Coast Regions", October 2017, Knowledge Management Branch, British Columbia Ministry of Environment and Climate Change Strategy, Victoria, BC.

AWWA Manuals of Practice, American Waterworks Association

BC Design Guidelines for Drinking Water Systems in BC

British Columbia Forests, Land and Resource Operations and British Columbia Ministry of Environment. BC FLNRO & BC MOE. 2016. Environmental Flow Needs Policy, https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water-rights/efn_policy_mar-2016_signed.pdf

Canada, Department of Fisheries and the Environment, Atmospheric Environment Services (Canada). Hydrological Atlas of Canada. 1975. Mean Annual Lake Evaporation. Accessed on July 10, 2021, from https://open.canada.ca/data/en/dataset/67de4f04-855d-5d23-bb4a-2a270d1488d0

CRD. 2021. Leech River Water Quality Analyses Report, October 2021

Capital Regional District (CRD). 2021a. Leech Water Supply Area (Future Water Supply). Retrieved on June 29, 2021, from https://www.crd.bc.ca/service/drinking-water/watershed-protection/leech-water-supply-area-future-water-supply

CRD. 2021b. Sooke Water Supply Area (Primary Water Supply). Retrieved on June 29, 2021, from https://www.crd.bc.ca/service/drinking-water/watershed-protection/sooke-water-supply-area-primary-water-supply

CRD. 2021c. Goldstream Water Supply Area (Secondary Water Supply). Retrieved on June 29, 2021, from https://www.crd.bc.ca/service/drinking-water/watershed-protection/goldstream-water-supply-area-secondary-water-supply

CRD. 2021d. Sooke Lake Reservoir Daily Inflow Calculations (2002-2020). Excel file (Sooke Res Daily Inflow Calcs 2021.xlsx" received from CRD via email on June 18, 2021.

CRD. 2019. Staff Report: Fisheries Water Release Program. Report to Regional Water Supply Commission Meeting of Wednesday, May 15, 2019.

CRD. 2018. Watershed Hydrology Monitoring Plan Leech Water Supply Area

CRD. 2017. Climate Projections for the Capital Region, July. Retrieved on June 29, 2021, from https://www.crd.bc.ca/docs/default-source/climate-action-pdf/reports/2017-07-17_climateprojectionsforthecapitalregion_final.pdf

CRD. 2015. Leech Water Supply Area: An Assessment for Source Water Protection and Land Management, Watershed Protection Division Integrated Water Services, April.

CRD. 2014. Watershed Hydrometeorological Stations, March.

CRD. 2012. 2012 Strategic Plan for the Greater Victoria Water Supply System, April.

Demarchi, D.A. 2011. An Introduction to the Ecoregions of British Columbia. Ecosystem Information Section Ministry of Environment, Victoria, British Columbia. Accessed on July 14, 2021 at https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/ecosystems/broad-ecosystem/an_introduction_to_the_ecoregions_of_british_columbia.pdf

Engineers & Geoscientists British Columbia (EGBC). 2020. Developing Climate Change-Resilient Designs for Highway Infrastructure in British Columbia, Version 2.0. Retrieved on July 16, 2021, from https://www.egbc.ca/getmedia/b60921fc-a820-41be-868f-02f0d3d92892/EGBC-BCMOTI-Climate-Resilient-Design-Highway-V2-0.pdf.aspx

GeoAdvice, 2020. RWS Transmission Mains: Hydraulic Capacity Analysis and Transient Pressure Analysis – Final Report

Government of Canada (Canada). 2021a. Historical Data. Retrieved on July 15 from https://climate.weather.gc.ca/historical_data/search_historical_data_e.html

Government of Canada (Canada). 2021b. Historical Hydrometric Data Search. Retrieved on July 15 from https://wateroffice.ec.gc.ca/search/historical_e.html

Kerr Wood Leidal Consulting Engineers (KWL). 2017. Goldstream Watershed Reservoirs Inflow Design Flood Update 2017, Final Report – Revision 0, December.

KWL. 2016. Sooke Lake and Deception Gulch Reservoir Probably Maximum Precipitation and Probable Maximum Flood Update FINAL. Prepared for Capital Regional District – Integrated Water Service, July 11.

Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD). 2018. Biogeoclimatic Ecosystem Classification Subzone/Variant Map for the South Island Resource District South Coast Region. Accessed on July 10, 2021, from https://www.for.gov.bc.ca/ftp/HRE/external/!publish/becmaps/PaperMaps/wall/DSI_SouthIslandResourceDistrict_SouthCoastRegion__wall.pdf

Niemann, O. 1993. Analysis of Precipitation Data Collected for the Sooke and Goldstream Watersheds – 1991 to 1992. Department of Geography, University of Victoria, Victoria, BC.

Pacific Climate Impacts Consortium (PCIC). 2021. Plan2Adapt Version 2.1.0. Retrieved on July 14, 2021, from https://services.pacificclimate.org/plan2adapt/app/

Wang T, Hamann A, Spittlehouse D, and Carroll C. 2016. Locally Downscaled and Spatially Customizable Climate Data for Historical and Future Periods for North America. PLoS ONE 11(6): e0156720. doi: 10.1371/journal.pone.0156720

Werner, A.T., Prowse, T.D. & Bonsal, B.R. 2019. Characterizing the Water Balance of the Sooke Lake Reservoir, British Columbia over the Last Century. Climate 3(1), 241- 263. https://doi.org/10.3390/cli3010241

Appendix A
Hydraulic Data Tables
(from GeoAdvice 2020)

Table A-6.2: HGL at RWS Connection Points for 2018 MDD Demands

						2018 MDD Scenario - Kapoor Tunnel - In Service				2018 MDD Scenario - Kapoor Tunnel - Out of Service			
Junction ID	Export	Description	Main ID	Main No.	Main HGL	Max HGL (m)	Min HGL (m)	Avg HGL (m)	Avg Flow (L/s)	Max HGL (m)	Min HGL (m)	Avg HGL (m)	Avg Flow (L/s)
JCT07047	Holland Meters	1280 Burnside Rd West (Burnside / Holland Meter, 2 meters in Chamber, Branch	PPE05627	1	116	113	106	111	2	113	100	109	2
JCT15815	Wilkinson Meter	3802 Wilkinson Rd (Branch)	PPE03244	1	116	112	104	110	53	112	98	108	52
JCT15809	Marigold Meter	353 Marigold Rd (Branch)	PPE04840	1	116	112	103	109	0	112	97	108	0
JCT15806	Burnside / Admirals Meter	621 Burnside Rd West (Burnside / Admirals, Branch)	PPE04839	1	116	112	103	109	0	112	96	107	0
JCT15750	Dupplin Meter	394 Dupplin Rd (Branch)	PPE03795	1	116	112	102	109	37	112	95	107	36
JCTGA20670	Admirals Meter	1102 Admirals Rd (Line)	PPE25238	2A	116	113	105	110	24	112	98	108	23
JCT15746	Cecilia/Craigflower Meter	Unmetered Esquimalt Connection (Esquimalt PCS)	PPE52852	2	116	112	104	109	54	112	97	108	53
JCT15721	Cecilia/Craigflower Meter	Unmetered Victoria Connection	PPE52848	2	116	112	102	109	53	112	96	107	52
JCT15720	Cecilia/Craigflower Meter	Unmetered Victoria Connection	PPE52847	2	116	112	102	109	53	112	96	107	52
JCTGA19058	Cecilia/Craigflower Meter	Unmetered Victoria Connection	PPE10527	2	116	112	102	109	53	112	95	107	52
JCT20453	Cecilia/Craigflower Meter	Unmetered Victoria Connection	PPE10530	2	116	112	102	109	53	112	95	107	52
JCT20457	Cecilia/Craigflower Meter	Unmetered Victoria Connection	PPE10532	2	116	112	102	109	53	112	95	107	52
JCT17314	Cecilia/Craigflower Meter	Unmetered Victoria Connection	PPE08685	2	116	112	102	109	53	112	95	107	52
JCT24772	Cecilia/Craigflower Meter	Unmetered Victoria Connection	PPE08702	2	116	112	102	109	53	112	95	107	52
JCTGA20620	Admirals / TCH Meters	3150 Admirals Rd (TCH / Admirals, 2 Meters in Chamber, Branch)	PPE67157	3	116	112	103	109	23	112	97	108	22
JCT15790	Tillicum Meter	314 Burnside Rd West (Branch)	PPE00575	3	116	112	102	109	63	112	96	107	62
JCT15763	Cloverdale Meter	729 Cloverdale Ave (Branch)	PPE06632	3	116	111	97	107	40	111	91	105	40
JCT15754	Tolmie / Douglas Meter	3199 Douglas St (Tolmie / Douglas, Branch)	PPE05759	3	116	111	97	107	99	111	91	105	98
JCT15774	Somerset Meter	3193 Somerset St (Branch)	PPE01634	3	116	111	93	106	12	111	88	104	12

