

# Water Use Planning and Management Study

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Prepared for:





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## Executive Summary

### Study Summary

The City of Parkville (City) needs to increase the resiliency and reliability of its' water supply system now and in the future to meet the desired level of service and adapt to climate change. In recent years, the reliability of the Englishman River and Arrowsmith Dam Reservoir surface water supply system has been lower than desired, resulting in reduced availability of water for Environmental Flow Needs (EFN) in the Englishman River and more frequent implementation of water use restrictions to lower peak summer water demands. Expected climate change impacts include increased variability of rainfall and hydrological patterns and longer hot summer periods, resulting in higher water use.

This Water Use Planning and Management Study was prepared to guide management of the water system with the objective of ensuring long-term sustainability and resilience in the water supply and to achieve a balance between human and environmental needs when withdrawing water from the Englishman River and groundwater aquifers. The study is commissioned and led by the City of Parkville with partial funding from the Englishman River Water Service (ERWS) joint venture with the Regional District of Nanaimo. As such, the analysis and recommendations focus primarily on securing a sustainable and resilient water supply for the City and the role of the ERWS in supplying water to the Nanoose Bay area is also included in the Study scope.

The study includes updated projections of water demand as it relates to population growth, indoor and outdoor water use habits, land development, and tourism, as well as water supply considering predicted changes in rainfall, groundwater availability and river flows. Projections for water demand and supply are made to the year 2075 (i.e., 50-year time horizon) as well as for the short (10-year) and medium (25-year) time horizons to assist in determining when to initiate planning and design for critical water supply infrastructure and whether the large capital expenditures recommended in the 2011 Arrowsmith Water Service conceptual planning reports can be deferred to future years. Ultimately, the current Study aligns with the anticipated design life of existing and proposed water supply infrastructure that ranges from 50 to 100 years and includes allowances for adjusting timelines based on community growth and the impacts of climate change.

In the short term, implementation of more robust water demand management programs combined with optimized use of existing groundwater sources is recommended. The most effective water demand management strategies and conservation programs are those that encourage reduction in seasonal outdoor water use during irrigation periods. In addition, assessment and development of a potential new water supply source is recommended. Feasibility assessment for a new water supply source would be conducted in the short term, with design and construction proceeding over the medium to long term.

### Water Supply System Information

The City of Parkville water system is supplied by both groundwater and surface water sources. Surface water is supplied through the Englishman River Water Service (ERWS), jointly owned by the City (74%) and the Regional District of Nanaimo (RDN) (26%) under a Joint Venture Agreement. The ERWS assets include the Water Intake and Treatment Facility that supplies water to both the City and RDN's Nanoose Bay Peninsula Water Service Area (NBP WSA) from the Englishman River. Other main components of the ERWS system include the raw water intake, pump station, supply main, water treatment plant (WTP), and a high-lift pump station that feeds into the water transmission and distribution system.

Source storage for the ERWS is provided by the Arrowsmith Water Service (AWS), owned by the City (63.9%), RDN (22.4%) and Town of Qualicum Beach (13.7%) under another joint venture agreement. The AWS owns the Arrowsmith Dam Bulk Water Supply Facility on the upper Englishman River watershed. The City of Parkville is

responsible for operating and managing the dam and for releasing water during late spring, summer and fall to supply environmental flow needs under the Provincial Provisional Operating Rule. The entire Englishman River Watershed area is approximately 324 km<sup>2</sup>; however, the Arrowsmith Dam Reservoir catchment area is only a small fraction of it at 4.9 km<sup>2</sup> (1.5% of the total area). It is located at an elevation of 810 m above sea level and 25 km upstream from the mouth of the river. The Arrowsmith Dam Reservoir has a storage volume of 9 Mm<sup>3</sup>, which includes approximately 2 Mm<sup>3</sup> of residual storage, and in addition to the dam spillway there are two low level outlet (LLO) pipes from the reservoir that are controlled by the City's SCADA system.

In addition to the surface water supply, the City of Parksville extracts groundwater from 16 active water source wells (WSW) at two well fields located within the City limits: the Railway Station Well Field and the Springwood Well Field. The City's SCADA system controls operation of the WSWs such that they are cycled on and off throughout the day based on reservoir levels to supplement the water supply system.

The current allocation of ERWS supply for the NBP WSA, in combination with existing groundwater sources within the NBP WSA, is sufficient to meet the needs for that area until the capacity of the ERWS treatment plant is increased which is currently planned for the 2030s.

## Key Findings

|                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Need to Improve Water Supply Resiliency</b> | <p>The City of Parksville has implemented Water Conservation Level 4 restrictions to limit non-essential water use 4 times in past 5 years, which is a much higher frequency than the desired level of service for the water system. The reliability of the Arrowsmith Dam Reservoir to meet its intended functions under the current operating conditions is approximately 60% (i.e., Level 4 restrictions are likely to be needed in 18 out of 30 years on average), whereas a preferred target for water supply reliability is 97% (Level 4 needed 1 out of 30 years on average). Although the current conditions noted above do not meet the desired target level of service, the existing sources have sufficient capacity to meet essential community demands and river flows for the OCP time horizon.</p> |
| <b>EFN Releases Dominate ERWS Reliability</b>  | <p>Federally and provincially mandated environmental flow release rates from Arrowsmith Dam Reservoir are determined based on the downstream Englishman River flows measured at the Water Survey of Canada (WSC) hydrometric monitoring gauge located at the Highway 19 A bridge. This gauge is also used to monitor Environmental Flow Needs (EFN), which is the rate of river flow required for proper functioning of aquatic ecosystems. The City is working to increase the operational flexibility of the reservoir release rates to better balance community and EFN needs through the operating period while also allowing for more water to be retained in the reservoir when possible for use in late summer and reduce the likelihood that Water Conservation Level 4 is needed.</p>                    |

|                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Reduce Seasonal Water Use</b>               | Current water conservation efforts are focused on managing outdoor water demand through seasonal irrigation restrictions and public education. The current Maximum Day Demand (MDD) for the City of Parksville and NBP WSA is made up of approximately 72% Seasonal Demand (or outdoor water use) and 28% Base Demand (or indoor water use). Additional efforts in water demand management are recommended including development of a 10-year Demand Management Plan to minimize or prevent further reduction of water source reliability. The plan includes specific management measures that can be implemented to reduce outdoor water use and ideally defer the need for water infrastructure capacity improvements. At present, the ERWS water treatment plant and two pump stations will require planned capacity upgrades in the 2030s. Enhanced demand management and increased summer use of groundwater may enable these upgrades to be deferred by up to 10 years.                                                                                                                                                                                                                          |
| <b>Further Optimization of Groundwater Use</b> | Current groundwater use is 22 - 35 % below the annual licensed withdrawal volume limit for the Springwood and Railway Station wells and below the withdrawal rates before 2020 prior to the WTP coming online. Upon review of recent short- and long-term groundwater trends it is apparent that there are seasonal fluctuations in the groundwater levels in Aquifer 216 with decreasing groundwater trends during the drier summer months and increasing groundwater trends during the wetter winter months. Further model analysis to optimize the withdrawals and maintain aquifer health is recommended to determine if summer groundwater use can be safely and sustainably increased, which would enable the current level of reliability for the ERWS source to be sustained until a new water supply source can be developed.                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Exploration of Water Source Options</b>     | <p>An initial review of five potential new surface water storage options (Shelton Lake, Healy Lake, an unnamed tributary to the South Englishman River, Moriarty Creek and Fish Tail Lake) was conducted to determine the estimated capital cost, construction risks, land impacts, environmental benefits/flow needs, and environmental impacts and associated regulatory risks. Recommendations include further engineering and environmental feasibility assessment for the preferred options after completing a structured decision-making process that would include engagement with regulators and First Nations.</p> <p>At Arrowsmith Dam Reservoir, options for increasing the capacity and removing the hydraulic limitations for access to the lower storage volume were also considered, which do marginally improve the reliability; however, the inflow to the watershed remains the same and is the limiting factor for meeting the reliability targets.</p> <p>It is also recommended to conduct a preliminary investigation of potential new groundwater sources, and to continue to monitor current efforts by the RDN to assess the feasibility of aquifer storage and recovery.</p> |



## 1. Introduction

### 1.1 Background

The City of Parksville (City) is looking to build resilience in its drinking water supply, including water sources, transmission system, and storage facilities to prepare the water supply for growth, climate change, and emergencies. In recent years, reliability of the surface water supply has been low resulting in implementation of increased water conservation measures through the peak summer demand periods as well as reduced availability for Environmental Flow Needs (EFN). These challenges have made it clear that water supply and use must be carefully managed to ensure the community will continue to have a sustainable supply of clean, safe, and affordable drinking water well into the future.

Water is supplied to the City and Nanoose Bay Peninsula Water Service Area (NBP WSA) from the Englishman River Water Service (ERWS) and Arrowsmith Water Service (AWS). The ERWS is jointly owned by the City (74%) and the Regional District of Nanaimo (RDN) (26%) under a Joint Venture Agreement and includes the Water Intake and Treatment Facility. AWS is owned by the City (63.9%), RDN (22.4%) and Town of Qualicum Beach (Town) (13.7%) under another joint venture agreement and includes the Arrowsmith Dam Bulk Water Supply Facility. The City, RDN and Town are the holders of the Arrowsmith Dam Reservoir and Conditional Water Licence #C134068. The City is responsible for operating and managing the dam and release rates under the Provincial Provisional Operation Rule.

The City of Parksville's water supply from the Arrowsmith Dam Reservoir is supplemented by the City's Springwood and Railway Station well systems. Nanoose Bay Peninsula water supply from the Arrowsmith Dam Reservoir is supplemented by groundwater systems owned and operated by the RDN.

This Water Use Planning and Management Study was developed to guide management of the water system with the objective of ensuring long-term sustainability and resilience in the water supply and to achieve a balance between human and environmental needs when withdrawing water from the Englishman River and groundwater aquifers.

### 1.2 Planning Horizon

The Study includes projections of water demand considering population growth, water use, land development, and tourism, as well as factors that influence water supply such as predicted changes in rainfall, groundwater availability, and river flows. Projections for water demand and supply are made to the year 2075 (50-year) and short (10-year) and medium (25-year) time horizons are also included. The time horizons were selected to assist in determining when to initiate planning and design for critical water supply infrastructure and whether large capital expenditures can be deferred to future years. The projections align with the anticipated design life of existing and proposed water supply infrastructure that ranges from 50 to 100 years and includes allowances for adjusting timelines based on community growth and the impacts of climate change.



## 1.3 Scope and Goals

The Water Use Planning and Management Study is intended to assist the City and RDN in the management of a resilient water supply and the efficient and sustainable delivery of service for future generations. The plan includes the following tasks:

- Document the history of the system and review the regulatory framework for the ERWS and AWS, existing surface water and groundwater water licences, and environmental flow needs for the Englishman River.
- Provide a summary of the specific analysis tools, methodologies and data needed to comprehensively assess the existing and future water supply, demand projections, climate change, and power generation potential.
- Review of existing water supply system data and future water supply sources including available surface water and groundwater, as well as current aquifer health.
- Review of population growth projections and land use changes to prepare a 50-year water demand forecast that accounts for seasonal tourism, climate change impacts, and potential operational changes.
- Development and review of plausible water system scenarios that represent the current (or status quo) and future system (including future climate and demands), adoption of various demand management strategies, and/or implementation of new capital projects (e.g. new water supply source).
- Review of water supply system resiliency and redundancy by determining:
  - the spatial and temporal variations for historical and future rainfall patterns to project water availability and capacity at existing sources and proposed new sources;
  - assessing changes in temperature and duration of heat waves in summer months resulting in shifting or longer high water demand periods; and
  - incorporating changes to existing and future environmental flow needs for the Englishman River.
- Review of opportunities to offset system costs and capitalize on power generation possibilities within the water system including solar and hydropower.
- Identify the need, scale, approximate cost, and timing of construction of future water supply sources, transmission system improvements, and demand management strategies, as well as the associated life cycle cost analysis for recommended capital expenditures and anticipated operation and maintenance costs, to ensure sustainable delivery of water.

## 1.4 Common Abbreviations

|                   |                                                               |
|-------------------|---------------------------------------------------------------|
| ADD               | Average Day Demand                                            |
| AWS               | Arrowsmith Water Service                                      |
| AMI               | Automated Meter Infrastructure                                |
| BD                | Base Demand                                                   |
| ENV               | Ministry of Environment and Parks                             |
| EFN               | Environmental Flow Needs                                      |
| ERWS              | Englishman River Water Service                                |
| FAR               | Floor Area Ratio                                              |
| GCM               | Global Circulation Model                                      |
| GWELLS            | Groundwater Wells and Aquifers database                       |
| ICI               | Industrial Commercial Institutional                           |
| IPCC              | International Panel on Climate Change                         |
| LLO               | Low Level Outlet                                              |
| m <sup>3</sup>    | Cubic metre (1,000 litres)                                    |
| m <sup>3</sup> /s | Cubic metre per second                                        |
| MAD               | Mean Annual Discharge                                         |
| MDD               | Maximum Day Demand                                            |
| Mm <sup>3</sup>   | Million cubic metres (1,000,000 m <sup>3</sup> )              |
| ML                | Megalitre (1,000 m <sup>3</sup> or 1,000,000 litres)          |
| MWh/year          | Megawatt hours per year                                       |
| MLD               | Megalitres per day (1,000 m <sup>3</sup> /d or 1,000,000 L/d) |
| NBP               | Nanoose Bay Peninsula                                         |
| NRW               | Non Revenue Water                                             |
| PCIC              | Pacific Climate Impacts Consortium                            |
| RDN               | Regional District of Nanaimo                                  |
| SCADA             | Supervisory Control and Data Acquisition                      |
| SD                | Seasonal Demand                                               |
| SSP               | Shared Socioeconomic Pathway                                  |
| VIHA              | Vancouver Island Health Authority                             |
| WSA               | Water Service Area                                            |
| WSW               | Water Source Wells                                            |

## 2. Current Water System

### 2.1 Existing System Overview

#### Englishman River and Arrowsmith Reservoir Watersheds

##### Englishman River Watershed

The Englishman River Watershed is located on the east coast of Vancouver Island near the City of Parksville. The river drains a watershed area of roughly 324 km<sup>2</sup> draining the east-facing slopes of Mount Arrowsmith (El. 1,820 m) and Mount Moriarty Ridge (El. 1,610 m) (see Figure 2-1). The majority of the watershed lies in the Coastal Western Hemlock and Coastal Douglas Fir biogeoclimatic zones with small areas of the watershed above 1,000 m in the Coastal Mountain-Heather Alpine and Mountain Hemlock Zones.

The generalized bedrock geology of the Englishman River watershed includes the following major bedrock types: Karmutsen Formation (basalt) from the Late Triassic, Sicker Group (volcanic) from the Paleozoic Period, and Nanaimo Group (sand, gravel, coal) from the Late Cretaceous. Surficial deposits are of glacial origin. The soils within the lower watershed are predominantly loamy sands and sandy clay loams.

The primary land-uses are privately owned forestry lands, the majority of which is owned and managed by Mosaic Forest Management. Other land use types in the lower reaches of the watershed include agriculture and suburban development.

The watershed has all species of salmon, including steelhead and the Englishman River is designated a sensitive stream by the BC government under the Fish Protection Act. The anadromous reach of the Englishman River is approximately 13 km long, downstream of Englishman River Falls, while upper reaches of the river support local trout populations.

The Englishman River Watershed lies within the Mount Arrowsmith Biosphere Region, recognized by UNESCO as part of a network of regions around the world as learning places for sustainable development<sup>1</sup>. The key aim is to promote solutions that reconcile conservation of biodiversity with sustainable use through engagement and collaboration with First Nations, regional governments, and local stakeholders.

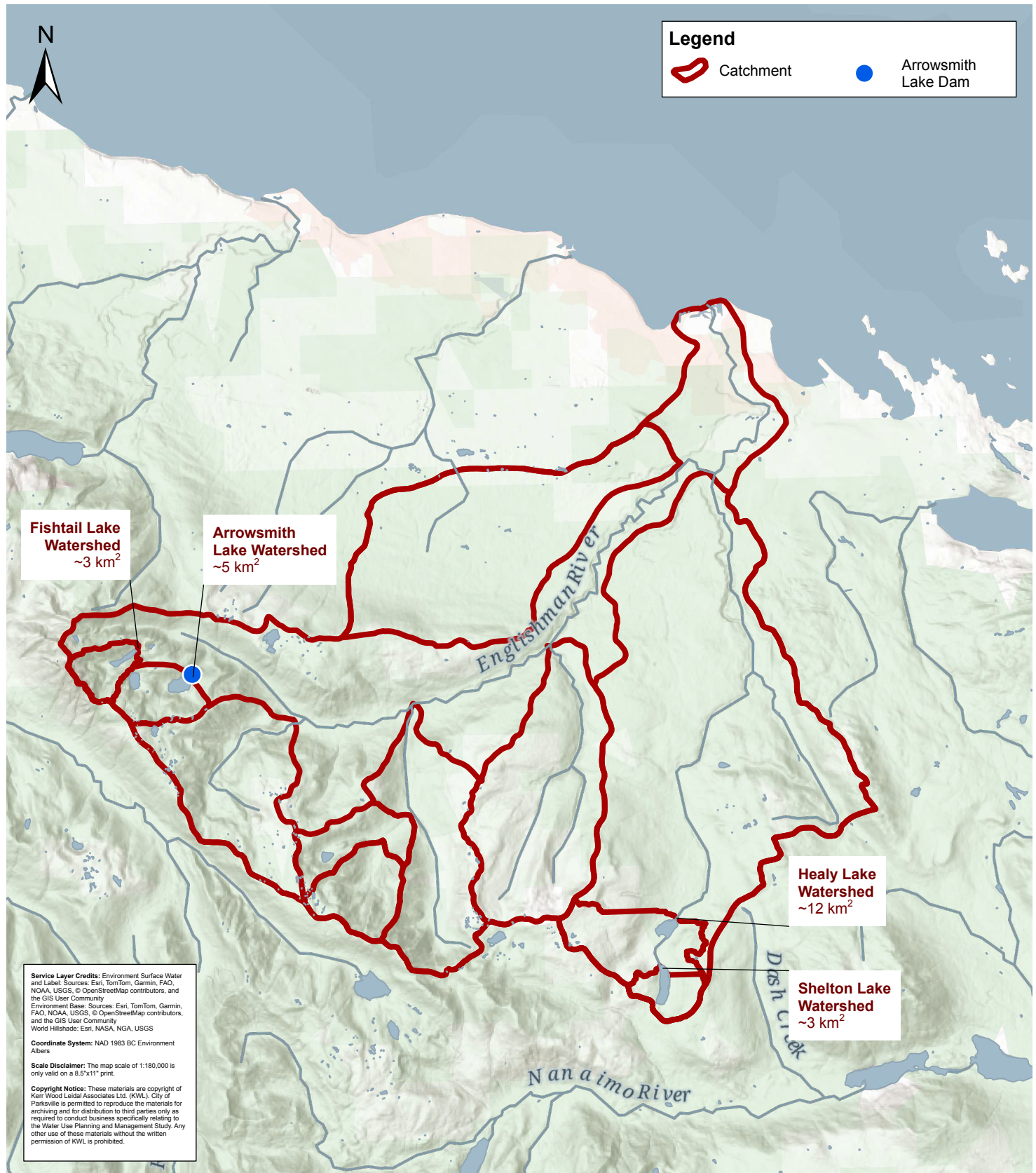
<sup>1</sup> Mount Arrowsmith Biosphere Region. <https://www.mabr.ca/>

## City of Parksville

### Water Use Planning and Management Study



**KERR WOOD LEIDAL**  
consulting engineers



Project No. 2248.018

Date June 2026

Scale 1:180,000

0 1.25 2.5 5 Kilometers

## Englishman River and Arrowsmith Lake Watersheds

**Figure 2-1**

## Arrowsmith Reservoir Watershed and Dam

Arrowsmith Dam Reservoir located on Arrowsmith Creek in the headwaters of the Englishman River on the east facing slopes of Mount Arrowsmith about 25 km upstream of the mouth of the Englishman River. The drainage area of the Arrowsmith Reservoir is 1.5% of the total drainage area of the Englishman River basin. Arrowsmith Reservoir is located at elevation 828.5 m; the average watershed elevation is about 1,050 m. The watershed is mostly forested and primarily consists of either exposed bedrock or very shallow soils over bedrock.

The Arrowsmith Dam was constructed between 1997 and 1999 and was commissioned in 2000. It is located at the outlet of Arrowsmith Reservoir and is a concrete gravity structure with a free overflow spillway located on the left (north) abutment and two low level outlets (LLOs). At the full storage level of 828.5 m, the reservoir has a live storage volume of 9 Mm<sup>3</sup>.

The upper LLO is a 900 mm diameter pipe and the lower LLO is a 600 mm diameter pipe which acts as a siphon when water levels fall below the upper LLO. The upper (gravity) LLO, with an invert elevation of 810.45 m, has a maximum capacity of approximately 1.34 m<sup>3</sup>/s (115.8 MLD). At this elevation, the residual storage in the reservoir is approximately 2 Mm<sup>3</sup>. The lower (siphon) LLO with an invert elevation of 801.5 m, has a maximum capacity that was designed to be twice the maximum community raw water flow at the original intake site at the time the dam was constructed or 0.76 m<sup>3</sup>/s (65.7 MLD). Not all of the storage below elevation 810.45 m (2.0 Mm<sup>3</sup>) may be accessible as it is unknown at what level the siphon could no longer function due to cavitation. The potential for the siphon to cavitate, thus losing ability to release water through the siphon, increases as the water level decreases.

The characteristics of the dam described above are taken from the Arrowsmith Dam Operation and Maintenance Manual (AWS, 2023).

A section of the dam showing the range of reservoir levels above the upper (gravity) LLO and the lower (siphon) LLO are shown in Figure 2-2.

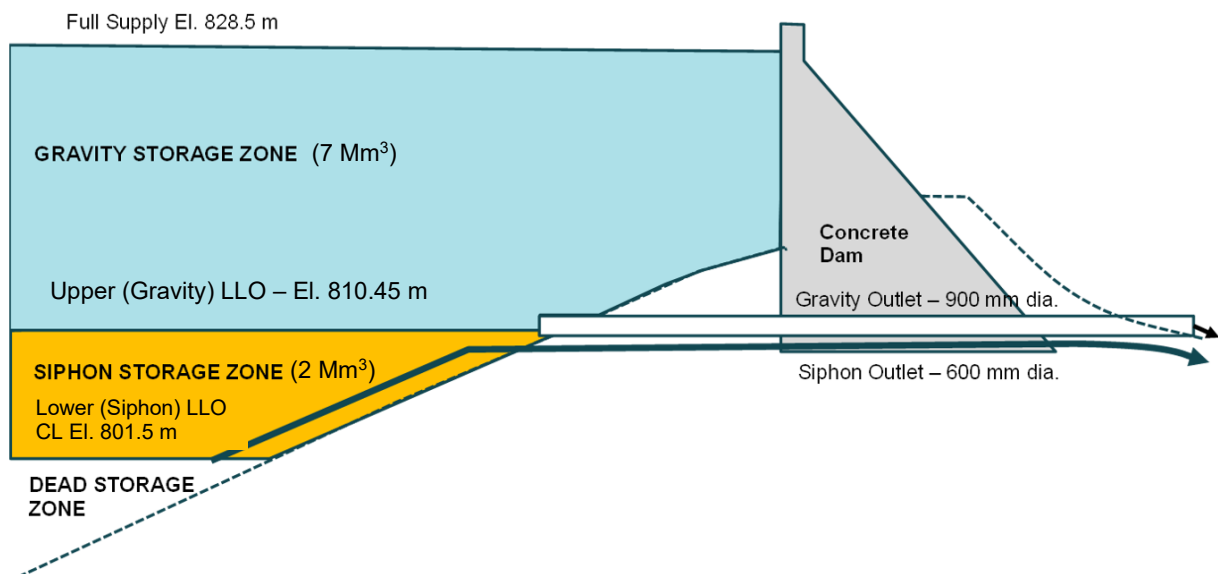


Figure 2-2: Arrowsmith Dam Upper Storage (Blue) and Lower Storage (Yellow)



Flow through the two LLOs are controlled by electrically actuated valves downstream of the dam. The 900 mm gravity flow high LLO splits into two small pipes and is controlled using parallel 500 mm diameter butterfly and 250 mm diameter ball valves. Downstream of the valves the flow discharges to the outlet channel through parallel 600 mm and 250 mm diameter outlet pipes.

The flow in the low level LLO (siphon) is controlled using a 350 mm motorized butterfly valve located near the outlet of the siphon which is controlled to keep the siphon charged at all times. Both the high LLO and low LLO pipes have orifice plates fastened to the outlets to prevent cavitation of the outlet valves during high reservoir level conditions. The orifice plate on the low LLO is removed when lake levels drop below 822.5 m.

Power for the valve actuators is provided by batteries that are charged with solar panels and there is a back-up generator on-site. Monitoring and controls are available at the dam through City of Parksville's SCADA system.

The overflow spillway is a 12 m wide ogee crest spillway with a downstream chute and flip bucket designed to pass the Probable Maximum Flood (PMF) for the Arrowsmith Watershed estimated at the time of the construction of the dam to be 42 m<sup>3</sup>/s.

A summary of the dam characteristics is provided in Table 2-1.

**Table 2-1: Arrowsmith Dam Characteristics**

| Parameter                              | Value                                 |
|----------------------------------------|---------------------------------------|
| Watershed area                         | 4.9 km <sup>2</sup>                   |
| Full Storage Elevation                 | 828.5 m                               |
| Reservoir Surface Area at Full Storage | 0.3 km <sup>2</sup>                   |
| Storage Volume                         | 9 Mm <sup>3</sup>                     |
| High LLO Invert El.                    | 810.45 m                              |
| High LLO Max. Capacity                 | 117.5 MLD<br>(1.34 m <sup>3</sup> /s) |
| Low LLO (Siphon) Invert El.            | 801.50 m                              |
| Low LLO (Siphon) Max. Capacity         | 65.6 MLD<br>(0.76 m <sup>3</sup> /s)  |
| Spillway                               | 12 m wide ogee                        |
| Inflow Design Flood Peak Flow          | 42 m <sup>3</sup> /s                  |

The most recent dam safety review (DSR) of Arrowsmith Dam was carried out in 2022 by Stantec (Stantec, 2022). The DSR was triggered as per the schedule for DSR updates under the BC Dam Safety Regulation and as a requirement under the City's Dam Safety Management System. No special safety concerns regarding the dam were raised when the DSR was triggered. The key findings of the 2022 DSR were:

- Overall the dam is in good condition and performing within its historical design limits. No critical safety deficiencies were identified in the review.
- None of the 19 recommendations made to address deficiencies and non-conformances at the dam, require immediate capital upgrades to the infrastructure at the dam with all the recommendations requiring either on-going monitoring, improvements to instrumentation or documentation updates.

## River Intake and Water Treatment Plant

In 1999, when Arrowsmith Dam was constructed, the City of Parksville raw water intake was located downstream of the Highway 19A Bridge. In 2019, a new water treatment plant (WTP) and raw water intake upstream of the Highway 19 Bridge were constructed; the new intake is located about 4.5 km upstream of the original intake location. The Water Survey of Canada (WSC) hydrometric monitoring gauge which measures flow in the Englishman River, (Englishman River near Parksville Gauge – 08HB002) is located at the Highway 19 A bridge. This gauge is used to monitor Environmental Flow Needs (EFN) in the Englishman River as discussed in Section 2.5.

The main components of the intake and treatment system include:

- **River Intake:** Bar screen intake located on the Englishman River.
- **Raw Water Pump Station:** Pumps raw water from intake to the WTP and filters the water using sand separators.
- **Raw Water Supply Main:** 700 mm diameter HDPE (DR 13.5 & DR 17) pipe with a 550 m length. A coagulant injection chamber is located on this main 150 m upstream of the WTP.
- **Water Treatment Plant:** Includes fine strainers, primary and secondary ultra filtration membranes, ultraviolet disinfection and chlorination.
- **High Lift Pump Station:** Pumps from the WTP to the Top Bridge and Springwood #4 Reservoirs via transmission mains.

The capacity of each component is summarized in Table 2-2.

**Table 2-2: Summary of Intake and WTP System Capacities**

| Facility                                                                                                                                                                                                      | Nominal Existing Capacity (MLD) | Nominal Potential Expanded Capacity (MLD) | Data Source |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-------------------------------------------|-------------|
| Intake Screen and Weir                                                                                                                                                                                        | 48                              | 48                                        | 1           |
| Raw Water Pump Station                                                                                                                                                                                        | 19                              | 48                                        | 1           |
| Raw Water Supply Main to WTP                                                                                                                                                                                  | 48                              | 48                                        | 1           |
| Water Treatment Plant                                                                                                                                                                                         | 16                              | 47                                        | 2           |
| High Lift Pump Station                                                                                                                                                                                        | 19                              | 48                                        | 1           |
| Notes:<br>1. CH2MHill, Water Intake, Treatment Plant, and Supply Mains, Final Pre Design Report, June 5, 2014.<br>2. Englishman River Water Service Water Treatment Plant Operations Update, January 9, 2023. |                                 |                                           |             |

As per the 2022 Englishman River Water Service Joint Venture Agreement, the capital cost apportionment for the water intake and WTP systems is 74% to the City and 26% to RDN; however, the operating costs are shared based on actual flows to each partner that may be close to these estimates but vary year to year.

## Groundwater System

The City of Parksville currently extracts groundwater from 16 active water source wells (WSW) to supplement their surface water supply. All WSWs are registered with the Ministry of Environment and Parks (ENV) in the provincial Groundwater Wells and Aquifers (GWELLS) database.

The active WSWs all divert water from Aquifer 216 and are located within two well fields: the Railway Station Well Field and the Springwood Well Field, both located in the City. The City's SCADA system controls operation of the WSWs such that they are cycled on and off throughout the day based on reservoir levels to supplement the water supply system.

Well information, including installation date, well depth, and screen depths along with static groundwater level data and available head is included in the Task 1 – Water Supply Well Data Compilation and Overview of the Englishman River Aquifers (Waterline, September 15, 2025) report in Appendix B.

Summary information for annual groundwater use for the City's active WSWs is provided in Table 2-3, below for two different time periods: 2015-2019 and 2020-2024. The data shows that for the period from 2015 to 2024 the average annual diversion rate was approximately 987,000 m<sup>3</sup>/year, which is below the existing use groundwater licence application maximum diversion volume. In addition, the data shows that the total diversion rate has reduced since the new intake and WTP came into service in 2019; this is discussed further in Section 6.3.

**Table 2-3: Summary of Groundwater Water Use**

| Location                                                                                                                                                                                                                                 | Average Annual Diversion Volume (m <sup>3</sup> /year) 2015-2019 | Average Annual Diversion Volume (m <sup>3</sup> /year) 2020-2024 | Existing Use Groundwater Licence Application Maximum Diversion Volume <sup>1</sup> (m <sup>3</sup> /year) | Estimated Groundwater Available <sup>2</sup> (m <sup>3</sup> /year) |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| Railway Station Wells                                                                                                                                                                                                                    | 487,500                                                          | 369,700                                                          | 595,820                                                                                                   | 226,120                                                             |
| Springwood Wells                                                                                                                                                                                                                         | 692,200                                                          | 408,390                                                          | 608,002                                                                                                   | 199,612                                                             |
| <b>Total</b>                                                                                                                                                                                                                             | <b>1,179,700</b>                                                 | <b>778,090</b>                                                   | <b>1,203,822</b>                                                                                          | <b>425,732</b>                                                      |
| Notes<br>1. Existing Use Groundwater Licence Application Maximum Diversion Volume as per the BC Water Sustainability Act<br>2. Existing Use Groundwater Licence Application Maximum minus Recorded Annual Diversion Volume for 2020-2024 |                                                                  |                                                                  |                                                                                                           |                                                                     |

## Transmission System

The transmission system conveys water from the WTP to the Top Bridge Reservoir (also known as the Industrial Reservoir) and Springwood #4 Reservoir, and to the Nanoose Bay Peninsula Pump Station (also known as Craig Bay Pump Station #2), which is owned and operated by the RDN and supplies water to the NBP WSA.