						2018 MDD Scenario - Kapoor Tunnel - In Service				2018 MDD Scenario - Kapoor Tunnel - Out of Service			
Junction ID	Export	Description	Main ID	Main No.	Main HGL	Max HGL (m)	Min HGL (m)	Avg HGL (m)	Avg Flow (L/s)	Max HGL (m)	Min HGL (m)	Avg HGL (m)	Avg Flow (L/s)
JCT15777	Maplewood Meter	3220 Maplewood Rd (Branch)	PPE01635	3	116	111	91	105	110	111	87	103	106
JCT17446	Mallek Meter	2999 Cook St (Cook / Mallek, Branch)	PPE10641	3	116	111	91	105	8	111	87	103	8
JCT20606	Cook Meter	2999 Cook St (Cook / Mallek, Branch)	PPE03572	3	116	111	91	105	52	111	87	103	50
JCT15758	North Dairy Meter	1650 North Dairy Rd (Branch)	PPE03592	3	116	110	84	102	0	110	81	100	0
JCT15757	Shelbourne Meter	3199 Shelbourne St (Branch)	PPE03370	3	116	110	84	102	126	110	81	100	126
JCT15738	Richmond Meter	3101 Richmond Rd (Branch)	PPE01718	3	116	110	81	101	5	110	79	99	5
JCT15737	Oak Bay #1/2 Meter	1998 Lansdowne Rd (Branch)	PPE08849	3	116	110	80	101	205	110	78	99	204
JCT15744	Oak Bay #3/Foul Bay Meter	3133 Foul Bay Rd (Branch)	PPE05366	3	116	110	80	101	69	110	78	99	68
JCTGA19076	Cedar Hill #1/2/Mount Tolmie Meter	1855 Cedar Hill Cross Rd (East, Branch)	PPE10831	3	77	78	75	77	193	78	75	77	191
JCT07078	Burnside Meters	1446 Burnside Rd West (Burnside / Helmcken, 3 Meters in Chamber (Burnside West Line and 2 Branch)	PPE05495	4	169	164	144	158	2	130	105	119	2
JCT15825	Blue Ridge Meter	1398 Blue Ridge Rd (Branch)	PPE08641	4	169	163	143	157	6	129	105	119	6
JCT15827	Roy Meter	1298 Roy Rd (Branch)	PPE03216	4	169	163	142	157	1	129	104	119	1
JCT15833	Layritz Meter	698 Mann Ave (Branch)	PPE06920	4	169	163	141	156	52	129	103	118	52
JCT15836	Markham Meter	4701 West Saanich Rd (Branch)	PPE14377	4	169	162	140	155	84	129	102	117	84
JCT15845	Cherry Tree Meter	4869 Cherry Tree Bend (Branch)	PPE03088	4	169	162	138	154	197	129	100	117	190
JCT15850	SPS - Central Saanich	Main No. 4 Connection to Hamsterly PS / Bear Hill Reservoir	PPE05123	4	169	158	130	148	188*	128	94	110	185*
JCT15861	Alderley Meter	5551 Alderley Rd (Branch)	PPE00189	4	114	114	114	114	33	114	89	103	33
JCTGA19018	Martindale Meters	(Central Saanich Consumption) (0402MTR02) Martindale PS - 2 meters billed	PPE01515	4	114	99	99	99	5	99	87	97	6
JCTGA18892	Lochside Meters	(Central Saanich Consumption) (0403MTR02, 0403MTR03) Lochside, Stellys PS - 2 meter	PPE01306	4	114	114	106	109	6	113	86	99	6
JCT15969	Tsawout Meters	(Central Saanich Consumption) (0462MTR02) Tsawout Chamber - 2	PPE05718	4	114	114	104	109	4	113	85	98	4

						2018 MDD Scenario - Kapoor Tunnel - In Service				2018 MDD Scenario - Kapoor Tunnel - Out of Service			
Junction ID	Export	Description	Main ID	Main No.	Main HGL	Max HGL (m)	Min HGL (m)	Avg HGL (m)	Avg Flow (L/s)	Max HGL (m)	Min HGL (m)	Avg HGL (m)	Avg Flow (L/s)
		meters 2" & 10", 7538 Central Saanich R											
JCTGA19070	Mt Newton Meter	(Central Saanich Consumption) Mount Newton PS	PPE13977	4	114	94	94	94	13	94	85	92	12
JCT16015	SPS - North Saanich	Main No. 4 Connection to Lowe Road PS	PPE02751	4	114	114	89	100	189	110	81	91	188*
JCTGA19080	McTavish Inlet Meter	McTavish Inlet Meter	PPE14093	4	114	113	85	98	149	110	81	90	133*
JCT05133	JdF Distribution System	Main No. 7 Start	PPE04836	7	116	115	111	113	60	114	103	111	57**
JCT04007	JdF Distribution System	Main No. 7 Terminus (Metchosin)	PPE04319	7	116	115	111	113	5	114	104	111	6**
JCT02874	JdF Distribution System	Main No. 8 Start	PPE02902	8	116	116	114	115	70	115	105	113	67**
JCT02589	JdF Distribution System	Main No. 8 Terminus (Metchosin)	PPE00374	8	116	115	112	114	13	115	104	112	13**
JCT04656	JdF Distribution System	Main No. 14 Start	PPE02814	14	169	166	156	163	7	130	116	125	8**
JCTGA036	JdF Distribution System	Main No. 14 Terminus (Highlands)	PPE07823	14	169	166	155	163	0	130	116	125	0**
JCT00885	JdF Distribution System	Main No. 15 Terminus (Sooke)	PPE00953	15	91-98	95	89	92	85	99	88	93	81

Table A-6.4: HGL at RWS Connection Points for 2050 MDD Demands – Before Upgrades (Red Shade) and After Upgrades (Green Shade)