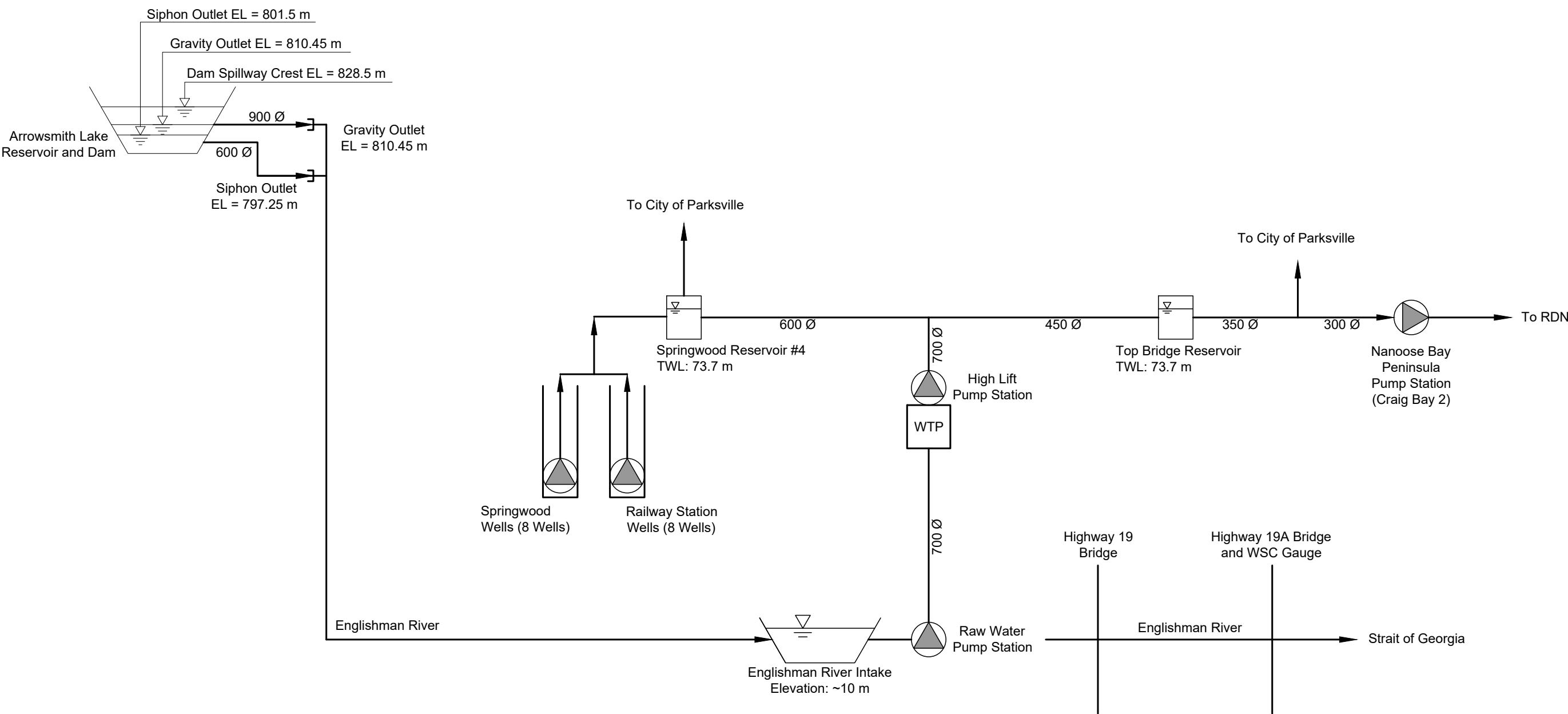
The nominal capacity of the transmission system components is summarized in Table 2-4. The transmission main capacity is based on the flow at the maximum allowable pipe velocity as per the City's design criteria.

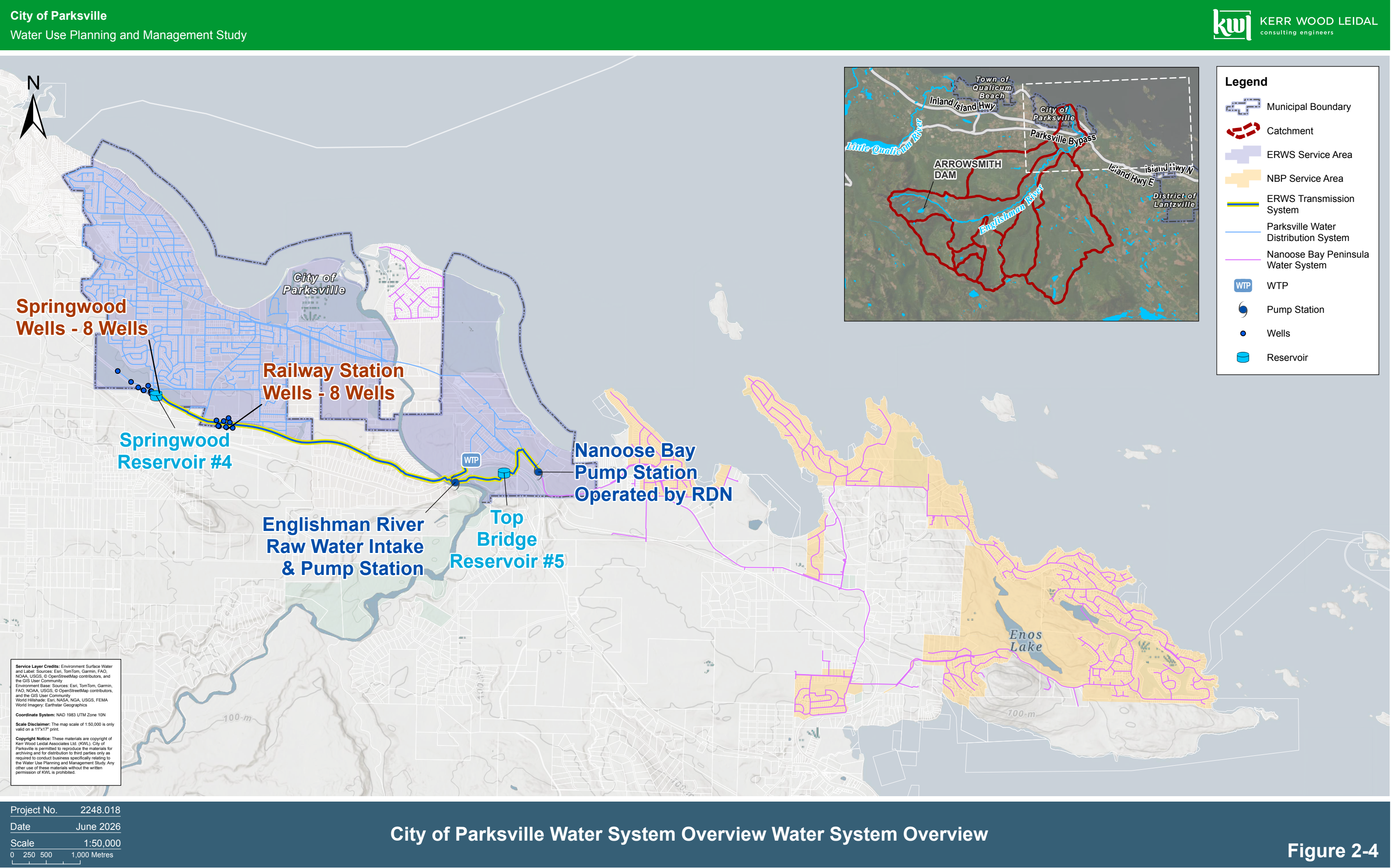


**Table 2-4: Summary of Transmission System Capacities**

| Transmission System Facility                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Nominal Existing Capacity (MLD) | Nominal Expanded Capacity (MLD) | Data Source |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|-------------|
| ERWS Treated Water Supply Main from WTP to Diversion Point (700 mm dia. HDPE DR 11)                                                                                                                                                                                                                                                                                                                                                                                                                                        | 48                              | 48                              | 1           |
| ERWS Treated Water Supply Main to Industrial/Top Bridge Reservoir (450 mm dia. HDPE DR varies, 11-17)                                                                                                                                                                                                                                                                                                                                                                                                                      | 22                              | 22                              | 1           |
| ERWS Treated Water Supply Main to Springwood Reservoir #4 (600 mm dia. HDPE DR varies, 11-17)                                                                                                                                                                                                                                                                                                                                                                                                                              | 38                              | 38                              | 2           |
| Transmission/Distribution Main from Industrial/Top Bridge Reservoir to Nanoose Bay Peninsula Pump Station (350 & 300 mm dia. ductile iron, pressure class unknown)                                                                                                                                                                                                                                                                                                                                                         | 12                              | 12                              | 3           |
| Nanoose Bay Peninsula Pump Station (Craig Bay PS#2)                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 7.4                             | 9.1                             | 4           |
| Notes:<br>1. Contract 1: Intake, WTP and Top Bridge Reservoir Transmission Main Record Drawings. Capacity has been calculated based on a design velocity of 2 m/s.<br>2. Contract 2: Springwood Reservoir Transmission Main Record Drawings. Capacity has been calculated based on a design velocity of 2 m/s.<br>3. Parksville Water Model.aprx InfoWater Pro Model provided by City of Parksville on December 10, 2024.<br>4. McElhanney, Nanoose Bay Peninsula Pump Station, Preliminary Design Report, March 16, 2018. |                                 |                                 |             |

Figure 2-3 shows a schematic of the various components of the water supply system, while Figure 2-4 shows an overview of the water system including the groundwater sources and the transmission system.







## 2.2 History of Water Supply

The first water supply study carried out for the RDN commenced in 1972 and the study considered the water supply needs across the region from Cedar to Bowser (. Three potential sources of water supply were identified for the region including Cameron Lake/Little Qualicum River, Englishman River, and Jump Creek in the Nanaimo River watershed.

The dry summer and low snowpack of 1985 put noticeable stress on all water supplies on Vancouver Island. In response, the RDN and the Greater Nanaimo Water District decided to act on the recommendation from the 1972 report to carry out a detailed study of the Englishman River watershed to identify feasible water supply storage locations. This study was completed in 1987 and identified six potential locations for dams and water supply reservoirs within the Englishman River watershed (Chatwin, 1987). After carrying out evaluation of the sites and comparing watershed/forestry considerations, geotechnical considerations, hydrotechnical/environmental considerations, and water transmission considerations Healey Lake was identified as the preferred site location for a storage reservoir in the watershed.

In 1990, a referendum authorized borrowing of \$450,000 for preliminary design of a regional water supply system servicing from Lantzville to Qualicum Beach with a focus on the Englishman River and Bonnel Creek as water supply sources. Further investigations and preliminary design studies for an Englishman River regional water supply were carried out in 1992 and finalized in 1995. These studies identified Arrowsmith Lake as the preferred storage reservoir location to support conservation flows and municipal water supply because it was the most economically viable option with the least environmental impact. On November 16, 1996, the City and RDN voted in favour of development for a water supply system within the Englishman River watershed with Arrowsmith Lake as the source water storage reservoir location.

### Arrowsmith Water Service

The Arrowsmith Water Service (AWS) was formed as a joint venture between the RDN, the City and the Town of Qualicum Beach with the mandate to develop a regional water supply system on the Englishman River. The original plan for construction of the water supply infrastructure was to construct a dam at Arrowsmith Lake as a first phase with the intake and bulk transmission system construction to proceed as the second phase.

In 1996, the City, on behalf of the AWS partners, applied for a water licence for construction of the Arrowsmith Dam along with a bulk water intake located just downstream of the confluence of the Englishman River and the South Englishman River. On March 4, 1997, a conditional water licence (C110050) was issued to the City, the RDN and the Town of Qualicum Beach, on behalf of AWS, for construction of the Arrowsmith Dam to store 9 Mm<sup>3</sup> of water for community water supply and conservation purposes with a precedence date of August 10, 1995. The conditional water licence also allowed for a withdrawal of up to 48 MLD up to a maximum of 7 Mm<sup>3</sup> from the Englishman River for community water supply. The conditional water licence was issued based on the premise that the City would continue to use the existing intake, located downstream of the Highway 19A bridge, until such time as new intake location was identified and a new intake was constructed.

Construction of the Arrowsmith Dam was completed in 1999 and the dam was commissioned in 2000.

Between 2005 to 2009, further progress was made on the AWS capital plan focusing on the location of a new intake. After a review of economic viability, environmental impact, land ownership, and implications to the existing water system, the approximately 10 km reach of the river between the

Highway 19 and Highway 19A bridges was recommended for further investigation to identify a site for the treatment plant and intake.

In 2011, the partners revised the AWS agreement to continue to maintain and operate Arrowsmith Dam but remove the mandate to manage future capital projects. The AWS partners continue to hold the water licence for Arrowsmith Dam with the City being responsible for ongoing maintenance and operation of the dam.

Site selection and construction of the new intake site, including updates to the original water licence (C110050) required to permit construction of the new intake, is discussed further in the following section.

## Englishman River Water Service

The ERWS, a joint venture between the City and RDN, was established in 2011 to move forward with funding, designing, constructing and operating the proposed Englishman River intake and water treatment plant.

It was determined that year-round withdrawal of water from Englishman River was needed to ensure adequate water supply. However, given the presence of large increases in turbidity in the Englishman River during winter flood events, an upgraded treatment system was required. A two-stage treatment process of filtration followed by disinfection was identified as a means to meet the requirements of the Guidelines for Canadian Drinking Water Quality and Vancouver Island Health Authority.

Relocation of the raw water intake was required because continued use of the City raw water intake, located downstream of the Highway 19A bridge, was not favoured for the following reasons:

1. There is potential for contamination/chemical spill in the river water from a vehicle accident on either the Highway 19A bridge, the Highway 19A bridge or the railway.
2. The intake was located within the floodplain and could be compromised during a large flood event.
3. The infiltration gallery intake required frequent and onerous maintenance to maintain full capacity.
4. The limited depth of the Englishman River flow at the intake location could limit potential for raw water withdrawal, especially during low summer flow conditions.

Therefore, a new location of the raw water intake was required. The site selection involved a multi-stage process including discussions with First Nations, provincial and federal regulators, and local stakeholder groups to obtain feedback on watershed management pertaining to a relocated intake (Associated Engineering, 2011). An optimization process to identify a shortlist of site locations along the 10 km stretch of the Englishman River was carried out. This process considered five criteria including:

1. Land use compatibility
2. Heritage/archaeology concerns
3. Ecological impacts
4. Geotechnical considerations
5. Water system implications

Three sites were shortlisted and further assessed using a triple bottom line approach based on multi-criteria decision theory. Each site was assigned a relative ranking to reflect how well it performed for each criterion. Those scores were then added, using a relative weighting criteria based on feedback from First Nations, the City, regulators, and local stakeholders. Based on this evaluation, a site located

upstream of the Highway 19A bridge was selected as the preferred option because it provided the best balance between the criteria.

On January 17 2013, the conditional water licence C110050 was superseded by C129710 to update the licensed volumes and withdrawal rates to metric units and extend the period for construction of the works until December 31, 2016.

The planning and design then moved into preliminary and detailed design phases for the intake and the plant. This was carried out over the period from 2013 to 2017 and was led by CH2MHill, now Jacobs. Construction of the intake and plant was completed in 2019.

A conditional water licence (C134068), which supersedes C129710, was issued to the City, the RDN and the Town of Qualicum Beach, on behalf of the AWS, on October 26, 2017 which permitted construction of the raw water intake at the location upstream of the Highway 19A bridge and extended the permitted construction period to December 31, 2020. The current licence (C134068) has the same precedence date of August 10, 1995 as the original licence (C110050) under which the Arrowsmith Dam was constructed.

## 2.3 Provincial and Federal Regulations and Standards

There are several provincial and federal regulations and standards governing water in British Columbia and Canada that pertain to the provision of water supply for domestic or drinking water uses as it pertains to this study.

### BC Water Sustainability Act

The *BC Water Sustainability Act, SBC 2014, C. 15* (WSA) and associated regulations came into effect on February 29, 2016. The WSA is intended to protect surface water and groundwater resources in BC and requires licensing of non-domestic groundwater use (e.g., water systems, irrigation, commercial or industrial use) in the province.

Regulations that are enacted under the WSA to aid the province in management of water include:

- *Water Sustainability Regulation, B.C. Reg. 184/2024*
- *Groundwater Protection Regulation, B.C. Reg. 253/2022*
- *Dam Safety Regulation, B.C. Reg. 32/2023*
- *Water Sustainability Fees, Rentals and Charges Tariff Regulation, B.C. Reg. 187/2023*
- *Water Districts Regulation, B.C. Reg. 38/2016*

Through water licences issued to the City, the WSA regulates the maximum volume of water that can be stored at Arrowsmith Dam Reservoir and the maximum withdrawal rate from the Englishman River at the WTP along with the required Environmental Flow Needs (EFN) to be maintained in the river downstream of the intake to support river habitat health. The WSA also regulates the total volume of water that can be withdrawn from groundwater. Furthermore, the WSA authorizes construction and operation of the works associated with the bulk water supply system including Arrowsmith Dam, the raw water pump station at the WTP and the groundwater wells.

## Drinking Water Protection Act and Regulation

The BC *Drinking Water Protection Act, SBC 2001* (DWPA) governs the construction and operation of drinking water supply systems in BC to protect public health and safety. Supplying water to two or more residences is considered a water supply system. The DWPA requires that a Construction Permit and a Permit to Operate be issued by the local health authority, in accordance with the DWPA *Drinking Water Protection Regulation (B.C. Reg. 168/2025)* (DWPR) prior to operating any new water source that will be connected to an existing water system.

The DWPA and DWPR are outcome-based and rely on broad powers delegated to Medical Health Officers and Drinking Water Officers of the five independent Health Authorities to interpret the legislation and supporting policy issued by the province. The City of Parksville and Englishman River Water Service are within the jurisdiction of the Island Health Authority. Decisions regarding drinking water safety are prioritized based on risks to human health. Three key policy references for drinking water regulation in BC are the Drinking Water Officers' Guide, the Design Guidelines for Drinking Water Systems in British Columbia, and the Health Canada Guidelines for Canadian Drinking Water Quality.

### Drinking Water Officer's Guide

The Drinking Water Officer's Guide (DWOOG) contains all provincial health policy related to drinking water (Ministry of Health, 2025). The DWOOG is intended to assemble practical public health knowledge and experience for the benefit of public health officials and the public, and to refine policy and practice to reflect the legislative regime established under the DWPA. This regime is based upon a multi-barrier approach, which seeks to address threats to drinking water at various stages, including its source, treatment systems, distribution, and at the tap.

### Design Guidelines for Drinking Water Systems in British Columbia

The Design Guidelines for Drinking Water System in British Columbia recommend that water sources for drinking water systems should have a sufficient reliability to provide the maximum projected water withdrawals up to the 50-year return period drought, or the extreme drought of record including considerations for multiple years of drought and changes in drought frequency. This is equivalent to a reliability of 49 out of 50 years or 98%, (Ministry of Health, 2023).

### Guidelines for Canadian Drinking Water Quality

Guidelines for Canadian Drinking Water Quality are developed by the Federal-Provincial-Territorial Committee on Drinking Water and published by Health Canada. Although non-binding under BC legislation, the Guidelines are an important standard which guide construction and operation of drinking water systems in BC and regulatory decisions by the regional Drinking Water Officer under the DWPA and DWPR (Health Canada, 2025).

## Provincial Fisheries Act

The BC *Fisheries Act, RSBC, 1979, Chapter 137* regulates the licensing of fisheries, the licensing of fish and aquatic plant processors and fish buying stations as well as fish protective devices including maintaining fish passage at dams and other hydraulic facilities through installation of fish passage works, fish screens and proper operation to maintain adequate river flows.



## Federal Fisheries Act

The federal *Fisheries Act, RSC, 1985, F-14* regulates the proper management and control of fisheries as well as the conservation and protection of fish and fish habitat. Under Sections 34.4 (1) and 35(1) of the Fisheries Act, no person shall carry out any work, undertaking or activity that results in killing fish or in the harmful alteration, disruption or destruction of fish habitat.

Environmental Flow Needs (EFN) is regulated under the provincial Water Sustainability Act; however, the provincial Fisheries Act, and the federal Fisheries Act work in unison to protect habitat in the Englishman River from potential harm resulting from operation of the water supply system. Although both the provincial and federal fisheries acts do not directly regulate the water supply system, the City could be liable for contravention of these acts if operation of the water system is found to result in death of fish, harmful alteration, disruption or destruction of fish habitat and/or adversely impact fish passage.

## Local Government Act and Community Charter

The *Community Charter, SBC, 2005* provides the statutory framework for all municipalities in BC except the City of Vancouver. The Community Charter sets out municipalities' core areas of authority, including the provision of services, public health regulation, entering into agreements, property taxation, financial management, and procedures such as adopting and enforcing bylaws.

The BC *Local Government Act, RSBC 2015* (LGA) is the primary legislation for regional districts and improvement districts, setting out the framework for structure and operations, as well as the main powers and responsibilities. Certain municipal provisions of the LGA also apply to municipalities for matters not covered by the Community Charter. The LGA covers planning and land use powers.

## 2.4 Water Licences

Under the provisions of the WSA, the province issues water licences to permit use of surface water and groundwater. The licences indicate the maximum volume that can be extracted or stored, the location where the water is extracted or stored and for what purpose. Some licences also state a maximum daily withdrawal rate. Licences are issued both for use of surface water as well as ground water.

The provincial water licence database includes all current water licences on record. The licences are issued on a first in time first in right basis, with older licences having precedence over newer licences during time of water scarcity. Licensees are required to apply for an Emergency Order with the provincial Water Comptroller to operate outside the requirements stated in the licence.

### Surface Water

A summary of the surface water licences within the Englishman River Watershed is included in Table 2-5. The table provides a total consumptive use for water that is diverted from the natural water courses and non-consumptive use for water that is temporarily diverted from a natural watercourse and returned, such as Arrowsmith Dam Reservoir, where water is stored in winter/spring and released into the river in summer.

Locations of the points of diversion for the current water licences within the Englishman River Watershed are shown in Figure 2-5.

**Table 2-5: Summary of Surface Water Licences in the Englishman River Watershed**

| Use                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | No. Licensed Withdrawals | Total Annual Volume <sub>1</sub> (Mm <sup>3</sup> /year) | Principal Licensee                                                                                                         |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|----------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| <b>Consumptive Use</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                          |                                                          |                                                                                                                            |
| Domestic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 18                       | 0.0158                                                   | Various – Private                                                                                                          |
| Enterprise                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 2                        | 0.0199                                                   | Hezz Camp Co.                                                                                                              |
| Irrigation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 9                        | 0.1852                                                   | Various – Private                                                                                                          |
| Livestock                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 3                        | 0.0023                                                   | Various – Private                                                                                                          |
| Water Delivery                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 1                        | 0.0249                                                   | BC Parks – Water System                                                                                                    |
| Waterworks – Local Authority                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 3                        | 0.8794                                                   | City of Parksville – Original Intake                                                                                       |
| Waterworks – Local Authority                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 1                        | 7.0000 <sub>2</sub>                                      | City of Parksville/ERWS – ERWS Treatment Plant                                                                             |
| Total Consumptive Use                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                          | 8.1275                                                   |                                                                                                                            |
| <b>Non-Consumptive Use</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                          |                                                          |                                                                                                                            |
| Conservation – Use of Water                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 2                        | 1.8753                                                   | Department of Fisheries and Oceans                                                                                         |
| Land Improvement                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 2                        | 0.0200                                                   | Various – Private                                                                                                          |
| Storage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                        | 9.0000                                                   | City of Parksville/Arrowsmith Water Service (Regional District of Nanaimo, City of Parksville, and Town of Qualicum Beach) |
| <p>Note:</p> <ol style="list-style-type: none"> <li>1. To allow for comparison of the licenced uses, where total annual maximum withdrawal is not stated in the licence, the total annual volumes have been calculated using maximum daily licenced withdrawal multiplied by 365. Although water licences may allow up to a maximum daily volume to be withdrawn, the actual total annual volume is likely to be less as some uses may not require water year-round. For instance, irrigation use would normally only be required through spring and summer months.</li> <li>2. The maximum licenced daily withdrawal rate for the ERWS water treatment plan raw water intake is 48 m<sup>3</sup>/day (Conditional Water Licence C134068). The value shown in the table above for City of Parksville ERWS Treatment plant is the maximum annual licenced withdrawal volume.</li> </ol> |                          |                                                          |                                                                                                                            |

The summary indicates that at a maximum of 7.0 Mm<sup>3</sup>/year, the City of Parksville (as the water licence holder representing the AWS and ERWS) has the largest consumptive licence in the Englishman River watershed. Note that the maximum daily licensed withdrawal rate is 48 MLD; currently the withdrawal is practically limited to 16 MLD because the pump station at the Englishman River intake has an existing capacity of 19 MLD while the WTP capacity is 16 MLD. The AWS has the only storage licence in the watershed to store up to 9 Mm<sup>3</sup> of water at Arrowsmith Dam Reservoir for conservation and community water supply.







## Groundwater

The City of Parksville is currently withdrawing groundwater from 16 WSWs with a total licence application diversion volume of 1,203,822 m<sup>3</sup>/year. The individual WSW existing use groundwater licence application diversion volumes are provided in the Task 1 – Water Supply Well Data Compilation and Overview of the Englishman River Aquifers (Waterline, September 15, 2025) report in Appendix B. The individual WSW diversion volumes stipulated in the licence applications are based on historical water use. The Railway Station Well Field diversion rates are based on 2014 annual diversion volumes and the Springwood Well Field diversion rates are based on 2016 annual diversion volumes.

Parksville was beneficially using groundwater prior to the enactment of the Water Sustainability Act in 2016 such that it was eligible to apply for existing use groundwater licences for the 16 WSWs and continue withdrawing water under the authority of Section 140 while they await licence approvals from BC Ministry of Water, Lands and Resource Stewardship (WLRS). Details of the groundwater licence application volumes for each of the City's active water supply wells are provided in Appendix B, Table 5.

Regional groundwater use (including types of use) and licensing for the aquifers in the Parksville area, including the Englishman River watershed are also summarized in Appendix B.

## 2.5 Environmental Flow Needs

Environmental Flow Needs (EFN) refers to the rate of river flow required for proper functioning of aquatic ecosystems. River flow rates below a Critical Environmental Flow Threshold (CEFT) likely result in irreversible harm to ecosystems and fish. The following section outlines the history of EFN study and regulation for the Englishman River.

### 1996 Arrowsmith Dam Water Licence

EFN for fish on the Englishman River were incorporated into the Arrowsmith Dam water licence in 1997. It was proposed that the largest proportion of the storage in Arrowsmith Reservoir should be allocated to provide minimum summer flow for fish (MoE, 1996). As part of referrals during review of the licence application, the Department of Fisheries and Oceans Canada (DFO) outlined specific EFNs for fish on the Englishman River as part of the water licence, including:

- Spawning river flow of 8.5 m<sup>3</sup>/s (734 MLD) is maintained from October to December and is to not fall below 5.67 m<sup>3</sup>/s (490 MLD).
- Rearing river flow in summer (July to October) is to be maintained at 1.13 m<sup>3</sup>/s (97.6 MLD- the EFN threshold) and should never fall below 0.71 m<sup>3</sup>/s (61.3 MLD – the CEFT).

Provincial Fisheries EFN requirements, in the Arrowsmith Dam water licence were similar to those of DFO – that the minimum summer river flow, in excess of all other withdrawals, be maintained at 1.13 m<sup>3</sup>/s for drought conditions up to the 1:20 year return period. A target flow of 1.55 m<sup>3</sup>/s was established to be maintained at the Englishman River near Parksville WSC gauge at the Highway 19A Bridge. This target included the EFN of 1.13 m<sup>3</sup>/s plus additional 0.38 m<sup>3</sup>/s to support the projected monthly water supply demand, which was being withdrawn at the original intake location downstream of the gauge at that time.

The water licence report also states that an analysis of the flow data collected at the WSC gauge prior to construction of the dam indicates that flows below 1.13 m<sup>3</sup>/s occurred frequently and that several months in the period of record show the mean monthly river flow rate falling below 0.71 m<sup>3</sup>/s. As such,

the construction of storage on Arrowsmith Reservoir was expected to provide additional water, over and above natural flow rates, for enhancement of river baseflows and to benefit fish.

For comparison, the City of Parksville and NBP WSA Maximum Day domestic water demands averaged 0.15 m<sup>3</sup>/s and 0.06 m<sup>3</sup>/s respectively between 2021 and 2024; in total less than 20% of the EFN threshold.

## 2008 Operating Order

In January 2008, the Ministry of Water, Land and Air Protection (now MWLRS), issued an Order for Arrowsmith Dam Reservoir under Section 18 of the Water Act. The Order required that:

1. The licensees for Arrowsmith Dam Reservoir shall install, maintain and operate gauges and provide water level and flow measurements including water levels at Arrowsmith Lake, flow on Arrowsmith Creek at outlet of Arrowsmith Dam Reservoir, at the Englishman River near Parksville Gauge located at the Highway 19A bridge and measure water withdrawals from the river at the community intake, at that time, located downstream of the Highway 19A bridge.
2. Arrowsmith Dam Reservoir be maintained at full supply by July 1 of each year.
3. Between June 1 and October 31 in any year, that if the Englishman River flow is below 1.6 m<sup>3</sup>/s at the Englishman River near Parksville Gauge that flow shall be released from Arrowsmith Dam Reservoir to maintain flow greater than 1.6 m<sup>3</sup>/s in the Englishman River.
4. When residual volume is greater than 75% of the total reservoir volume at Arrowsmith Dam Reservoir on August 31, the Engineer under the Water Act (in consultation with fisheries agencies and the water licensees) may increase the minimum flow required to be maintained in the Englishman River.
5. When volume of water in Arrowsmith Dam Reservoir is less than 25% of the total reservoir volume on September 30 of any year, the Engineer under the Water Act may decrease the minimum flow required to be maintained in the Englishman River.
6. The operation rule shall be revised when the intake works are relocated above the Englishman River near Parksville (08HB002) hydrometric gauge.

## 2014 Aquatic Effects Assessment

In 2014, an aquatic effects assessment was performed to support permitting for a new raw water intake (LGL, 2014). As previously discussed, the raw water intake structure on the Englishman River was to be moved from its location downstream of the Highway 19A Bridge to a location on the north bank approximately 4.5 km upstream. The key concern was that water withdrawals at the new intake site would result in a potential reduction of baseflows downstream of the new intake during the low flow summer period that could affect the amount and quality of functional fish habitat in the lower 5 km of river channel. The aquatic effects assessment was conducted by LGL using Habitat Suitability Indices for Steelhead (*Oncorhynchus mykiss*), Chinook (*O. tshawytscha*), Coho (*O. kisutch*) and Chum (*O. keta*). This assessment established a relationship between weighted useable area (WUA) versus discharge along the section of the Englishman River downstream of the proposed intake location to the river mouth, and across the range of expected summer flow levels (less than 5 m<sup>3</sup>/s). The analysis was completed assuming a pump station capacity of ~28.8 MLD.

The aquatic effects assessment showed that maximum instantaneous water withdrawals of ~28.8 MLD would result in:

- A reduction in WUA of up to 9% for Steelhead parr and Chinook summer fry during median summer flow conditions (50% exceeded flow for July).
- A reduction of 14% of WUA for Chinook summer fry and 13% of WUA for Steelhead parr at 80% exceedance flows in August.
- A reduction of up to 15% of WUA for Chinook summer fry and 13% of WUA for Steelhead parr, at 90% exceedance flow in August and September.

To protect fish and fish habitat downstream of the new intake site, the 2015 aquatic effects assessment proposed adherence to the Provisional Operating Rule curves for the Arrowsmith Dam Reservoir to maintain discharges of 1.6 m<sup>3</sup>/s in median summer baseflow conditions, 1.2 m<sup>3</sup>/s during 2-year to 5-year return period drought conditions and 0.9 m<sup>3</sup>/s during 10-year to 20-year return period drought conditions.

It is important to note that the WUA versus discharge relationships that were developed in the 2015 aquatic effects assessment are dependent on river morphology. As the morphology of the Englishman River changes, the relationship between weighted useable area versus discharge changes and may require reassessment.

## 2023/2024 Review of Operation Order from 2008

In 2023, KWL was retained by the City to carry out a review and update of the operating rules for Arrowsmith Dam Reservoir (KWL, 2024). In September 2023, KWL facilitated a meeting between representatives of the City, DFO, BC Ministry of Forests, and Snaw'naw'as First Nation to discuss Arrowsmith Dam Reservoir Provisional Operation Rule. A summary of this discussion as it pertains to EFN concerns on Englishman River is as follows:

- It is preferable to set and maintain a constant EFN release as opposed to a reducing EFN releases throughout the summer.
- The majority of rearing habitat for steelhead is situated upstream of the intake site, which benefits from the release of flows from the Arrowsmith Dam Reservoir.
- The minimum EFN releases provided in the LGL aquatic effects assessment is likely a good estimate of EFN for instream areas downstream of the intake in the absence of more recent information.

An initial review of Arrowsmith Dam Reservoir reliability using the installed capacity of the City's raw water intake, indicates that a flow of 1.0 m<sup>3</sup>/s (86.4 MLD) is a reasonable minimum river flow target which balances maintaining reliability of the water supply system with maintaining sufficient flow in the lower reaches of the Englishman River to prevent detrimental impacts to fish and other aquatic species. The outcome of the review was to take an adaptive management approach to balancing system reliability, EFN and community water supply with a flow 1.0 m<sup>3</sup>/s as the target for establishing the EFN.