					2050 MDD Scenario - Kapoor Tunnel - In Service		2050 MDD Scenario - Kapoor Tunnel - Out of Service	
					Before Upgrades	After Upgrades	Before Upgrades	After Upgrades
Junction ID	Connection Point	Main No.	LoS Sooke Lake Reservoir (HGL - m)	LoS Goldstream System (HGL - m)	Average HGL (m)	Average HGL (m)	Average HGL (m)	Average HGL (m)
JCT00885	Main No. 15 Terminus	15	92	93	98	99	99	99
JCT02589	Main No. 8 Terminus	8	114	112	113	114	110	113
JCT02874	Main No. 8 Start	8	115	113	115	115	111	115
JCT04007	Main No. 7 Terminus	7	113	111	113	114	109	113
JCT04656	Main No. 14 Start	14	163	125	160	162	121	125
JCT05133	Main No. 7 Start	7	113	111	113	114	109	113
JCT07047	Export - Holland Meters (x2)	1	111	109	110	112	107	112
JCT07080	Burnside Meters (Burnside/Helmcken - Supply Outlet x2)	4	158	119	154	158	115	121
JCT15720	Craigflower Meter - Craigflower Rd @ Lampson St. #3	2	109	107	108	110	105	110
JCT15721	Craigflower Meter - Craigflower Rd @ Lampson St. #2	2	109	107	108	110	105	110
JCT15737	Oak Bay Meters #1 & #2 - Lansdowne Rd @ Foul Bay Rd	3	101	99	101	103	97	102
JCT15738	Richmond Meter - Richmond Rd (Supply Outlet)	3	101	99	101	103	98	103
JCT15744	Oak Bay #3 & Foul Bay Meters - Foul Bay Rd @ Lansdowne Rd	3	101	99	100	103	97	102
JCT15746	Craigflower Meter - Craigflower Rd (Esquimalt PCS)	2	109	108	109	111	105	110
JCT15750	Dupplin Meter - Dupplin Rd (Supply Outlet)	1	109	107	108	110	105	110
JCT15754	Tolmie/Douglas Meter - Douglas St (Supply Outlet)	3	107	105	106	108	103	108
JCT15757	Shelbourne Meter - Shelbourne St @ N Dairy Dr.	3	102	100	102	104	98	103
JCT15758	North Dairy Meter - North Dairy Rd (Supply Outlet)	3	102	100	102	104	98	103

					2050 MDD Scenario - Kapoor Tunnel - In Service		2050 MDD Scenario - Kapoor Tunnel - Out of Service	
					Before Upgrades	After Upgrades	Before Upgrades	After Upgrades
Junction ID	Connection Point	Main No.	LoS Sooke Lake Reservoir (HGL - m)	LoS Goldstream System (HGL - m)	Average HGL (m)	Average HGL (m)	Average HGL (m)	Average HGL (m)
JCT15763	Cloverdale Meter - Douglas St (Supply Outlet)	3	107	105	106	108	103	108
JCT15774	Somerset Meter - Tolmie Ave (Supply Outlet)	3	106	104	105	107	102	106
JCT15777	Maplewood Meter - Cook St (Supply Outlet)	3	105	103	104	106	101	106
JCT15790	Tillicum Meter - Tillicum Rd (Supply Outlet)	3	109	107	108	110	105	110
JCT15806	Burnside/Admirals Meter - Burnside Rd (Supply Outlet)	1	109	107	109	111	105	110
JCT15809	Marigold Meter - Marigold Rd (Supply Outlet)	1	109	108	109	111	105	110
JCT15815	Wilkinson Meter - Wilkinson Rd (Supply Outlet)	1	110	108	109	111	106	111
JCT15825	Blue Ridge Meter - Blue Ridge Rd (Supply Outlet)	4	157	119	153	158	115	121
JCT15827	Roy Meter - Roy Rd (Supply Outlet)	4	157	119	153	157	114	120
JCT15833	Layritz Meter - Layritz Park (Supply Outlet)	4	156	118	152	156	113	119
JCT15836	Markham Meter - West Saanich Rd (Supply Outlet)	4	155	117	151	156	113	119
JCT15845	Cherry Tree Bend Meter - Cherry Tree Bend	4	154	117	151	155	112	118
JCT15850	Hamsterly Pump Station	4	148	110	144	148	105	111
JCT15860	Alderley Meter - Alderley Rd (Supply Outlet)	4	114	103	114	115	99	105
JCT15959	Lochside Meters	4	109	99	110	110	95	101
JCT15969	Central Saanich Rd - Tsawout Meter (Supply Outlet x2)	4	109	98	109	109	95	100
JCT16015	Lowe Meter - Lowe Road Pump Station	4	100	91	102	102	88	94
JCT17314	Cecelia & Craigflower Meter - Unmetered Victoria Connection	2	109	107	108	110	105	110
JCT17446	Mallek Meter - Cook St (Supply Outlet)	3	105	103	104	106	101	106

					2050 MDD Scenario - Kapoor Tunnel - In Service		2050 MDD Scenario - Kapoor Tunnel - Out of Service	
					Before Upgrades	After Upgrades	Before Upgrades	After Upgrades
Junction ID	Connection Point	Main No.	LoS Sooke Lake Reservoir (HGL - m)	LoS Goldstream System (HGL - m)	Average HGL (m)	Average HGL (m)	Average HGL (m)	Average HGL (m)
JCT20453	Cecelia & Craigflower Meter - Unmetered Victoria Connection	2	109	107	108	110	105	110
JCT20457	Cecelia & Craigflower Meter - Unmetered Victoria Connection	2	109	107	108	110	105	110
JCT20606	Cook St Meter - Cook St @ Mallek Cres	3	105	103	104	106	101	106
JCT23804	Mount Newton Meter	4	108	98	108	109	94	100
JCT23902	McTavish Reservoir Inlet	4	98	90	100	101	87	93
JCTGA036	Main No. 14 Terminus	14	163	125	160	162	121	124
JCTGA18864	Martindale Meter	4	112	101	112	112	97	103
JCTGA18880	Cecilia & Craigflower Meter - Unmetered Victoria Connection	2	109	107	108	110	105	110
JCTGA19058	Cecelia & Craigflower Meter - Unmetered Victoria Connection	2	109	107	108	110	105	110
JCTGA19076	Mount Tolmie, Cedar Hill #1 & Cedar Hill #2 Meters (RWS Connection)	3	77	77	77	77	77	77
JCTGA19080	McTavish Inlet Meter	4	98	90	101	101	87	93
JCTGA20620	Admirals/TCH Meters - Admirals Rd (Supply Outlet)	3	109	108	109	111	106	110
JCTGA20670	Admirals Meter	2A	110	108	109	111	106	111
					FAIL: HGL < LoS Target		PASS: HGL > LoS Target	

Appendix B
Cost Estimates

	Option	2022$	Mid-Point of Construction	Inflated $
Supply				
Deep Northern Intake/Floating Pump Station	S3	$72,505,000	12/31/2031	$87,929,000
Leech River Diversion	S4/RWT1	$16,700,000	12/31/2044	$26,204,000
Sooke Lake Saddle Dam Hydraulic Improvements	M1	$10,000,000	12/31/2044	$15,691,000
Water Treatment				
Japan Gulch Dam Decommissioning	T2/T4	$10,256,000	12/31/2033	$12,940,000
Direct Filtration	T2/T4	$736,155,000	12/31/2035	$966,353,000
Clearwell	T2/T4	$23,999,000	12/31/2036	$32,134,000
Treated Water Pump Station	T2/T4	$29,780,000	12/31/2036	$39,873,000
Japan Gulch Water Filtration Plant Stage 2 Balancing Tank	M2	$15,384,000	12/31/2036	$20,599,000
Raw Water Transmission Mains				
DNI Transmission Main to Head Tank	M3	$38,768,000	06/30/2032	$47,483,000
3rd Main - Sooke Lake Dam to Head Tank	M4	$7,384,000	12/31/2032	$9,134,000
Jack Lake – Head Tank to Japan Gulch + 2 PS @ 2100 ADD	RWT5*	$208,649,000	12/31/2037	$284,959,000
Goldstream Reservoir Connector				
Goldstream Dam to Japan Gulch	M5	$67,075,000	12/31/2032	$82,971,000
Stage 1 Balancing Tank	M6	$5,538,000	12/31/2032	$6,850,000
Treated Water Transmission Mains				
Phase 1 Upgrades	M7	$7,499,000	6/30/2024	$7,838,000
Phase 2 Upgrades	M8	$38,204,000	6/30/2029	$44,085,000
Phase 3 Upgrades	M9	$55,293,000	6/30/2039	$77,792,000
Phase 4.1 Upgrades	M10	$47,670,000	6/30/2049	$81,771,000
Phase 4.2 Upgrades	M11	$48,928,000	6/30/2049	$83,930,000
East-West Connector				
Option 2 Transmission Main	M12	$58,562,000	6/30/2036	$77,639,000
Storage Tank				
Storage Hill Tank	M13	$12,820,000	12/31/2038	$17,859,000
Smith Hill Tank Pump Station	M14	$17,148,000	12/31/2038	$23,888,000
	Totals	**$1,528,000,000**		**$2,048,000,000**