## 2024 and 2025 Operation Orders

In 2024 and 2025, the Ministry of Water Land and Resource Stewardship (WLRS) issued operation orders under Section 9 of Water Sustainability Act providing AWS, the holder of Conditional Water Licence C134068, leave to release minimum flow from Arrowsmith Dam Reservoir to maintain a targeted minimum flow of 1.0 m<sup>3</sup>/s in the Englishman River downstream of the dam for an operating season between June and the end of October. The orders stipulated that:

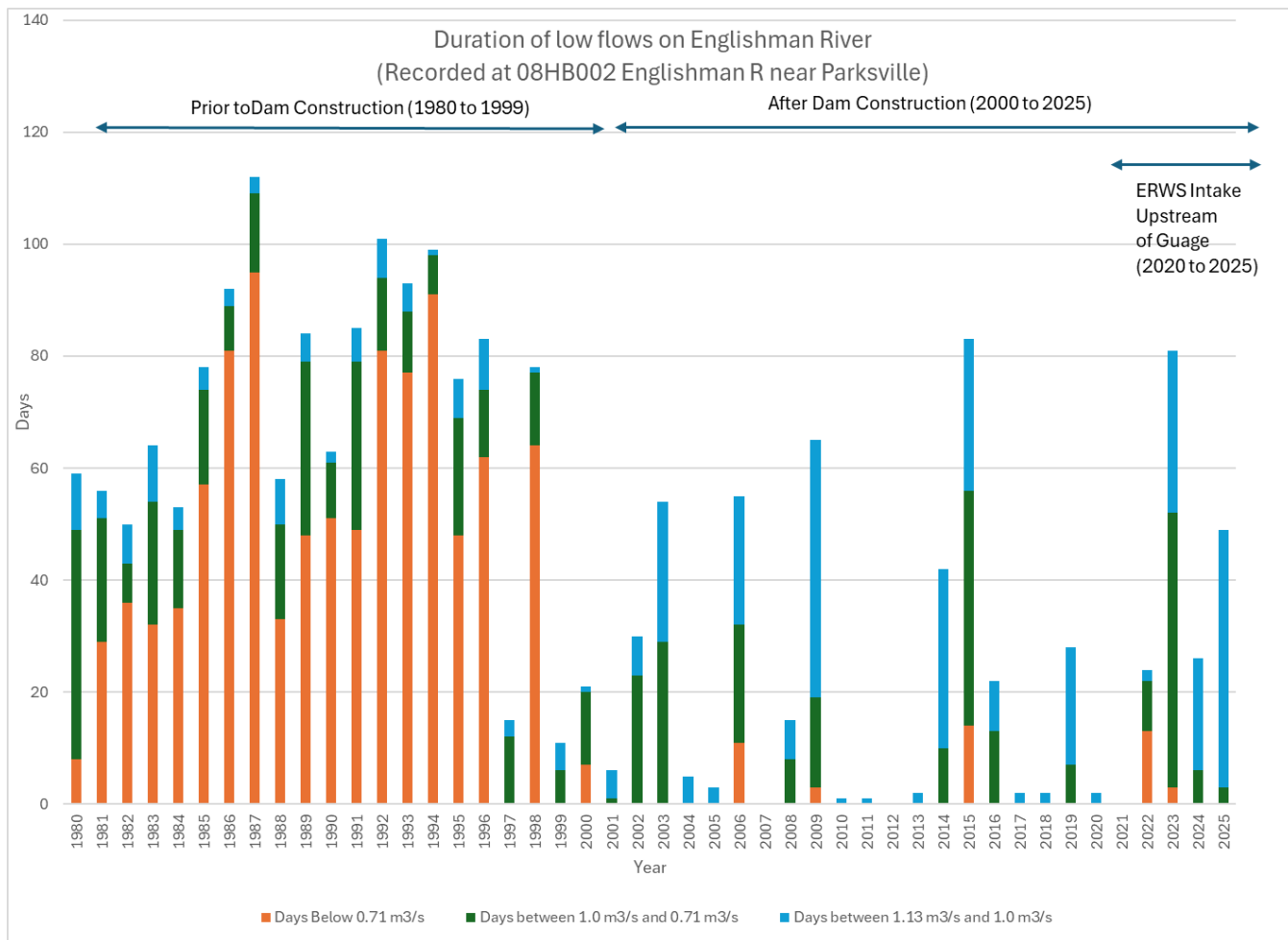
1. Flow be measured at the water survey of Canada (WSC) hydrometric gauge number 08HB002 located at the Highway 19A bridge downstream of the raw water intake.
2. The City implement Stage 3 watering restrictions when flow in the river at WSC08HB002 are less than 1.6 m<sup>3</sup>/s and at or above 1.2 m<sup>3</sup>/s and Stage 4 when flows drop below 1.2 m<sup>3</sup>/s.
3. That flow releases from Arrowsmith Dam Reservoir be managed to ramp down to 1.0 m<sup>3</sup>/s only as necessary to preserve a minimum flow of 1.0 m<sup>3</sup>/s through October 31.
4. The City provides weekly updates on the status of river flows and Arrowsmith Dam Reservoir levels including any intent to adjust flow releases from the reservoir to ramp up or ramp down flows in the Englishman River.

Although not specifically ordered, WLRS recommended in the cover letter for the Orders that the WSC gauge be routinely checked and calibrated as necessary to ensure accuracy. City staff are ensuring that routine checks and calibration of the gauge are being completed.

## EFN and duration of low flows in Englishman Rier

Figure 2-6 shows the duration of low flows recorded for the Englishman River at the hydrometric gauge (WSC 08HB002) located at the Highway 19A bridge. The figure shows the number of days flows were recorded below the CEFT (0.71 m<sup>3</sup>/s) and between the CEFT and the EFN. Both the current (2025) EFN of 1.0 m<sup>3</sup>/s and previous EFN of 1.13 m<sup>3</sup>/s are included in the graph.

It can be seen that the annual minimum daily average flows in the Englishman River have been lower than the EFN target, particularly before the Arrowsmith Dam was constructed. A review of the daily river flow data indicates that during low flow periods, even when the annual minimum daily average flows are above the EFN, the river flow may fluctuate above and below the EFN for short periods of time. This is reflective of the challenges of managing releases from Arrowsmith Dam Reservoir to achieve the EFN target, when the gauge is 25 km downstream of the dam and there is a considerable time delay between release and measurement.

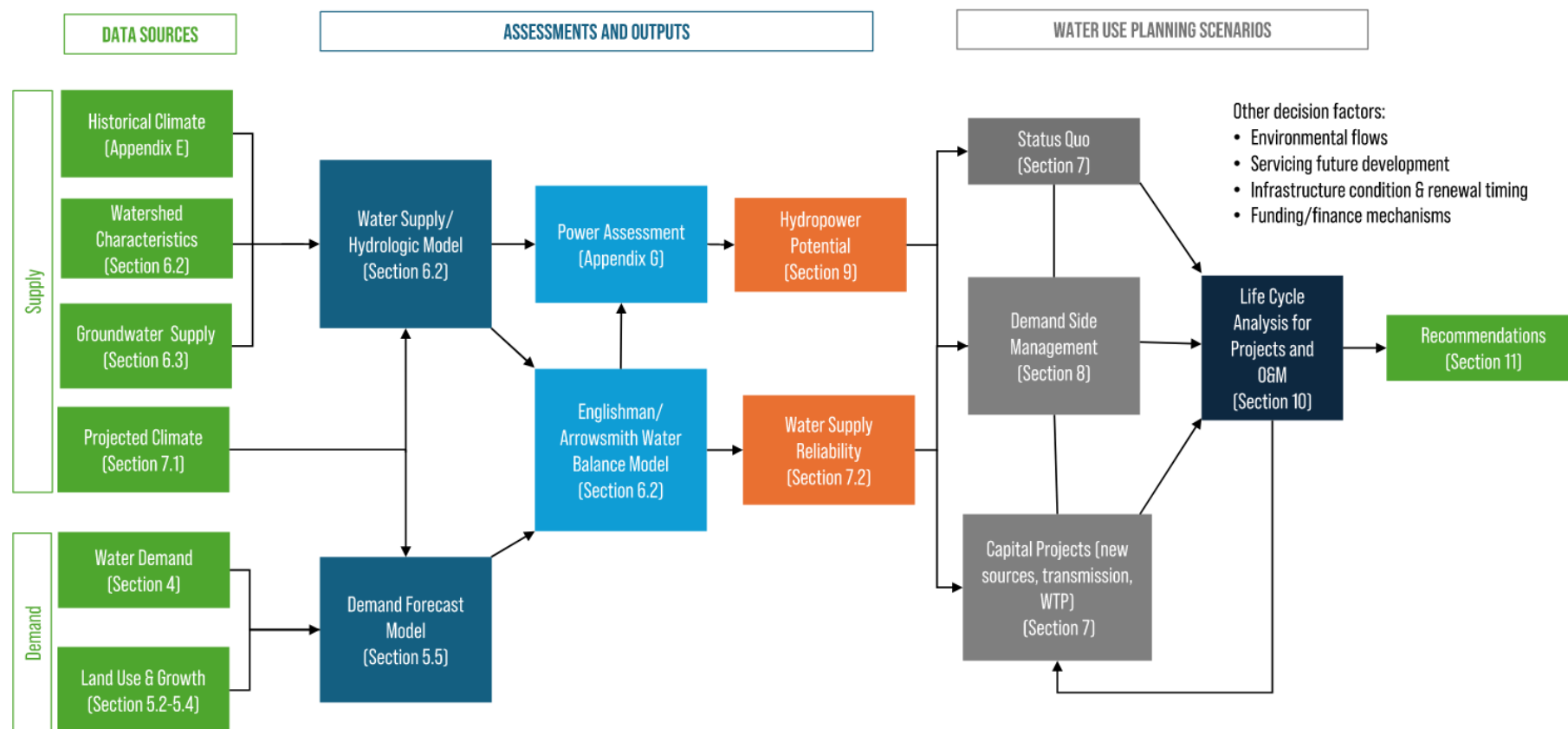


**Figure 2-6: Englishman Duration of Low Flow at Hydrometric Gauge (WSC 08HB002)**

## **3. Water Use Planning Approach**

### **3.1 Overview**

An overview of the approach used to develop the Water Use Planning and Management Study is shown in Figure 3-1; data sources, analysis tools and methodologies are shown in the figure and are discussed in detail in the following sections.



**Figure 3-1: Water Use Planning Approach**



## 3.2 Data Sources

A wide range of data sources were used for development of the Study. A summary of the key data and the sources used in the analysis is provided below; further details on specific data sets are documented in the relevant sections of the plan and references provided in Appendix A.

Information provided by the City of Parksville included:

- Population data.
- Water customer meter data for all uses in the City, 2020 - 2024.
- Groundwater use and well data for the Springfield and Railway Well Fields, 2021 - 2024.
- Water Utility System Master Plan (GeoAdvice, 2024) and the associated hydraulic model files.
- GIS data for the ERWS assets and land use (existing and future).
- SCADA information at water system facilities.
- Source flow records from ERWS WTP, 2021 - 2024.
- Record drawings for the Arrowsmith Dam.

Information provided by RDN included:

- Population data.
- Water customer meter data for Nanoose Bay Peninsula Water Service Area, 2020 - 2024.
- LiDAR data for key areas of the surrounding watersheds (provided by Mosaic).
- GIS data for the Nanoose Bay Peninsula Water Service Area and land use.
- Nanoose Bay Peninsula (Craig Bay 2) Pump Station Records, 2021 - 2024.
- Nanoose Bay Peninsula Water Service Area Well Records, 2021 - 2024.

Information sources for the hydrological components are as follows:

- Water Survey of Canada gauges: Arrowsmith Creek at Outlet of Arrowsmith Lake (08HB080) and Englishman River Near Parksville (08HB002).
- Historical Daily Gridded Meteorological Datasets from the Pacific Climate Impacts Consortium (PCIC).

Information sources for the groundwater components are as follows:

- Waterline's proprietary Enviro Web Services (EWS) geodatabase system.
- Hydrogeological data from local and regional studies prepared by various consultants and provided by the City as summarized in Appendix B – Task 1 Groundwater System Review (Waterline, April 2025).
- The provincial Groundwater Wells and Aquifers (GWELLS) database managed by the Ministry of Environment and Parks (ENV).

### 3.3 Analysis Tools and Methods

#### Demand Forecast Model

The demand forecasts have been completed incorporating the best practices outlined by the Pacific Institute, which is a highly regarded independent research and policy analysis non-profit institute. The water demand forecasts were developed using “end-use” methods which estimate water demands based on population and land use projections and projected unit water demands.

The water demand projections are disaggregated (split up) into residential indoor demands; institutional, commercial, and industrial (ICI) indoor demands; seasonal demands (e.g., irrigation); and non-revenue water (e.g., leakage). Detailed information on current water use and water demands along with future estimates of water demand is provided in Sections 4 and 5, respectively.

#### Englishman River Hydrological Model

A hydrological model was developed to calculate inflow to Arrowsmith Dam Reservoir and Englishman River flows under existing and future climate conditions. The model was originally developed in previous studies to support the planning for the ERWS intake and has been updated for this project.

Inputs to the model include land cover, soil type, precipitation, and temperature across the watershed. The hydrological model performance was reconfirmed by comparing weekly average river flow records collected by Water Survey of Canada (WSC) from the Englishman River near Parksville (08HB002) at the Highway 19A bridge and Arrowsmith Creek at outlet of Arrowsmith Lake (08HB080) operated prior to construction of the Arrowsmith Dam. The period from 1990 to 1997, before construction of the dam, was used for checking hydrological model performance to eliminate influence of dam operations on river flow.

The model was then used to simulate inflow to Arrowsmith Lake and natural flow in the Englishman River watershed downstream of the Arrowsmith Dam using baseline, current (2020s) and future climate data. These flows were then used as input to the Reservoir Operation/Water Balance model to evaluate surface water reliability as discussed further below.

Detailed information on the hydrological model including calibration results and how the hydrological model is applied for baseline and future climate conditions is provided in Appendix E.

#### Reservoir Operation/Water Balance Model

A reservoir operation model was developed to simulate water levels in the Arrowsmith Dam Reservoir by using a mass balance approach and optimizing reservoir operation to satisfy the EFN and withdrawal at the raw water intake. Inputs to the model include storage volume and outflow capacities vs water level in Arrowsmith Dam Reservoir, historical and future inflows into the reservoir, baseflows in the Englishman River downstream of the Arrowsmith Dam, a temporal distribution of raw water intake withdrawals, and allowances for EFN.

The performance of the reservoir operation model was confirmed by comparing model results to reservoir water level records available over the baseline climate period (2000 to 2010). The baseline period was used to check model performance due to limited availability of recent spatially distributed recorded climate data. Similar water balance models were also developed to calculate required storage volumes for alternative surface water sources and EFN under climate change conditions. Detailed information on the reservoir operation and water balance model including information on how the model was used for the project is provided in Appendix E.

## Ground Water Conceptual and Numerical Models

Assessment and analysis of existing and future groundwater potential in Parksville and the surrounding area is informed by two groundwater models and associated studies completed by the RDN, including:

- The Refined Water Budget for Nanoose (referred to as the Nanoose model; Golder, 2020).
- The Refined Water Budget for French Creek (referred to as the French Creek model; WSP, 2023).

The Nanoose model includes areas south of the lower Englishman River watershed with the river forming part of the northwest boundary of the model, while the French Creek model includes areas north of the Englishman River with the river forming the southeast boundary of the model. As such, the French Creek model includes Aquifer 216 and the Parksville WSWs.

Summary information on the numerical model software, domains, boundary conditions, calibration, and climate change impacts is provided in the memorandum Task 2 – Hydrogeological Assessment of Parksville's Water Supply Well Operations and the Englishman River Aquifers (Waterline September 16, 2025) report in Appendix C, along with information provided in the reference reports by WSP.

Further analysis of groundwater using RDN's calibrated numerical groundwater models was not completed as part of this Study; however, this model may be available to support future phases of work if required.

## Rapid Hydro Assessment Model (RHAM)

The RHAM tool is used to estimate runoff in the Englishman River watershed to identify and estimate the feasibility of installing hydroelectric generation at multiple points on the Englishman River system. The RHAM tool is also used to determine the cost and feasibility of the interconnection of a generation facility to the BC Hydro system and/or a City facility.

Further information on the RHAM tool methodology and hydropower potential is provided in Appendix G and Section 8.

## Life Cycle Cost Analysis

Potential water supply and demand strategies are assessed using a simplified lifecycle cost analysis to facilitate comparison of the relative financial performance of the potential water use strategies, and to estimate the order-of-magnitude cost implications for cost recovery including water utility tax and fee rates and development cost charge rates. Given the high margins of uncertainty in estimates of the costs to implement the potential strategies, the analysis is conducted using 2025 constant dollars and no discount rate is applied to future costs. Capital expenditures are annualized by dividing them into the estimated average lifespan of the assets that would be acquired, and are added to annual operating costs, yielding rough estimates of annualized lifecycle costs. Uncertainty ranges are also estimated based on the conceptual stage of development of the potential strategies. For most strategies the uncertainty is estimated to be  $\pm 50\%$ .

Lifecycle cost analysis is not conducted for existing water system operations or assets. The intent of the analysis is to assess the potential financial implications of the strategies relative to the status quo.

The results of the life cycle cost analysis are provided in Section 10.

## 4. Water Use and Existing Demands

### 4.1 Source Flow

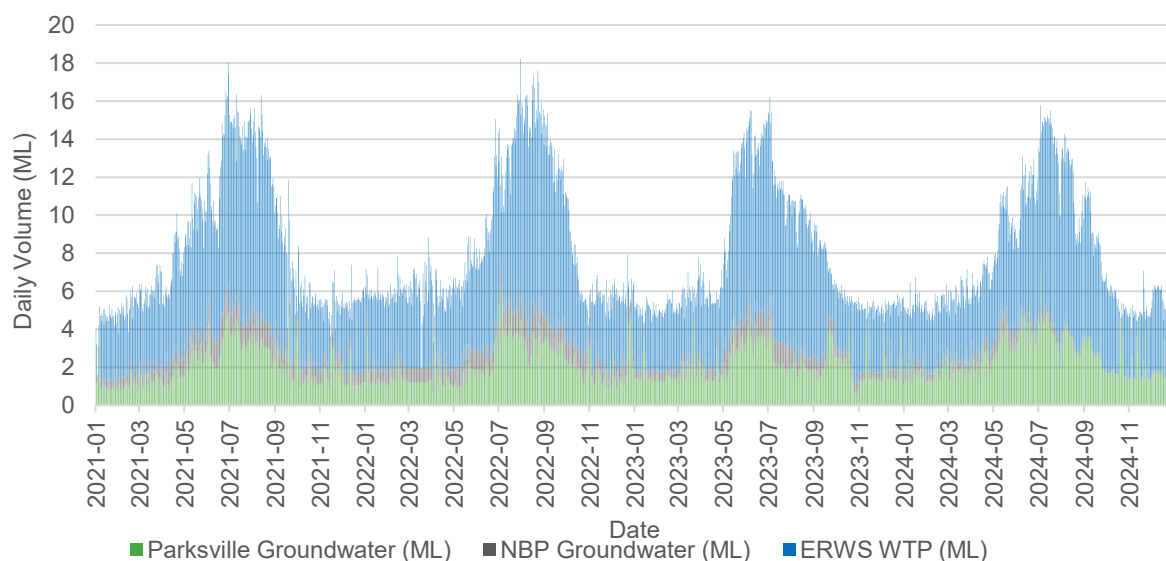
Water supply for the City includes groundwater wells (Springwood and Railway Station Well Fields) and water from the Englishman River via the raw water intake and ERWS Water Treatment Plant.

Supply to the Nanoose Bay Peninsula Water Service Area (WSA) is from groundwater wells owned by RDN and from the ERWS WTP via the Nanoose Bay Peninsula Pump Station (also known as Craig Bay 2).

The following data sources were used to compile a historical record of the source flow for the City and the NBP WSA:

- Daily Source Records from ERWS WTP, 2021 - 2024 (Daily Flow ERWS WTP only.xlsx).
- Daily Parksville Groundwater Well Records, 2021 - 2024 (49.a Well Data.xlsx).
- Monthly Nanoose Bay Peninsula Pump Station Records, 2021 - May 2021 (250203-mw-Nanoose Water Production 2020-24.xlsx).
- Daily Nanoose Bay Peninsula Pump Station Records, June 2021 - 2024 (49.b WTP & Craig Bay flows.xlsx).
- Monthly NBP WSA Well Records 2021-2024 (250203-mw-Nanoose Water Production 2020 - 24.xlsx).

A stacked area chart summarizing the daily totals from each supply source is shown in Figure 4-1. The stacked column totals represent the total daily water supply to Parksville and Nanoose Bay from all three sources.



**Figure 4-1: 2021 - 2024 Daily Source Flow Summary**

## 4.2 Existing Demand Summary

Water system demands have been divided into the following components for the purpose of this study:

- **Base demand (BD):** Typical water usage on an average winter day, calculated as the average daily demand in the months of January-March, November, and December. Base demands comprise various use types within the system, including:
  - Residential: Ground oriented residential development, typically single unit detached, or two unit detached developments.
  - Multi Unit Residential: Residential development greater than two units.
  - Industrial, Commercial, and Institutional (ICI): All non residential users, including industrial, commercial and institutional.
  - Non Revenue Water (NRW): Water that is produced and distributed but is not billed to customers. Typically includes leakage, unauthorized uses, and discrepancies due to metering inaccuracies.
- **Seasonal demand (SD):** Irrigation use and other seasonally dependant uses on the peak summer day. Seasonal demand is the difference between Average Day Demand (ADD) and Base Demand (BD). SD is typically annualized (multiplied by the number of days in the year) to estimate the total annual quantity of water used for irrigation, but also other uses of water that only occur in warmer weather including evaporative cooling and increased tourism. These other uses are a small component of SD in most BC communities, though the impact of tourism on SD in Parksville is estimated in Section 5.3.
- **Maximum Day Demand (MDD)** is the total peak day demand and is the sum of the base and seasonal demand components.
- **Average Day Demand (ADD)** is the sum of the demand for a calendar year, divided by the number of days in the year.

The WTP and groundwater production data was combined with the flow records from the Nanoose Bay Peninsula Pump Station to estimate BD, ADD and MDD for the City and the Nanoose Bay Peninsula WSA. The demand estimates are summarized in Table 4-1. Lower base demand in 2021 in Parksville is likely related to reduced use of institutional and commercial facilities during the COVID-19 pandemic, which was observed in most communities during the pandemic.

**Table 4-1: 2021 - 2024 Demand Summary**

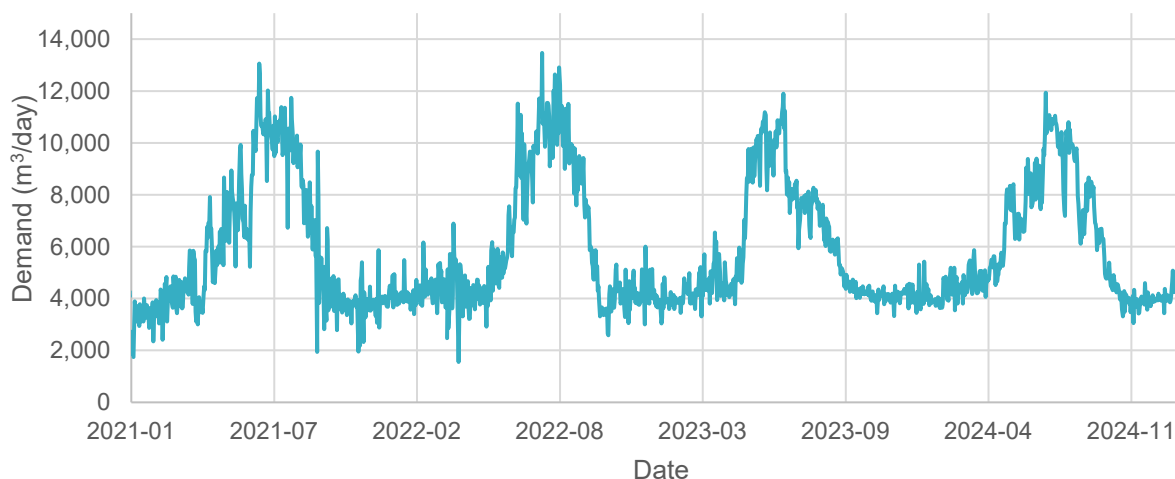
| Year | Parksville (m <sup>3</sup> /day) |       |        | Nanoose Bay Peninsula WSA (m <sup>3</sup> /day) |       |       |
|------|----------------------------------|-------|--------|-------------------------------------------------|-------|-------|
|      | BD                               | ADD   | MDD    | BD                                              | ADD   | MDD   |
| 2021 | 3,833                            | 5,858 | 13,054 | 1,479                                           | 2,368 | 5,712 |
| 2022 | 4,287                            | 5,944 | 13,467 | 1,684                                           | 2,511 | 5,604 |
| 2023 | 4,190                            | 5,811 | 11,902 | 1,082                                           | 1,956 | 5,017 |
| 2024 | 4,166                            | 5,884 | 11,940 | 1,190                                           | 1,965 | 4,581 |

The following sections provide a summary of the various demand components for each service area including seasonal demand which is the difference between MDD and BD.



### 4.3 City of Parksville Existing Demands

The historical daily demand record for 2021 - 2024 for the City is shown in Figure 4-2.



**Figure 4-2: 2021 - 2024 Daily Demand Summary for City of Parksville**

The following data sources were used to complete an analysis of the various water uses within City of Parksville:

- Customer water meter data, 2020 - 2024. Customer properties are 100% metered, and meters are read 2 times per year, in March and September. (2020.1 - 2024.2 Commercial Consumption Data.xlsx, 2020.1 - 2024.2 Family Consumption Data.xlsx, 2020.1 - 2024.2 Residential Consumption Data.xlsx, 2020.1 - 2024.2 Multi-Family Consumption Data.xlsx).
- Irrigation volumes from various irrigation sites managed by the City (Irrigation volume area KB.docx).

Table 4-2 provides a summary of the existing demands used for this study for the City.

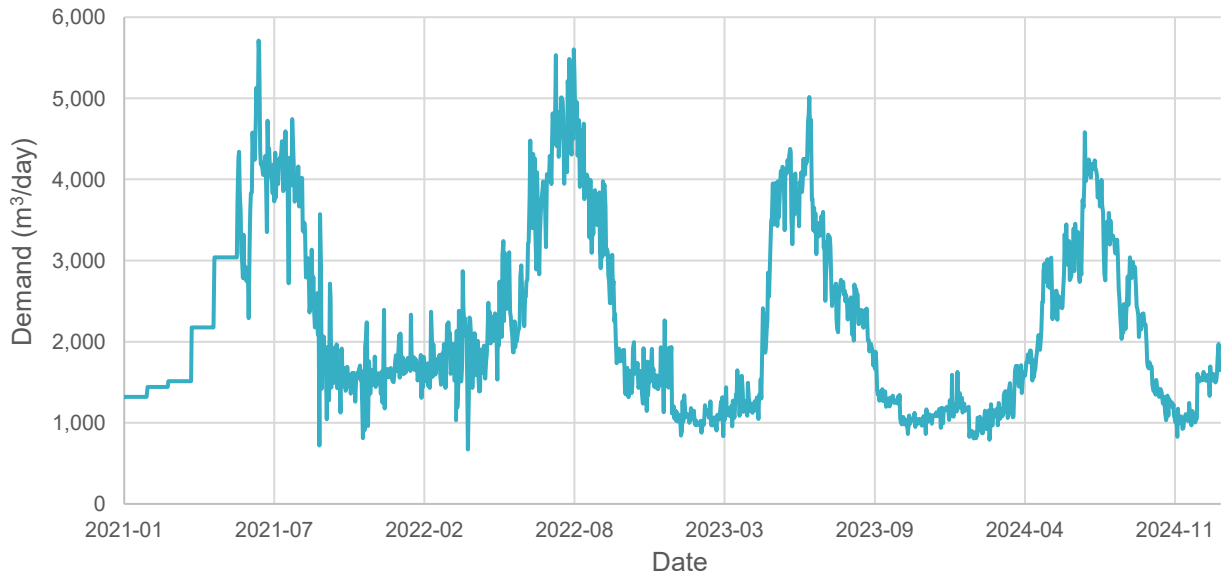
**Table 4-2: City of Parksville Existing Demand Summary**

|                                              |                                                        |                                            |
|----------------------------------------------|--------------------------------------------------------|--------------------------------------------|
| <b>Max Day Demand</b><br>MDD = 13,467 m³/day | <b>Base Demand</b><br>BD = 4,166 m³/day                | BD Residential = 1,592 m³/day              |
|                                              |                                                        | BD Multi Family Residential = 697 m³/day   |
|                                              |                                                        | BD ICI = 1,077 m³/day                      |
|                                              |                                                        | Non Revenue Water = 800 m³/day = 20% of BD |
|                                              | <b>Seasonal Demand on Max Day</b><br>SD = 9,301 m³/day | SD Residential = 3,805 m³/day              |
|                                              |                                                        | SD Multi Family Residential = 1,917 m³/day |
|                                              |                                                        | SD ICI = 1,806 m³/day                      |
|                                              |                                                        | City Irrigation = 1,774 m³/day             |

Based on an existing residential population of 14,718, the per capita residential (single family and multi-family) base demand rate for the City is 156 L/ca/day.

## 4.4 Nanoose Bay Peninsula WSA Existing Demands

The historical daily demand record for 2021 - 2024 for the Nanoose Bay Peninsula WSA is shown in Figure 4-3.



**Figure 4-3: 2021 - 2024 Daily Demand Summary for Nanoose Bay Peninsula WSA**

During the data collection phase, the RDN noted that the NBP WSA has been on Stage 4 watering restrictions every year since 2021, which has resulted in a significant reduction of water usage in the summer months. Also, there appears to have been higher water demand during the period between early 2021 and December 2022 compared with 2023 and 2024 which is potentially due to a large leak or meter error, in the order of 500 - 600 m³/day.

The following data sources were used to complete an analysis of the various water uses within Nanoose Bay Peninsula Water Service Area:

- Customer water meter data, 2020- 2024 provided. NBP WSA is 100% metered, and residential meters are read 2 times per year, ICI and multi family meters are read 4 times per year (Nanoose consumption report Feb 2025.xlsx, NBP Commercial Consumption – 2020-24 – MFD vs ICI by Quarter.xlsx).

Table 4-3 provides a summary of the existing demands used for this study for Nanoose Bay Peninsula WSA.

**Table 4-3: Nanoose Bay Peninsula WSA Existing Demand Summary**

|                                                          |                                                                     |                                                       |
|----------------------------------------------------------|---------------------------------------------------------------------|-------------------------------------------------------|
| <b>Max Day Demand</b><br>MDD = 5,712 m <sup>3</sup> /day | <b>Base Demand</b><br>BD = 1,190 m <sup>3</sup> /day                | BD Residential = 795 m <sup>3</sup> /day              |
|                                                          |                                                                     | BD Multi Family Residential = 63 m <sup>3</sup> /day  |
|                                                          |                                                                     | BD ICI = 36 m <sup>3</sup> /day                       |
|                                                          |                                                                     | Non Revenue Water = 297 m <sup>3</sup> /day           |
|                                                          | <b>Seasonal Demand on Max Day</b><br>SD = 4,521 m <sup>3</sup> /day | SD Residential = 4,024 m <sup>3</sup> /day            |
|                                                          |                                                                     | SD Multi Family Residential = 316 m <sup>3</sup> /day |
|                                                          |                                                                     | SD ICI = 181 m <sup>3</sup> /day                      |

Based on an existing residential population of 6,178, the per capita residential base demand rate for the Nanoose Bay Peninsula WSA is 139 L/ca/day.

It should be noted that the NBP wells provide approximately 30% or 360 m<sup>3</sup>/day of the base demand and approximately 20% or 911 m<sup>3</sup>/day of the maximum day demand. Accounting for the NBP well source flow separately from the ERWS system is necessary for assessing the existing and future river intake, WTP and transmission system capacities reported in later sections of this report.

## 4.5 Per Capita Unit Rate Comparison

The per capita base demand unit rate for Parksville and NBP WSA were calculated to be 156 L/ca/day and 139 L/ca/day, respectively. For comparison, the unit rates calculated in 2014 for Parksville and NBP WSA were 156 L/ca/day and 163 L/ca/day, respectively.

The rates calculated for this study were compared to rates observed in other jurisdictions. Residential base demand rates calculated by KWL for other local jurisdictions are as follows:

- Town of Sidney – 160 L/ca/day (2025)
- City of Nanaimo – 146 L/ca/day (2023)
- City of Courtenay – 279 L/ca/day (2023)
- Town of Comox – 218 L/ca/day (2023)
- City of White Rock – 190 L/ca/day (2024)
- City of Richmond – 185 L/ca/day (2022)
- City of Surrey – 200 L/ca/day (2019)
- District of Oak Bay – 180 L/ca/day (2018)

The base demand unit rates for Parksville and NBP WSA are relatively low compared to other jurisdictions. This could be attributed to transient populations (i.e., people not living in the community year round), existing water conservation initiatives and education for users, and/or customer accounts being 100% metered.

## 5. Forecasted Water Demand

### 5.1 Best Practices for Water Demand Forecasting

Water demand forecasting methodologies broadly fall into two general categories:

1. End-use methods based on population and land use projections and adjustments to estimates of unit water demands.
2. Statistical methods that involve data collection and regression analysis to extrapolate historical trends.

End-use methods are generally more reliable for long-term forecasts (e.g., ten years or more) than statistical methods, and do not rely on complex software models or large quantities of historical data. For these reasons, an end-use approach that incorporates population and land use forecasting is used as the basis for the water use forecasting completed as part of the Study.

The Pacific Institute (Heberger, Donnelly, & Cooley, 2016) identifies eight best practices for developing urban water demand forecasts that avoid the potential pitfall of consistently overestimating future water demand. The best practices, and features of a forecast that incorporate them, are as follows:

1. **Account for Water Conservation and Efficiency.** The primary cause of over-estimation of water demand in forecasts is failure to account for reductions in unit water demands that result from new construction that use fixtures and appliances that meet current codes and standards, as well as retrofits of existing housing stock over time. The analysis includes separate parameters for the following:
  - a. Separate unit water demands in existing and new building stock.
  - b. Replacement rates for fixtures and appliances that gradually reduce unit water demands associated with existing building stock.
  - c. Demand reductions resulting from water conservation programs and metering.
2. **Account for Changes in Economic Activity.** Changes in population and land use that drive water demand are influenced by economic conditions for the community and its primary industries. Without specific information about the community and its economic context, foreseeable opportunities and risks, and economic plans, the potential for large errors in long-range water demand forecasts is high. The forecast mitigates this major source of potential error by tailoring growth rates to the community based on the planning department's forecasts and allowing for commercial and institutional growth to keep up in line with residential growth.
3. **Account for Changes in Water Price.** Customers typically respond to rising prices by decreasing consumption; however, no adjustments were made to account for water pricing for this forecast. In general, if a large increase in consumption charges for water or sewer service (relative to inflation) is expected to occur during the forecast timeframe, a reduction in the forecast should be considered.
4. **Check for Consistency with Other Relevant Planning Documents.** Water demand forecasts used for this plan incorporate growth forecasts that are consistent with other community plans, policies, and forecasts.
5. **Account for Expected Land Use Changes.** Gradual changes in land use patterns significantly impact water demands. A gradual shift in the mix of housing types from predominantly single-family

homes toward smaller homes with less landscape area tends to occur in urban communities as they grow, resulting in a reduction in per capita demands. Additionally, the ICI area in the community is already developed and future ICI growth is accounted for by increasing the Floor Area Ratio (FAR) at existing ICI zoned properties. The forecast reflects realistic rates of change in the quantity and character of land use and building stock over the forecast period based on the best available information.