*Jack Lake alignment with Pump Stations and transmission main sized for 2100 ADD Level of Service flow ~375 MLD

CAPITAL REGIONAL DISTRICT
2022 Master Plan

S3

Deep Northern Intake/Floating Pump Station					Prepared on: 8-Apr-22
Item No.	Description	Unit	Installed Cost		
			Quantity	Unit Price	Total Costs
1.0	General Requirements				
1.0	Mobilization/Demobilization	%	1	2%	$831,700
1.1	Bonding	%	1	1.5%	$623,800
1.2	Insurance	%	1	1.5%	$623,800
1.3	General Conditions	%	1	10%	$4,158,500
				Subtotal General Requirements	$6,237,800
2.0	Sooke Lake Reservoir Intake Pump Station (2100 ADD Firm Capacity - 375 MLD)				
2.1	Pump Station Floating Structure	LS	1	$4,178,744	$4,178,744
2.2	Pumps and motors - 75 MLD @ 92.6m TDH - 1,500 HP	each	6	$450,000	$2,700,000
2.3	Process stainless steel piping, fittings, welding, appurtenances	LS	1	$1,350,000	$1,350,000
2.4	Electrical, Instrumentation, Controls	LS	1	$2,468,623	$2,468,623
2.5	Standby power 4 X 1.5 MW generators	MW	6	$1,000,000	$6,000,000
2.6	ATS	each	1	$150,000	$150,000
2.7	Diesel tank farm for standby power	LS	1	$1,000,000	$1,000,000
2.8	BC Hydro High Voltage Supply and Connections	m	25,000	$700	$17,500,000
				Total Construction Costs	$41,585,167
Direct Costs:					
	Construction Costs				$41,585,167
	Contingency (% of Construction Costs)	35%			$14,554,800
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point	Years	$11,942,900
			12/31/2031	9.74	
				Total Direct Costs	$68,082,867
Indirect Costs:					
	Engineering (% of Direct Costs)	15%			$10,212,400
	Administration & Program Management (% of Direct Costs)	6%			$4,085,000
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%			$1,361,700
				Total Indirect Costs	$15,659,100
				Subtotal (Direct + Indirect Costs)	$83,741,967
	Interim Financing (% of Subtotal)	0%			$0
	Project Contingency (% of Subtotal)	5%			$4,187,100
				Total Capital Costs	$87,929,000

Notes:
1 Costs are in 2022 Canadian Dollars.
2 Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT

S4/RWT1

2022 Master Plan

Leech River Diversion					Prepared on: 8-Apr-22
Item No.	Description	Installed Cost			
		Unit	Quantity	Unit Price	Total Costs
1.0	General Requirements				
1.0	Mobilization/Demobilization	%	1	2%	$191,600
1.1	Bonding	%	1	1.5%	$143,700
1.2	Insurance	%	1	1.5%	$143,700
1.3	General Conditions	%	1	10%	$957,800
				Subtotal General Requirements	$1,436,800
2.0	Diversion works				
2.1	Diversion of Leech River to open channel flow in Leech Tunnel	LS	1	$8,141,600	$8,141,600
				Total Construction Costs	$9,578,400
Direct Costs:					
	Construction Costs				$9,578,400
	Contingency (% of Construction Costs)	35%			$3,352,400
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point 12/31/2044	Years 22.75	$7,359,100
				Total Direct Costs	$20,289,900
Indirect Costs:					
	Engineering (% of Direct Costs)	15%			$3,043,500
	Administration & Program Management (% of Direct Costs)	6%			$1,217,400
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%			$405,800
				Total Indirect Costs	$4,666,700
				Subtotal (Direct + Indirect Costs)	$24,956,600
	Interim Financing (% of Subtotal)	0%			$0
	Project Contingency (% of Subtotal)	5%			$1,247,800
				Total Capital Costs	$26,204,000

Notes:

1 Costs are in 2022 Canadian Dollars.

2 Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

M1

Sooke Lake Saddle Dam Hydraulic Improvements					Prepared on: 8-Apr-22
Item No.	Description	Unit	Installed Cost		
			Quantity	Unit Price	Total Costs
1.0	General Requirements				
1.0	Mobilization/Demobilization	%	1	2%	$114,700
1.1	Bonding	%	1	1.5%	$86,000
1.2	Insurance	%	1	1.5%	$86,000
1.3	General Conditions	%	1	10%	$573,600
				Subtotal General Requirements	$860,300
2.0	Saddle Dam Modifications				
2.1	Hydraulic modifications to dam culverts for additional flow*	LS	1	$4,875,200	$4,875,200
				Total Construction Costs	$5,735,500
Direct Costs:					
	Construction Costs				$5,735,500
	Contingency (% of Construction Costs)	35%			$2,007,400
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point	Years	$4,406,600
			12/31/2044	22.75	
				Total Direct Costs	$12,149,500
Indirect Costs:					
	Engineering (% of Direct Costs)	15%			$1,822,400
	Administration & Program Management (% of Direct Costs)	6%			$729,000
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%			$243,000
				Total Indirect Costs	$2,794,400
				Subtotal (Direct + Indirect Costs)	$14,943,900
	Interim Financing (% of Subtotal)	0%			$0
	Project Contingency (% of Subtotal)	5%			$747,200
				Total Capital Costs	$15,691,000

* Deception Gulch Dam and Sooke Lake Saddle Dam require upgrades to bring Deception Gulch Reservoir to full pool

Notes:

1 Costs are in 2022 Canadian Dollars.

2 Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

T2/T4

Japan Gulch Dam Decommissioning					Prepared on: 8-Apr-22
Item No.	Description		Installed Cost		
		Unit	Quantity	Unit Price	Total Costs
1.0	General Requirements				
1.0	Mobilization/Demobilization	%	1	2%	$117,600
1.1	Bonding	%	1	1.5%	$88,200
1.2	Insurance	%	1	1.5%	$88,200
1.3	General Conditions	%	1	10%	$588,200
				Subtotal General Requirements	$882,200
2.0	Decommissioning				
2.1	Removal and disposal of Japan Gulch Dam	LS	1	$5,000,000	$5,000,000
				Total Construction Costs	$5,882,200
Direct Costs:					
	Construction Costs				$5,882,200
	Contingency (% of Construction Costs)	35%			$2,058,800
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point 12/31/2033	Years 11.74	$2,078,400
				Total Direct Costs	$10,019,400
Indirect Costs:					
	Engineering (% of Direct Costs)	15%			$1,502,900
	Administration & Program Management (% of Direct Costs)	6%			$601,200
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%			$200,400
				Total Indirect Costs	$2,304,500
				Subtotal (Direct + Indirect Costs)	$12,323,900
	Interim Financing (% of Subtotal)	0%			$0
	Project Contingency (% of Subtotal)	5%			$616,200
				Total Capital Costs	$12,940,000