6. **Account for Climate Change and Drought.** Climate change may reduce the availability of water in some communities over time, necessitating increased efforts to conserve water and imposing constraints on water-intensive forms of development. Cycles of drought can have long-lasting impacts on water demands. In some regions, the longer, hotter summers predicted in climate models may increase water demands for irrigation and cooling systems. The forecast estimates current and future irrigation demands using an evapotranspiration (ET) calculation that includes adjustments for climate change for the Parksville region that was developed as part of the hydrological modelling (see Section 7.1 for details).
7. **Account for Uncertainty.** Even with the best available data and tools specific to the subject community, forecasts of water demand beyond a decade into the future rely on many assumptions about what will happen, most of which are beyond the control of the local government. Future legal, economic, and technological changes cannot reliably be predicted, but can profoundly impact growth rates and efficiency of water use. The forecast incorporates margins of uncertainty on several inputs and assumptions used in developing demand forecasts, including rates of community growth, future climate parameters influencing irrigation demands, and unit water demands for all indoor uses of water. The combined margin of uncertainty resulting from these factors is reported and illustrated as part of the demand forecast.
8. **Ensure Transparency, Stakeholder Engagement, and Review.** The purpose of a water demand forecast must be clearly stated, and the methodology should be transparent and subject to independent expert and stakeholder review. This water forecast has been prepared and reviewed by a multidisciplinary team that includes expertise in water system engineering, community planning, water demand management, and irrigation.

Demand forecasts have been completed incorporating the best practices noted above with a general approach to develop an estimate of current water demand that is segmented based on base and seasonal water use in residential, industrial, commercial and institutional (ICI) sectors. The estimates are based on population for residential demands, land areas and floor area ratios for ICI demands, and land areas for irrigation, which is the majority of seasonal demand. In addition, non-revenue water is estimated separately using information about the water system such as lengths of watermains and services.

Unit rates for each segment of water demand are estimated and calibrated using recent historical demands for each segment. In order to obtain an estimate of future demands, the resulting model of current water use is modified based on forecasted changes in population, ICI sector floor areas and land area based on anticipated modes of growth, as well as changes in unit demands resulting from anticipated efficiency improvements. The specifics for each segment of water use are described in the following sub-sections.



## 5.2 Residential Growth

The existing population and population forecast for the 50-year planning horizon is summarized in Table 5-1. The population estimate for Parksville is based on the most likely growth scenario projections provided by the City (1.54% per year). The population forecast for the Nanoose Bay Peninsula was provided by RDN and is based on a GIS review of available land and proposed development information to the year 2046. At present, the RDN has indicated there will be no further growth beyond what is contemplated in the Lakes District and Schooner Cove Phased Development Agreement. Although, it is uncertain whether all of this growth will be realized by 2046 or some time later, the build out year of 2046 is used for this analysis.

**Table 5-1: Existing Population and Population Forecast**

| Year                                                                                                                                                                                                                                                                                                                                                                                   | Parksville | Nanoose Bay Peninsula Water Service Area | Total  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|------------------------------------------|--------|
| 2021 Census                                                                                                                                                                                                                                                                                                                                                                            | 13,642     | N/A                                      | N/A    |
| 2025 (Existing)                                                                                                                                                                                                                                                                                                                                                                        | 14,718     | 6,178                                    | 20,896 |
| 2030                                                                                                                                                                                                                                                                                                                                                                                   | 15,886     | 8,350                                    | 24,236 |
| 2035                                                                                                                                                                                                                                                                                                                                                                                   | 17,148     | 10,522                                   | 27,669 |
| 2040                                                                                                                                                                                                                                                                                                                                                                                   | 18,510     | 12,693                                   | 31,203 |
| 2045                                                                                                                                                                                                                                                                                                                                                                                   | 19,980     | 14,865                                   | 34,844 |
| 2050                                                                                                                                                                                                                                                                                                                                                                                   | 21,566     | 14,865                                   | 36,431 |
| 2055                                                                                                                                                                                                                                                                                                                                                                                   | 23,279     | 14,865                                   | 38,143 |
| 2060                                                                                                                                                                                                                                                                                                                                                                                   | 25,127     | 14,865                                   | 39,992 |
| 2065                                                                                                                                                                                                                                                                                                                                                                                   | 27,122     | 14,865                                   | 41,987 |
| 2070                                                                                                                                                                                                                                                                                                                                                                                   | 29,276     | 14,865                                   | 44,141 |
| 2075                                                                                                                                                                                                                                                                                                                                                                                   | 31,601     | 14,865                                   | 46,466 |
| Notes:<br>1. Annual growth rate 1.54% per year for most likely projection scenario provided by the City of Parksville (email from Director of Community Planning, December 3, 2024).<br>2. Growth projection for Nanoose Bay Peninsula provided by Regional District of Nanaimo (email from Water Services Manager, December 12, 2024). No growth is expected beyond the 2046 horizon. |            |                                          |        |

In the City, residential growth is expected to occur mostly in the form of densification and infill in existing residentially zoned lots. Up to 3 ha of greenfield development was allowed for in the demand forecast within the water service area based on the existing zoning on undeveloped land. In Nanoose, up to 2 ha of greenfield development was allowed for in the demand forecast within the water service area based on the existing zoning on undeveloped land.

## 5.3 Tourism Growth

The existing water use associated with the tourism industry in Parksville was estimated based on the historic number of visits to Parksville and Qualicum Beach between 2019 and 2024. This data divides the visitors into daily and overnight visits for each month. The typical existing daily visitor profile was estimated by averaging the monthly visitors for 2019, 2023, and 2024 (2020 - 2022 were excluded due to reduced tourism associated with the COVID-19 Pandemic) and dividing by the number of days in each month. Parksville tourism is assumed to account for 80% of the tourism included in the Parksville and Qualicum Beach totals. This assumption is likely somewhat conservative (the Tourism Board estimates Parksville to be 65% of the total).

**Table 5-2: Estimated Existing Daily and Overnight Visitors in Parksville**

| Month               | Daily Visitors | Overnight Visitors | Monthly Water Use (cubic metres) |
|---------------------|----------------|--------------------|----------------------------------|
| January             | 1,295          | 361                | 117                              |
| February            | 1,413          | 409                | 130                              |
| March               | 2,017          | 576                | 184                              |
| April               | 1,329          | 663                | 166                              |
| May                 | 1,890          | 960                | 238                              |
| June                | 1,911          | 1,035              | 251                              |
| July                | 2,063          | 1,352              | 307                              |
| August              | 2,148          | 1,398              | 319                              |
| September           | 1,457          | 937                | 214                              |
| October             | 2,434          | 714                | 225                              |
| November            | 2,219          | 549                | 189                              |
| December            | 2,363          | 614                | 206                              |
| <b>Annual Total</b> | <b>22,539</b>  | <b>9,568</b>       | <b>2547</b>                      |
| <b>Average</b>      | <b>1,878</b>   | <b>797</b>         | <b>212</b>                       |

Notes: Extrapolated from data provided by the Parksville Qualicum Beach Tourism Association for visits by month from 2019 to 2024.

To estimate current water use, the daily visitors were assumed to use approximately 30% of the water demand of a typical residential user and an overnight visitor is assumed to use the same amount of water as a typical residential user. Based on current average residential water use of 156 L/c/d in Parksville, the estimated total annual water use by visitors to Parksville is 78 ML (212 m<sup>3</sup>/d annual average, 165 m<sup>3</sup>/d winter average, and a range of 117 m<sup>3</sup>/d in January to 319 m<sup>3</sup>/d in August). Approximately 23% of estimated visitor demand (17 ML) is seasonal. Visitor water use is largely commercial, as most visitors stay at hotels, resorts or campgrounds and eat at restaurants. Water use by visitors is therefore estimated to be approximately 78 ML/year and 3.4% of total Parksville use during the operating period. This is the estimated direct impact of visitor population on water demand, including washroom use and a basic amount for food preparation and washing. The operation of commercial facilities that serve tourists such as hotels, restaurants and attractions is not entirely represented in these estimates and are instead represented as commercial base and irrigation demands rather than population-driven demands. Tourism is assumed to grow proportionally with population at 1.5% per year.

## 5.4 ICI Growth

The existing ICI floor areas have been calculated using FAR and total available land area zoned for each industrial, commercial, and institutional use. The FAR was calibrated to match the metered average water use between 2021 and 2024. Commercial and institutional growth is assumed to align with residential growth (1.5 %/year growth in floor area). This development is assumed to come in the form of densification of existing commercial and institutional lands. These two assumptions together mean FAR will steadily increase, which is reasonable in Parksville where commercial zones are essentially built out at relatively low density. However, densification often includes a shift of residential zones to mixed use (e.g., mid-rise residential with ground floor commercial space) which could increase land area available for commercial uses. This mode of commercial growth would not likely significantly impact overall water demand.

The existing industrial floor area is not expected to grow significantly over the duration of the next 50 years.

## 5.5 Water Demand Projections

The water demand projections developed for the City and Nanoose Bay Peninsula WSA are divided into the end-uses described in the sections below.

### Residential Indoor Demand

The residential indoor demand estimate is based on current and forecast per capita indoor water use as calculated from the actual measured winter water use from residential water meters. No seasonal variation resulting from patterns of transient population (i.e., vacation rental, cottage rental, or campground) is included in the residential indoor demand calculation.

Per-capita residential indoor demands for the Parksville and Nanoose are calculated to be 156 L/cap/day and 139 L/cap/day respectively, based on the provided residential water meter data.

Demands associated with future population (new development) are estimated to be 140 L/c/d and calculated using lower unit demands drawn from research (DeOreo, Mayer, Dziegielewski, & Kiefer, 2016), for new homes that use efficient fixtures and appliances that meet current codes and standards.

Demands associated with current population are also adjusted in the forecast to account for natural replacement of old fixtures and appliances that meet current standards, until the unit demand is equal to that of new development. A fixture replacement rate of 2.5% was assumed, it results in a full replacement of all fixtures at a 40-year frequency.

### ICI Indoor Demand

The current and future ICI indoor water demand is forecasted by first calibrating the existing floor areas and benchmark ICI water usage per unit of floor area to the match the measured water usage. The total floor area of ICI units is estimated from total land area zoned for ICI use, by calibrating the existing gross floor area ratios to match the total floor area that results in the metered water use. The future ICI floor area is then estimated by including additional undeveloped land zoned for ICI use into the ICI lot area and increasing the FAR such that the calculated floor areas match the total expected ICI growth.

ICI indoor demands are calculated using water use intensity research data obtained from the Water Research Foundation study of indoor water use intensities (m<sup>3</sup>/year per m<sup>2</sup> of heated floor area) of a wide range of ICI facilities (Fedak, Hannon, Taylor, & Volckens, 2019). Current demands are estimated using the average 75<sup>th</sup> water use intensities for each category. Future commercial and institutional

demands associated with development are calculated using the average of 50<sup>th</sup> percentile of water use intensity from the same Water Research Foundation study for new facilities that use efficient fixtures and appliances that meet current codes and standards. Future industrial water use intensities are assumed to be the same as existing.

Demands associated with current commercial and institutional building stock are also adjusted in the forecast to account for natural replacement of old fixtures and appliances with models that meet current standards, until the unit demand is equal to that assumed for new development. As with residential use, a fixture replacement rate of 2.5% or 40-year frequency was assumed.

### **Seasonal Demand**

Seasonal demands are defined as the additional demands present in the summer months due primarily to landscape irrigation. These demands reach a maximum during periods of high soil moisture deficit and evapotranspiration. As noted in Section 5.3, a portion of tourism water demand is also seasonal; therefore, the estimated seasonal tourism demand is subtracted from total seasonal supply flow into the Parksville water system to estimate irrigation use.

As growing metropolitan areas densify, lawn and landscape irrigation demands will decrease with brownfield development and densification of already developed areas. As a result, seasonal demands per unit of area decrease as the overall irrigated area decreases with densification. Conversely greenfield developments can increase seasonal demand as the irrigated area increases with suburban expansion. Seasonal demand is therefore primarily a land-based calculation based on turf irrigation demand assumptions and estimates of the percentage of land area that is irrigated.

The forecast accounts for climate change based on modelling completed as part of the hydrological model development (see Section 7.1).

Future irrigation demand includes consideration of the following:

1. Landscape % Irrigated – assumed percentage of landscaped area (Residential and ICI) that is irrigated and calibrated to 2020 - 2024 water use data.
2. Residential Landscape Lot Coverage Ratio – allowance for change in residential development type (i.e., multi-family developments have a lower irrigated % compared to single family developments).
3. ICI Landscape Lot Coverage Ratio – allowance for change in ICI development type.
4. Park % Irrigated (future) – represents the percentage of park land that is irrigated.
5. Weekly calculated evapotranspiration based on the weekly weather pattern used as part of the hydrological model for existing and each future climate change scenario.

### **Non-Revenue Water**

The forecast of non-revenue water is based on the following factors:

- Distribution system characteristics including:
  - watermain length;
  - number and average length of service connections;
  - system pressure; and
  - Infrastructure Condition Factor (ICF) (A factor that represents the ratio of current water losses to a practical minimum level of loss that can be achieved based on the system characteristics).

- Water system service area for future serviced lands with:
  - watermain length per developed ha (km); and
  - service connections per developed ha (#).

Non-revenue water also includes apparent losses such as the following (American Water Works Association, 2020):

- Metering accuracy estimate from water audit results.
- Data handling errors from water audit results.
- Unauthorized consumption.
- Known unbilled water usage (includes watermain flushing use, firefighting water use, etc.)

## 5.6 Future Demand Summary

The water demand projection methodology was used to forecast Base Demand, Average Day Demand and Maximum Day Demand for the City and Nanoose Bay Peninsula WSA. The forecasted demand is summarized in Table 5-3 and Table 5-4 for scenarios for the 2030s, 2050s, and 2070s for the City and Nanoose Bay Peninsula WSA.

Table 5-6 and Table 5-7 summarize the demand projections for groundwater supplied by the City and Nanoose Bay Peninsula WSA along with Table 5-8 for surface water supplied by the ERWS.

The “best estimate” represents the median water use using all climate models evaluated, representing a status quo scenario (i.e., continuation of existing demand management measures, including pricing and watering restrictions). These scenarios incorporate natural replacement of existing stock of plumbing fixtures and appliances with models that meet current efficiency standards over time. The “high” and “low” estimates are based on the results from the extremes found in the same climate data sets.

**Table 5-3: City of Parksville Demand Forecast**

| Year  | City of Parksville (m <sup>3</sup> /day) |       |               |       |        |               |        |
|-------|------------------------------------------|-------|---------------|-------|--------|---------------|--------|
|       | BD                                       | ADD   |               |       | MDD    |               |        |
|       |                                          | Low   | Best Estimate | High  | Low    | Best Estimate | High   |
| 2024  | 4,200                                    | 5,900 |               |       | 11,900 |               |        |
| 2030s | 4,400                                    | 6,200 |               |       | 14,200 |               |        |
| 2050s | 4,900                                    | 7,300 | 7,400         | 7,700 | 15,600 | 17,200        | 19,600 |
| 2070s | 6,600                                    | 9,100 | 9,400         | 9,900 | 20,200 | 22,100        | 24,300 |



**Table 5-4: Nanoose Bay Peninsula WSA Demand Forecast**

| Year  | Nanoose Bay Peninsula WSA (m <sup>3</sup> /day) |       |               |       |       |               |        |
|-------|-------------------------------------------------|-------|---------------|-------|-------|---------------|--------|
|       | BD                                              | ADD   |               |       | MDD   |               |        |
|       |                                                 | Low   | Best Estimate | High  | Low   | Best Estimate | High   |
| 2024  | 1,200                                           | 2,000 |               |       | 4,600 |               |        |
| 2030s | 1,900                                           | 2,800 |               |       | 6,700 |               |        |
| 2050s | 2,500                                           | 3,600 | 3,700         | 3,800 | 7,500 | 8,200         | 9,400  |
| 2070s | 2,500                                           | 3,700 | 3,800         | 4,100 | 8,700 | 9,600         | 10,600 |

**Table 5-5: Total Demand Forecast for City of Parksville and Nanoose Bay Peninsula WSA**

| Year  | Total City of Parksville and Nanoose Bay Peninsula WSA (m <sup>3</sup> /day) |        |               |        |        |               |        |
|-------|------------------------------------------------------------------------------|--------|---------------|--------|--------|---------------|--------|
|       | BD                                                                           | ADD    |               |        | MDD    |               |        |
|       |                                                                              | Low    | Best Estimate | High   | Low    | Best Estimate | High   |
| 2024  | 5,400                                                                        | 7,800  |               |        | 16,500 |               |        |
| 2030s | 6,300                                                                        | 9,000  |               |        | 20,900 |               |        |
| 2050s | 7,400                                                                        | 10,900 | 11,100        | 11,500 | 23,100 | 25,400        | 29,000 |
| 2070s | 9,100                                                                        | 12,800 | 13,200        | 14,100 | 28,900 | 31,700        | 34,900 |

A further breakdown of forecast water demand that is supplied from groundwater is provided in Table 5-6 and Table 5-7. The forecast of City of Parksville groundwater supply for ADD is governed by the WSW's licence application while the MDD is an average of the maximum diversion rate from 2020 to 2024.