Notes:

1. Costs are in 2022 Canadian Dollars.
2. Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

T2/T4

WFP - Direct Filtration						Prepared on: 8-Apr-22
Item No.	**Description**	**Unit**	**Installed Cost**			
			Quantity	**Unit Price**		**Total Costs**
1.0	**General Requirements**					
1.0	Mobilization/Demobilization	%	1	2%		$8,444,400
1.1	Bonding	%	1	1.5%		$6,333,300
1.2	Insurance	%	1	1.5%		$6,333,300
1.3	General Conditions	%	1	10%		$42,222,200
			Subtotal General Requirements			$63,333,200
2.0	Filtration Plant					
2.1	390 MLD Direct Filtration Plant	LS	1	$358,889,000		$358,889,000
			Total Construction Costs			$422,222,200
Direct Costs:						
	Construction Costs					$422,222,200
	Contingency (% of Construction Costs)	35%				$147,777,800
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point: 12/31/2035	Years: 13.74		$178,240,500
			Total Direct Costs			$748,240,500
Indirect Costs:						
	Engineering (% of Direct Costs)	15%				$112,236,100
	Administration & Program Management (% of Direct Costs)	6%				$44,894,400
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%				$14,964,800
			Total Indirect Costs			$172,095,300
			Subtotal (Direct + Indirect Costs)			$920,335,800
	Interim Financing (% of Subtotal)	0%				$0
	Project Contingency (% of Subtotal)	5%				$46,016,800
			Total Capital Costs			$966,353,000

Notes:

1. Costs are in 2022 Canadian Dollars.
2. Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

T2/T4

WFP - Treated Water Pump Station					Prepared on: 8-Apr-22
Item No.	Description	Unit	Quantity	Installed Cost Unit Price	Total Costs
1.0	General Requirements				
1.0	Mobilization/Demobilization	%	1	2%	$401,900
1.1	Bonding	%	1	1.5%	$301,400
1.2	Insurance	%	1	1.5%	$301,400
1.3	General Conditions	%	1	10%	$2,009,400
				Subtotal General Requirements	$3,014,100
2.0	Pump Station				
2.1	Site clearing, stripping, grading, granular sub-base, base course, gravel fills throughout site and behind building walls	LS	1	$500,000	$500,000
2.2	Pump station walls, roof, concrete and reinforcement, outfit (25m X 20m)	m^2	500	$4,000	$2,000,000
2.3	Pumps and motors - 78 MLD @ 50 m TDH - 1,000 HP	each	6	$400,000	$2,400,000
2.4	Process stainless steel piping, fittings, welding, appurtenances	LS	1	$1,200,000	$1,200,000
2.5	Electrical, Instrumentation, Controls	LS	1	$1,830,000	$1,830,000
2.6	Standby power - 3 X 1.5 MW generators	MW	4.5	$1,000,000	$4,500,000
2.7	ATS	each	1	$150,000	$150,000
2.8	Diesel tank farm for standby power	LS	1	$1,000,000	$1,000,000
2.9	BC Hydro High Voltage Supply and Connections	m	5,000	$700	$3,500,000
				Total Construction Costs	$17,080,000
Direct Costs:					
	Construction Costs				$17,080,000
	Contingency (% of Construction Costs)	35%			$5,978,000
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point 12/31/2036	Years 14.74	$7,815,700
				Total Direct Costs	$30,873,700
Indirect Costs:					
	Engineering (% of Direct Costs)	15%			$4,631,100
	Administration & Program Management (% of Direct Costs)	6%			$1,852,400
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%			$617,500
				Total Indirect Costs	$7,101,000
				Subtotal (Direct + Indirect Costs)	$37,974,700
	Interim Financing (% of Subtotal)	0%			$0
	Project Contingency (% of Subtotal)	5%			$1,898,700
				Total Capital Costs	$39,873,000

Notes:
1. Costs are in 2022 Canadian Dollars.
2. Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

T2/T4

WFP - Clearwell					Prepared on: 8-Apr-22
Item No.	Description	Unit	Installed Cost		
			Quantity	Unit Price	Total Costs
1.0	General Requirements				
1.0	Mobilization/Demobilization	%	1	2%	$275,300
1.1	Bonding	%	1	1.5%	$206,500
1.2	Insurance	%	1	1.5%	$206,500
1.3	General Conditions	%	1	10%	$1,376,500
	Subtotal General Requirements				$2,064,800
2.0	Clearwell				
2.1	39,000 m^3 clearwell	m^3	39,000	$300	$11,700,000
	Total Construction Costs				$13,764,800
Direct Costs:					
	Construction Costs				$13,764,800
	Contingency (% of Construction Costs)	35%			$4,817,700
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point 12/31/2036	Years 14.74	$6,298,700
	Total Direct Costs				$24,881,200
Indirect Costs:					
	Engineering (% of Direct Costs)	15%			$3,732,200
	Administration & Program Management (% of Direct Costs)	6%			$1,492,900
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%			$497,600
	Total Indirect Costs				$5,722,700
	Subtotal (Direct + Indirect Costs)				$30,603,900
	Interim Financing (% of Subtotal)	0%			$0
	Project Contingency (% of Subtotal)	5%			$1,530,200
	Total Capital Costs				$32,134,000

Notes:

1 Costs are in 2022 Canadian Dollars.

2 Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

M2

Japan Gulch Water Filtration Plant Stage 2 Balancing Tank					Prepared on: 8-Apr-22
Item No.	Description	Unit	Installed Cost		
			Quantity	Unit Price	Total Costs
1.0	General Requirements				
1.0	Mobilization/Demobilization	%	1	2%	$176,500
1.1	Bonding	%	1	1.5%	$132,400
1.2	Insurance	%	1	1.5%	$132,400
1.3	General Conditions	%	1	10%	$882,400
	Subtotal General Requirements				$1,323,700
2.0	Storage/Balancing Tank				
2.1	25,000 m^3 cast in place concrete tank	m^3	25,000	$300	$7,500,000
	Total Construction Costs				$8,823,700
Direct Costs:					
	Construction Costs				$8,823,700
	Contingency (% of Construction Costs)	35%			$3,088,300
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point 12/31/2036	Years 14.74	$4,037,700
	Total Direct Costs				$15,949,700
Indirect Costs:					
	Engineering (% of Direct Costs)	15%			$2,392,500
	Administration & Program Management (% of Direct Costs)	6%			$957,000
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%			$319,000
	Total Indirect Costs				$3,668,500
	Subtotal (Direct + Indirect Costs)				$19,618,200
	Interim Financing (% of Subtotal)	0%			$0
	Project Contingency (% of Subtotal)	5%			$980,900
	Total Capital Costs				$20,599,000

Notes:

1. Costs are in 2022 Canadian Dollars.
2. Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

M3

DNI Transmission Main to Head Tank						Prepared on: 8-Apr-22
Item No.	Description	Unit	Installed Cost			
			Quantity	Unit Price	Total Costs	
1.0	General Requirements					
1.0	Mobilization/Demobilization	%	1	2%	$444,700	
1.1	Bonding	%	1	1.5%	$333,500	
1.2	Insurance	%	1	1.5%	$333,500	
1.3	General Conditions	%	1	10%	$2,223,500	
	Subtotal General Requirements				$3,335,200	
2.0	Transmission Main					
2.1	1.8m steel piping including bends, thrusting, valves	m	4,200	$4,500	$18,900,000	
	Total Construction Costs				$22,235,200	
Direct Costs:						
	Construction Costs				$22,235,200	
	Contingency (% of Construction Costs)	35%			$7,782,300	
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point 06/30/2032	Years 10.24	$6,748,000	
	Total Direct Costs				$36,765,500	
Indirect Costs:						
	Engineering (% of Direct Costs)	15%			$5,514,800	
	Administration & Program Management (% of Direct Costs)	6%			$2,205,900	
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%			$735,300	
	Total Indirect Costs				$8,456,000	
	Subtotal (Direct + Indirect Costs)				$45,221,500	
	Interim Financing (% of Subtotal)	0%			$0	
	Project Contingency (% of Subtotal)	5%			$2,261,100	
	Total Capital Costs				$47,483,000	

Notes:

1. Costs are in 2022 Canadian Dollars.
2. Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

M4

3rd Main - Sooke Lake Dam to Head Tank					Prepared on: 8-Apr-22
Item No.	Description	Unit	Installed Cost		
			Quantity	Unit Price	Total Costs
1.0	General Requirements				
1.0	Mobilization/Demobilization	%	1	2%	$84,700
1.1	Bonding	%	1	1.5%	$63,500
1.2	Insurance	%	1	1.5%	$63,500
1.3	General Conditions	%	1	10%	$423,500
	Subtotal General Requirements				$635,200
2.0	Transmission Main				
2.1	1.2m steel piping including bends, thrusting, valves	m	1,200	$3,000	$3,600,000
	Total Construction Costs				$4,235,200
Direct Costs:					
	Construction Costs				$4,235,200
	Contingency (% of Construction Costs)	35%			$1,482,300
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point: 12/31/2032	Years: 10.74	$1,355,000
	Total Direct Costs				$7,072,500
Indirect Costs:					
	Engineering (% of Direct Costs)	15%			$1,060,900
	Administration & Program Management (% of Direct Costs)	6%			$424,400
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%			$141,500
	Total Indirect Costs				$1,626,800
	Subtotal (Direct + Indirect Costs)				$8,699,300
	Interim Financing (% of Subtotal)	0%			$0
	Project Contingency (% of Subtotal)	5%			$435,000
	Total Capital Costs				$9,134,000

Notes:

1 Costs are in 2022 Canadian Dollars.

2 Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

RWT5*

Item No.	Description	Unit	Installed Cost: Quantity	Installed Cost: Unit Price	Installed Cost: Total Costs
Jack Lake – Head Tank to Japan Gulch + 2 PS @ 2100 ADD					Prepared on: 8-Apr-22
1.0	General Requirements				
1.0	Mobilization/Demobilization	%	1	2%	$2,393,400
1.1	Bonding	%	1	1.5%	$1,795,100
1.2	Insurance	%	1	1.5%	$1,795,100
1.3	General Conditions	%	1	10%	$11,967,100
				Subtotal General Requirements	$17,950,700
2.0	Pump Stations				
	Pump Station #2				
2.1	Site clearing, stripping, grading, granular sub-base, base course, gravel fills throughout site and behind building walls	LS	1	$200,000	$200,000
2.2	Pump station walls, roof, concrete and reinforcement, outfit (25m X 20m)	m^2	500	$4,000	$2,000,000
2.3	Pumps and motors - 125 MLD @ 93.942 m TDH - 2,400 HP	each	4	$500,000	$2,000,000
2.4	Process stainless steel piping, fittings, welding, appurtenances	LS	1	$1,000,000	$1,000,000
2.5	Electrical, Instrumentation, Controls	LS	1	$1,560,000	$1,560,000
2.6	Standby power - 4 X 1.5 MW generators	MW	6	$1,000,000	$6,000,000
2.7	ATS	each	1	$150,000	$150,000
2.8	Balancing Wet Well (1,000m3)	m^3	1,000	$300	$300,000
	Pump Station #3				
2.9	Site clearing, stripping, grading, granular sub-base, base course, gravel fills throughout site and behind building walls	LS	1	$200,000	$200,000
2.10	Pump station walls, roof, concrete and reinforcement, outfit (25m X 20m)	m^2	500	$4,000	$2,000,000
2.11	Pumps and motors - 125 MLD @ 95,285 m TDH - 2,400 HP	each	4	$500,000	$2,000,000
2.12	Process stainless steel piping, fittings, welding, appurtenances	LS	1	$1,000,000	$1,000,000
2.13	Electrical, Instrumentation, Controls	LS	1	$1,560,000	$1,560,000
2.14	Standby power - 4 X 1.5 MW generators	MW	6	$1,000,000	$6,000,000
2.15	ATS	each	1	$150,000	$150,000
2.16	Balancing Wet Well (1,000m3)	m^3	1,000	$300	$300,000
3.0	Transmission Mains and PCS				
3.1	1.8 m steel piping including bends, thrusting, valves HT to Jack Lake	m	11,600	$4,500	$52,200,000
3.2	1.8 m steel piping including bends, thrusting, valves Jack Lake to Japan Gulch	m	4,800	$4,500	$21,600,000
3.3	PCS to reduce pressure from 427m to 169m	each	3	$500,000	$1,500,000
				Total Construction Costs	$119,670,700
Direct Costs:					
	Construction Costs				$119,670,700
	Contingency (% of Construction Costs)	35%			$41,884,700
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point 12/31/2037	Years 15.74	$59,086,600
				Total Direct Costs	$220,642,000
Indirect Costs:					
	Engineering (% of Direct Costs)	15%			$33,096,300
	Administration & Program Management (% of Direct Costs)	6%			$13,238,500
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%			$4,412,800
				Total Indirect Costs	$50,747,600
				Subtotal (Direct + Indirect Costs)	$271,389,600
	Interim Financing (% of Subtotal)	0%			$0
	Project Contingency (% of Subtotal)	5%			$13,569,500
				Total Capital Costs	$284,959,000

Notes:
1 Costs are in 2022 Canadian Dollars.
2 Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

M5

Goldstream Connector - Goldstream Dam to Japan Gulch					Prepared on: 8-Apr-22
Item No.	Description	Unit	Installed Cost		
			Quantity	Unit Price	Total Costs
1.0	General Requirements				
1.0	Mobilization/Demobilization	%	1	2%	$769,400
1.1	Bonding	%	1	1.5%	$577,100
1.2	Insurance	%	1	1.5%	$577,100
1.3	General Conditions	%	1	10%	$3,847,100
				Subtotal General Requirements	$5,770,700
2.0	Transmission Main and Access Roadway				
2.1	1.2m steel piping GS dam to Jack Lake	m	2,400	$3,000	$7,200,000
2.2	1.8m steel piping Jack Lake to Japan Gulch	m	4,800	$4,500	$21,600,000
2.3	Access Roadway	m	2,400	$1,000	$2,400,000
2.4	Pressure Control Stations	each	3	$500,000	$1,500,000
				Total Construction Costs	$38,470,700
Direct Costs:					
	Construction Costs				$38,470,700
	Contingency (% of Construction Costs)	35%			$13,464,700
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point	Years	$12,308,100
			12/31/2032	10.74	
				Total Direct Costs	$64,243,500
Indirect Costs:					
	Engineering (% of Direct Costs)	15%			$9,636,500
	Administration & Program Management (% of Direct Costs)	6%			$3,854,600
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%			$1,284,900
				Total Indirect Costs	$14,776,000
				Subtotal (Direct + Indirect Costs)	$79,019,500
	Interim Financing (% of Subtotal)	0%			$0
	Project Contingency (% of Subtotal)	5%			$3,951,000
				Total Capital Costs	$82,971,000

Notes:

1 Costs are in 2022 Canadian Dollars.

2 Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

M6

Stage 1 Balancing Tank						Prepared on: 8-Apr-22
Item No.	Description	Unit	Installed Cost			
			Quantity	Unit Price	Total Costs	
1.0	General Requirements					
1.0	Mobilization/Demobilization	%	1	2%	$63,500	
1.1	Bonding	%	1	1.5%	$47,600	
1.2	Insurance	%	1	1.5%	$47,600	
1.3	General Conditions	%	1	10%	$317,600	
				Subtotal General Requirements	$476,300	
2.0	Storage/Balancing Tank					
2.1	9,000 m^3 cast in place concrete tank	m^3	9,000	$300	$2,700,000	
				Total Construction Costs	$3,176,300	
Direct Costs:						
	Construction Costs				$3,176,300	
	Contingency (% of Construction Costs)		35%		$1,111,700	
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point	Years		
			12/31/2032	10.74	$1,016,200	
				Total Direct Costs	$5,304,200	
Indirect Costs:						
	Engineering (% of Direct Costs)		15%		$795,600	
	Administration & Program Management (% of Direct Costs)		6%		$318,300	
	Miscellaneous/Specialty Consultants (% of Direct Costs)		2%		$106,100	
				Total Indirect Costs	$1,220,000	
				Subtotal (Direct + Indirect Costs)	$6,524,200	
	Interim Financing (% of Subtotal)		0%		$0	
	Project Contingency (% of Subtotal)		5%		$326,200	
				Total Capital Costs	$6,850,000	

Notes:

1. Costs are in 2022 Canadian Dollars.
2. Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

M7

Treated Water Transmission Mains - Phase 1 Upgrades					Prepared on: 8-Apr-22
Item No.	Description	Unit	Installed Cost		
			Quantity	Unit Price	Total Costs
1.0	General Requirements				
1.0	Mobilization/Demobilization	%	1	2%	$86,000
1.1	Bonding	%	1	1.5%	$64,500
1.2	Insurance	%	1	1.5%	$64,500
1.3	General Conditions	%	1	10%	$430,100
				Subtotal General Requirements	$645,100
2.0	Phase 1				
2.1	Watkiss PCS Upgrade	each	1	$500,000	$500,000
2.2	Main No.1 Upgrade - Semi-Urban	m	39	$4,000	$156,000
2.3	Associated PCS Upgrade as a result of Main No.1 HGL Increase	each	6	$500,000	$3,000,000
				Total Construction Costs	$4,301,100
Direct Costs:					
	Construction Costs				$4,301,100
	Contingency (% of Construction Costs)	35%			$1,505,400
		2.0%	Mid-point	Years	$262,200
	Inflation to Mid-point of Construction - (% per annum)		6/30/2024	2.23	
				Total Direct Costs	$6,068,700
Indirect Costs:					
	Engineering (% of Direct Costs)	15%			$910,300
	Administration & Program Management (% of Direct Costs)	6%			$364,100
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%			$121,400
				Total Indirect Costs	$1,395,800
				Subtotal (Direct + Indirect Costs)	$7,464,500
	Interim Financing (% of Subtotal)	0%			$0
	Project Contingency (% of Subtotal)	5%			$373,200
				Total Capital Costs	$7,838,000

Notes:

1 Costs are in 2022 Canadian Dollars.

2 Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

M8

Treated Water Transmission Mains - Phase 2 Upgrades					Prepared on: 8-Apr-22
Item No.	Description	Unit	Installed Cost		
			Quantity	Unit Price	Total Costs
1.0	General Requirements				
1.0	Mobilization/Demobilization	%	1	2%	$438,200
1.1	Bonding	%	1	1.5%	$328,700
1.2	Insurance	%	1	1.5%	$328,700
1.3	General Conditions	%	1	10%	$2,191,200
				Subtotal General Requirements	$3,286,800
2.0	Phase 2				
2.1	Main No.4 Upgrade - Rural	m	1,340	$3,500	$4,690,000
2.2	Main No.4 Upgrade - Semi Urban	m	2,345	$4,000	$9,380,000
2.3	Main No.4 Upgrade - Urban	m	911	$5,000	$4,555,000
				Total Construction Costs	$21,911,800
Direct Costs:					
	Construction Costs				$21,911,800
	Contingency (% of Construction Costs)	35%			$7,669,100
		2.0%	Mid-point	Years	$4,553,400
	Inflation to Mid-point of Construction - (% per annum)		6/30/2029	7.23	
				Total Direct Costs	$34,134,300
Indirect Costs:					
	Engineering (% of Direct Costs)	15%			$5,120,100
	Administration & Program Management (% of Direct Costs)	6%			$2,048,100
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%			$682,700
				Total Indirect Costs	$7,850,900
				Subtotal (Direct + Indirect Costs)	$41,985,200
	Interim Financing (% of Subtotal)	0%			$0
	Project Contingency (% of Subtotal)	5%			$2,099,300
				Total Capital Costs	$44,085,000

Notes:
1 Costs are in 2022 Canadian Dollars.
2 Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

M9

Treated Water Transmission Mains - Phase 3 Upgrades						Prepared on: 8-Apr-22
Item No.	Description	Unit	Installed Cost			
			Quantity	Unit Price		Total Costs
1.0	General Requirements					
1.0	Mobilization/Demobilization	%	1	2%		$634,300
1.1	Bonding	%	1	1.5%		$475,700
1.2	Insurance	%	1	1.5%		$475,700
1.3	General Conditions	%	1	10%		$3,171,300
					Subtotal General Requirements	$4,757,000
2.0	Phase 3					
2.1	Main No.4 Upgrade - Rural	m	1,640	$3,500		$5,740,000
2.2	Main No.4 Upgrade - Semi Urban	m	1,869	$4,000		$7,476,000
2.3	Main No.4 Upgrade - Urban	m	2,748	$5,000		$13,740,000
					Total Construction Costs	$31,713,000
Direct Costs:						
	Construction Costs					$31,713,000
	Contingency (% of Construction Costs)	35%				$11,099,600
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point: 6/30/2039	Years: 17.24		$17,421,000
					Total Direct Costs	$60,233,600
Indirect Costs:						
	Engineering (% of Direct Costs)	15%				$9,035,000
	Administration & Program Management (% of Direct Costs)	6%				$3,614,000
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%				$1,204,700
					Total Indirect Costs	$13,853,700
					Subtotal (Direct + Indirect Costs)	$74,087,300
	Interim Financing (% of Subtotal)	0%				$0
	Project Contingency (% of Subtotal)	5%				$3,704,400
					Total Capital Costs	$77,792,000

Notes:

1. Costs are in 2022 Canadian Dollars.
2. Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

M10

Treated Water Transmission Mains - Phase 4.1 Upgrades					Prepared on: 8-Apr-22
Item No.	Description	Unit	Installed Cost		
			Quantity	Unit Price	Total Costs
1.0	General Requirements				
1.0	Mobilization/Demobilization	%	1	2%	$546,800
1.1	Bonding	%	1	1.5%	$410,100
1.2	Insurance	%	1	1.5%	$410,100
1.3	General Conditions	%	1	10%	$2,734,100
				Subtotal General Requirements	$4,101,100
2.0	Phase 4.1				
2.1	Main No.3 Upgrade - Urban	m	4,648	$5,000	$23,240,000
				Total Construction Costs	$27,341,100
Direct Costs:					
	Construction Costs				$27,341,100
	Contingency (% of Construction Costs)	35%			$9,569,400
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point	Years	$26,404,200
			6/30/2049	27.25	
				Total Direct Costs	$63,314,700
Indirect Costs:					
	Engineering (% of Direct Costs)	15%			$9,497,200
	Administration & Program Management (% of Direct Costs)	6%			$3,798,900
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%			$1,266,300
				Total Indirect Costs	$14,562,400
				Subtotal (Direct + Indirect Costs)	$77,877,100
	Interim Financing (% of Subtotal)	0%			$0
	Project Contingency (% of Subtotal)	5%			$3,893,900
				Total Capital Costs	$81,771,000

Notes:

1 Costs are in 2022 Canadian Dollars.

2 Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

M11

Treated Water Transmission Mains - Phase 4.2 Upgrades					Prepared on: 8-Apr-22
Item No.	Description	Unit	Installed Cost		
			Quantity	Unit Price	Total Costs
1.0	General Requirements				
1.0	Mobilization/Demobilization	%	1	2%	$561,300
1.1	Bonding	%	1	1.5%	$420,900
1.2	Insurance	%	1	1.5%	$420,900
1.3	General Conditions	%	1	10%	$2,806,300
				Subtotal General Requirements	$4,209,400
2.0	Phase 4.2				
2.1	Main No.4 Upgrade - Rural	m	2,645	$3,500	$9,257,500
2.2	Main No.4 Upgrade - Semi-Urban	m	3,649	$4,000	$14,596,000
				Total Construction Costs	$28,062,900
Direct Costs:					
	Construction Costs				$28,062,900
	Contingency (% of Construction Costs)		35%		$9,822,000
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point	Years	$27,101,300
			6/30/2049	27.25	
				Total Direct Costs	$64,986,200
Indirect Costs:					
	Engineering (% of Direct Costs)		15%		$9,747,900
	Administration & Program Management (% of Direct Costs)		6%		$3,899,200
	Miscellaneous/Specialty Consultants (% of Direct Costs)		2%		$1,299,700
				Total Indirect Costs	$14,946,800
				Subtotal (Direct + Indirect Costs)	$79,933,000
	Interim Financing (% of Subtotal)		0%		$0
	Project Contingency (% of Subtotal)		5%		$3,996,700
				Total Capital Costs	$83,930,000

Notes:
1 Costs are in 2022 Canadian Dollars.
2 Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

M12

East-West Connector - Option 2 Transmission Main						Prepared on: 8-Apr-22
Item No.	Description	Unit	Installed Cost			
			Quantity	Unit Price		Total Costs
1.0	General Requirements					
1.0	Mobilization/Demobilization	%	1	2%		$671,800
1.1	Bonding	%	1	1.5%		$503,800
1.2	Insurance	%	1	1.5%		$503,800
1.3	General Conditions	%	1	10%		$3,358,800
				Subtotal General Requirements		$5,038,200
2.0	Linear Piping and Access					
2.1	1.0m steel piping including bends, thrusting, valves	m	4,300	$2,500		$10,750,000
2.2	0.5m steel piping including bends, thrusting, valves	m	14,000	$1,250		$17,500,000
2.3	Downstream PRV	ea	1	$300,000		$300,000
				Total Construction Costs		$33,588,200
Direct Costs:						
	Construction Costs					$33,588,200
	Contingency (% of Construction Costs)	35%				$11,755,900
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point	Years		$14,771,500
			6/30/2036	14.24		
				Total Direct Costs		$60,115,600
Indirect Costs:						
	Engineering (% of Direct Costs)	15%				$9,017,300
	Administration & Program Management (% of Direct Costs)	6%				$3,606,900
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%				$1,202,300
				Total Indirect Costs		$13,826,500
				Subtotal (Direct + Indirect Costs)		$73,942,100
	Interim Financing (% of Subtotal)	0%				$0
	Project Contingency (% of Subtotal)	5%				$3,697,100
				Total Capital Costs		$77,639,000

Notes:
1 Costs are in 2022 Canadian Dollars.
2 Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

M13

Smith Hill Tank					Prepared on: 8-Apr-22
Item No.	Description	Unit	Installed Cost		
			Quantity	Unit Price	Total Costs
1.0	General Requirements				
1.0	Mobilization/Demobilization	%	1	2%	$147,100
1.1	Bonding	%	1	1.5%	$110,300
1.2	Insurance	%	1	1.5%	$110,300
1.3	General Conditions	%	1	10%	$735,300
				Subtotal General Requirements	$1,103,000
2.0	Storage Tank				
2.1	Concrete cast-in-place tank	m^3	25,000	$250	$6,250,000
				Total Construction Costs	$7,353,000
Direct Costs:					
	Construction Costs				$7,353,000
	Contingency (% of Construction Costs)		35%		$2,573,600
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point	Years	$3,901,700
			12/31/2038	16.74	
				Total Direct Costs	$13,828,300
Indirect Costs:					
	Engineering (% of Direct Costs)		15%		$2,074,200
	Administration & Program Management (% of Direct Costs)		6%		$829,700
	Miscellaneous/Specialty Consultants (% of Direct Costs)		2%		$276,600
				Total Indirect Costs	$3,180,500
				Subtotal (Direct + Indirect Costs)	$17,008,800
	Interim Financing (% of Subtotal)		0%		$0
	Project Contingency (% of Subtotal)		5%		$850,400
				Total Capital Costs	$17,859,000

Notes:

1 Costs are in 2022 Canadian Dollars.

2 Construction costs will vary depending on market conditions at the time of tender.

CAPITAL REGIONAL DISTRICT
2022 Master Plan

M14

Smith Hill Tank Pump Station					Prepared on: 8-Apr-22
Item No.	Description	Unit	Installed Cost		
			Quantity	Unit Price	Total Costs
1.0	General Requirements				
1.0	Mobilization/Demobilization	%	1	2%	$196,700
1.1	Bonding	%	1	1.5%	$147,500
1.2	Insurance	%	1	1.5%	$147,500
1.3	General Conditions	%	1	10%	$983,500
				Subtotal General Requirements	$1,475,200
2.0	Pump Station				
2.1	Site clearing, stripping, grading, granular sub-base, base course, gravel fills throughout site and behind building walls	LS	1	$500,000	$500,000
2.2	Pump station walls, roof, concrete and reinforcement, outfit (25m X 20m)	m^2	500	$4,000	$2,000,000
2.3	Pumps and motors 20 MLD @ 50 m TDH	each	6	$300,000	$1,800,000
2.4	Process stainless steel piping, fittings, welding, appurtenances	LS	1	$900,000	$900,000
2.5	Electrical, Instrumentation, Controls	LS	1	$1,560,000	$1,560,000
2.6	Standby power 1 X 1.5 MW generators	MW	1.5	$1,000,000	$1,500,000
2.7	ATS	each	1	$100,000	$100,000
				Total Construction Costs	$9,835,200
Direct Costs:					
	Construction Costs				$9,835,200
	Contingency (% of Construction Costs)	35%			$3,442,300
	Inflation to Mid-point of Construction - (% per annum)	2.0%	Mid-point	Years	$5,218,700
			12/31/2038	16.74	
				Total Direct Costs	$18,496,200
Indirect Costs:					
	Engineering (% of Direct Costs)	15%			$2,774,400
	Administration & Program Management (% of Direct Costs)	6%			$1,109,800
	Miscellaneous/Specialty Consultants (% of Direct Costs)	2%			$369,900
				Total Indirect Costs	$4,254,100
				Subtotal (Direct + Indirect Costs)	$22,750,300
	Interim Financing (% of Subtotal)	0%			$0
	Project Contingency (% of Subtotal)	5%			$1,137,500
				Total Capital Costs	$23,888,000

Notes:
1 Costs are in 2022 Canadian Dollars.
2 Construction costs will vary depending on market conditions at the time of tender.