The Nanoose Bay Peninsula (NBP) WSA has a total estimated sustainable groundwater supply capacity of approximately 3,500 m<sup>3</sup>/day, while recent historical use has averaged much less as the service has preferentially used available capacity in the ERWS source. Based on conversations with RDN staff it is planned that as the NBP demands grow, the new demands will be supplied from groundwater until the sustainable groundwater yield is reached, to defer the need to upgrade the ERWS water treatment facility as long as practicable. Therefore it is assumed that groundwater use will be maximized by the 2030s when the treatment plant upgrade is expected to be required.

Table 5-8 shows the forecast water demand for City of Parksville and Nanoose Bay Peninsula WSA that is supplied by the ERWS system. This data is used for the WTP, Intake and Transmission system capacity analysis in Sections 7.7 and 7.8.

**Table 5-6: City of Parksville Demand Supplied by Groundwater**

| Year  | Parksville of Parksville Groundwater (m <sup>3</sup> /day) |       |               |       |       |               |       |
|-------|------------------------------------------------------------|-------|---------------|-------|-------|---------------|-------|
|       | BD                                                         | ADD   |               |       | MDD   |               |       |
|       |                                                            | Low   | Best Estimate | High  | Low   | Best Estimate | High  |
| 2024  | 1,800                                                      | 2,500 |               |       | 4,000 |               |       |
| 2030s | 2,300                                                      | 3,300 |               |       | 4,000 |               |       |
| 2050s | 2,300                                                      | 3,300 | 3,300         | 3,300 | 4,000 | 4,000         | 4,000 |
| 2070s | 2,300                                                      | 3,300 | 3,300         | 3,300 | 4,000 | 4,000         | 4,000 |

**Table 5-7: Nanoose Bay Peninsula WSA Demand Supplied by Groundwater**

| Year  | Nanosoe Bay Peninsula WSA Groundwater (m <sup>3</sup> /day) |       |               |       |       |               |       |
|-------|-------------------------------------------------------------|-------|---------------|-------|-------|---------------|-------|
|       | BD                                                          | ADD   |               |       | MDD   |               |       |
|       |                                                             | Low   | Best Estimate | High  | Low   | Best Estimate | High  |
| 2024  | 300                                                         | 400   |               |       | 900   |               |       |
| 2030s | 1,900                                                       | 2,100 |               |       | 3,500 |               |       |
| 2050s | 2,500                                                       | 2,800 | 2,800         | 2,800 | 3,500 | 3,500         | 3,500 |
| 2070s | 2,500                                                       | 3,000 | 3,000         | 3,000 | 3,500 | 3,500         | 3,500 |

**Table 5-8: City of Parksville and Nanoose Bay Peninsula WSA Demand Supplied by ERWS**

| Year  | ERWS (m <sup>3</sup> /day) |       |               |       |        |               |        |
|-------|----------------------------|-------|---------------|-------|--------|---------------|--------|
|       | BD                         | ADD   |               |       | MDD    |               |        |
|       |                            | Low   | Best Estimate | High  | Low    | Best Estimate | High   |
| 2024  | 3,300                      | 5,000 |               |       | 11,600 |               |        |
| 2030s | 2,100                      | 3,400 | 3,600         | 4,000 | 11,700 | 13,400        | 15,500 |
| 2050s | 2,700                      | 4,800 | 5,000         | 5,400 | 15,600 | 17,900        | 21,400 |
| 2070s | 4,300                      | 6,500 | 6,900         | 7,800 | 21,400 | 24,200        | 27,300 |

## 6. Existing Water System Assessment and Capacity

### 6.1 Reliability Targets

There are no regulations governing required bulk water supply reliability targets for community water systems; however, there are provincial guidelines and decisions from other local governments that help define an acceptable level of risk for communities.

The Design Guidelines for Drinking Water Systems in British Columbia recommend that water sources for drinking water systems should meet maximum projected water withdrawals up to the 50-year return period drought or the extreme drought of record including considerations for multiple years of drought and changes in drought frequency (Ministry of Health, 2023). A system being reliable during 50-year return period drought is equivalent to a reliability of 49 out of 50 years or 98%.

Some local examples of reliability targets for community water supply systems include:

- The reliability target for the CRD Regional Water Supply Service 2022 Master Plan (Stantec, 2022) is based on inflows during 2008 and 2009, which are considered to be a 1:50-year return period drought condition under current climate/demand and future climate/demand conditions to evaluate reliability of the Sooke Lake bulk water supply.
- As part of the Water Supply Strategy prepared for the City of Nanaimo, the South Fork and Jump Creek reservoirs (KWL, 2022) were found to have a reliability of about 86 out of 90 years or 96% which was considered suitable for supply.
- North Salt Spring Waterworks District (NSSWD) considered reliability of supply across a range of reliability targets: 9 out of 10 years (90%), 19 out of 20 years (95%) and 49 out of 50 years (98%) (KWL, 2024). After review of the results, the NSSWD Board selected the 95% reliability target as a reasonable level for their system.

Based on review of available guidelines, targets established by other jurisdictions and discussion with City staff it was determined that a storage reliability target of 29 years out of 30 on average (97%) be used for evaluating the capacity of the water supply system and required upgrades.

### 6.2 Englishman River Climate and Hydrology

The following section provides a summary of the climate, hydrological regime, hydrological modelling, and reservoir operation modelling used to understand the relationship between the Englishman River hydrology and historical water system reliability. Further details on the analysis can be found in Appendix E.

#### Local Climate and Hydrological Regime

The climate of the Englishman River watershed is typical of the east coast of Vancouver Island with cool and wet fall and winter seasons and warm and dry summers. There is a significant change in spatial variability in precipitation across the watershed with total amounts of approximately 1,000 mm near the mouth of the river at the Strait of Georgia with up to 3,250 mm in the headwaters. This differential is primarily due to the orographic rain shadow effects of the Mount Arrowsmith and Mount Moriarty massif located along the western boundary of the watershed, which lies perpendicular to the dominant direction of fall and winter storms coming off the Pacific Ocean.

Figure 6-1 provides the average monthly precipitation and temperature across the watershed from 1980 to 2010. These “climate normals” show that on average approximately 75% of the total annual rainfall falls in the six-month period between November and April, with only 25% falling in the remainder of the year between May to October. Figure 6-2 shows the recorded snow water equivalent (SWE) for the period from 2017 to 2025 at the Mt Arrowsmith Automatic Snow Pillow (ASP) located above Arrowsmith Dam Reservoir at El. 1465 m which shows seasonal accumulation of snow typically between early November and mid-June with average maximum SWE of about 1,150 mm.

The average monthly precipitation and temperature data shown in Figure 6-1 is an average of the PNWAMet Gridded Meteorological dataset from across the watershed area for the 1981 to 2010 period. The PNWAMet data set provides a continuous record of spatially distributed temperature and precipitation data between 1950 and 2012 (Werner, et al., 2019). Although more recent climate data is available from climate stations in Parksville, Qualicum, and Nanaimo, this recorded climate station data is at low elevation near the coast and is therefore not representative of the weather conditions across the entire watershed.

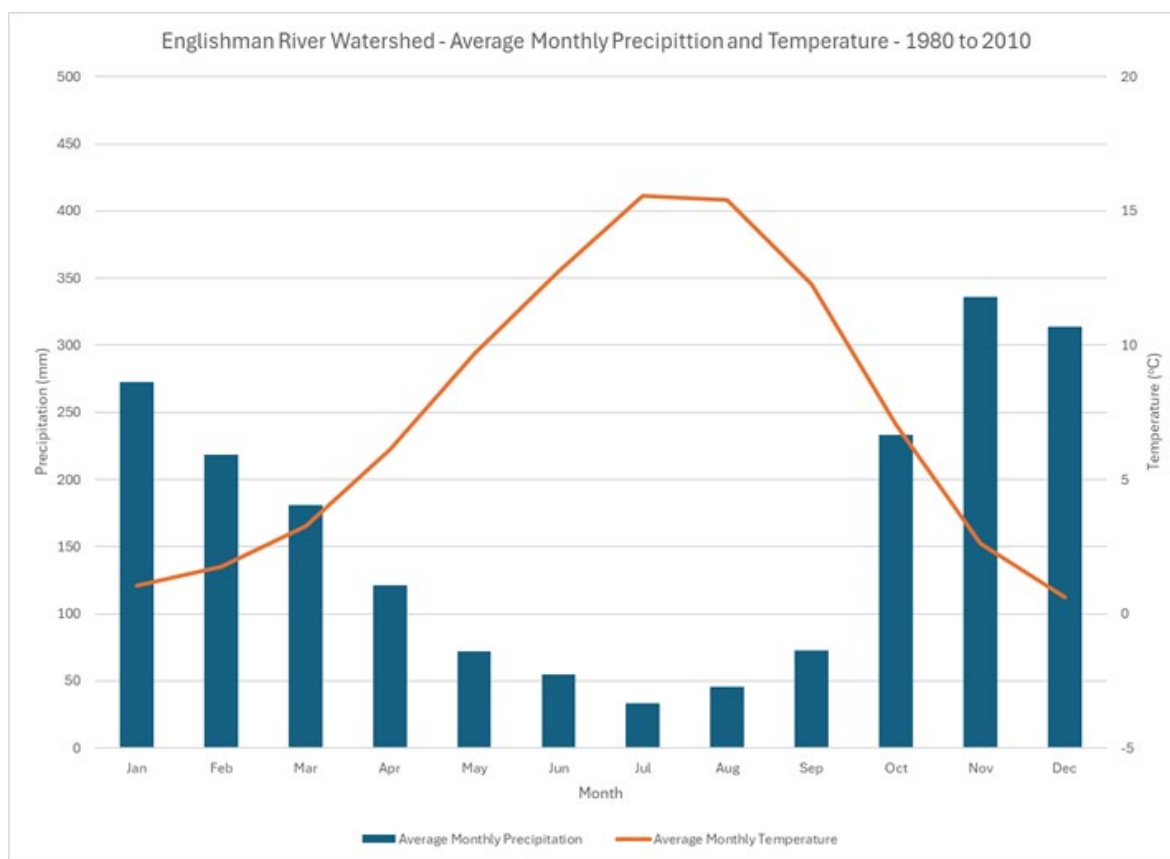
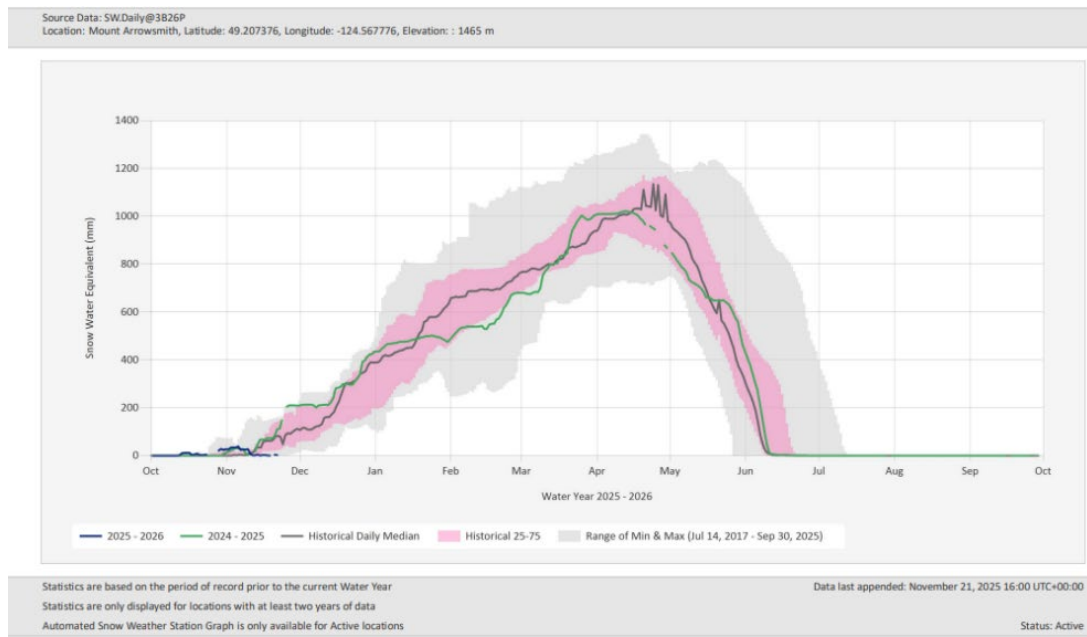


Figure 6-1: Monthly Average Precipitation and Temperature (1980 - 2010)



**Figure 6-2: Snow Water Equivalent for Mt Arrowsmith (ASP 3B2P)**

Source: BC Snow Survey

Streamflow records are available within the Englishman River watershed at the Englishman River near Parksville hydrometric gauge (08HB002) at Highway 19 A Bridge for the period from 1979 to present. Records are also available on Arrowsmith Creek (08HB080), near the outlet of Arrowsmith Dam Reservoir for a short period (1990 - 1998) prior to construction of the Arrowsmith Dam. The maximum, median and minimum daily flow hydrographs for Englishman River for the period before and after construction of the dam are shown in Figure 6-3. Average daily flow for Arrowsmith Creek is shown in Figure 6-4.

The hydrographs show that seasonal variation in flow runoff in the Englishman River mainstem is dominated by the seasonal rainfall pattern with higher flows in fall/winter and lower flows in spring/summer with very limited impact from spring snowmelt. The hydrographs also show the significant seasonal variation in flow between fall/winter and summer spring with baseflows in winter/fall being an order of magnitude larger or more on average than in summer. In addition, comparing the hydrographs prior to and after construction of the dam show an increase in summer baseflows as a result of the releases from Arrowsmith Dam Reservoir.

Finally, comparing the pre-dam and post-dam hydrographs for Englishman River show a reduction in flow in the late spring to early summer period (June and July). This reduction in late spring and early summer flow over-time is an indication of the changing hydrology of the Englishman River due to reduction in water stored in snowpack and earlier snowmelt runoff due to increases in temperature of time. The recorded changes in late spring and early summer flow align with trends previously modelled projections in streamflow for the Englishman River carried out over 20 years ago<sup>2</sup>.

<sup>2</sup> Paul H. Whitfield, Alex J. Cannon & Christopher J. Reynolds (2002) Modelling Streamflow in Present and Future Climates: Examples from the Georgia Basin, British Columbia, Canadian Water Resources Journal, 27:4, 427-456, DOI: 10.4296/cwrj2704427



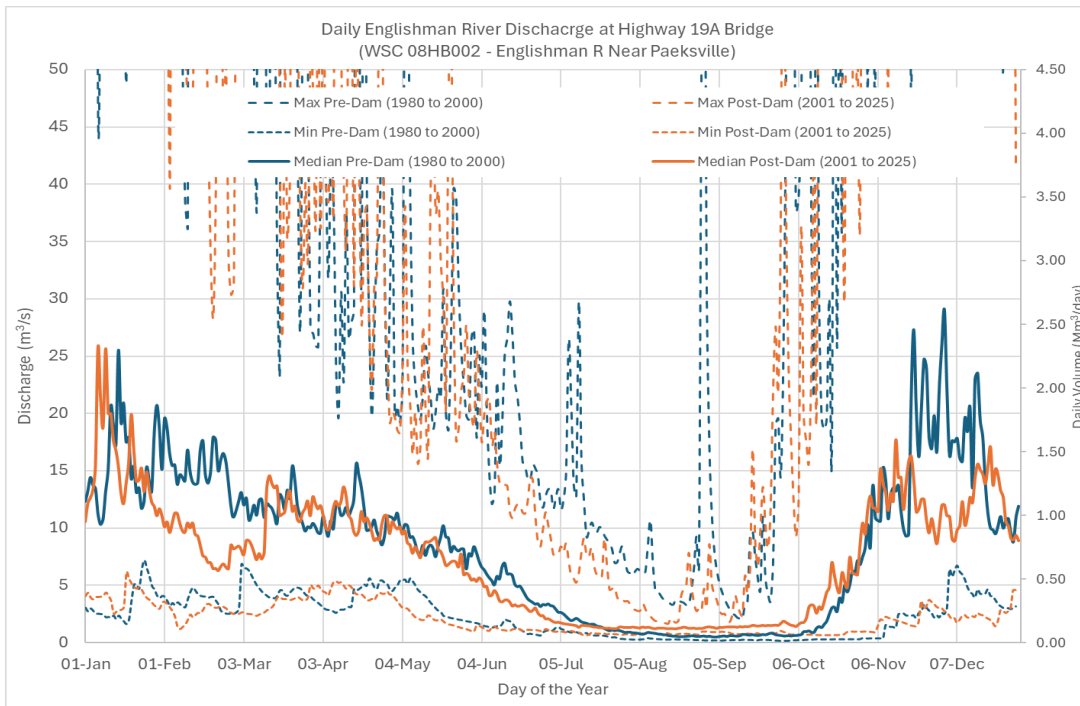


Figure 6-3: Daily Streamflow Records for Englishman River

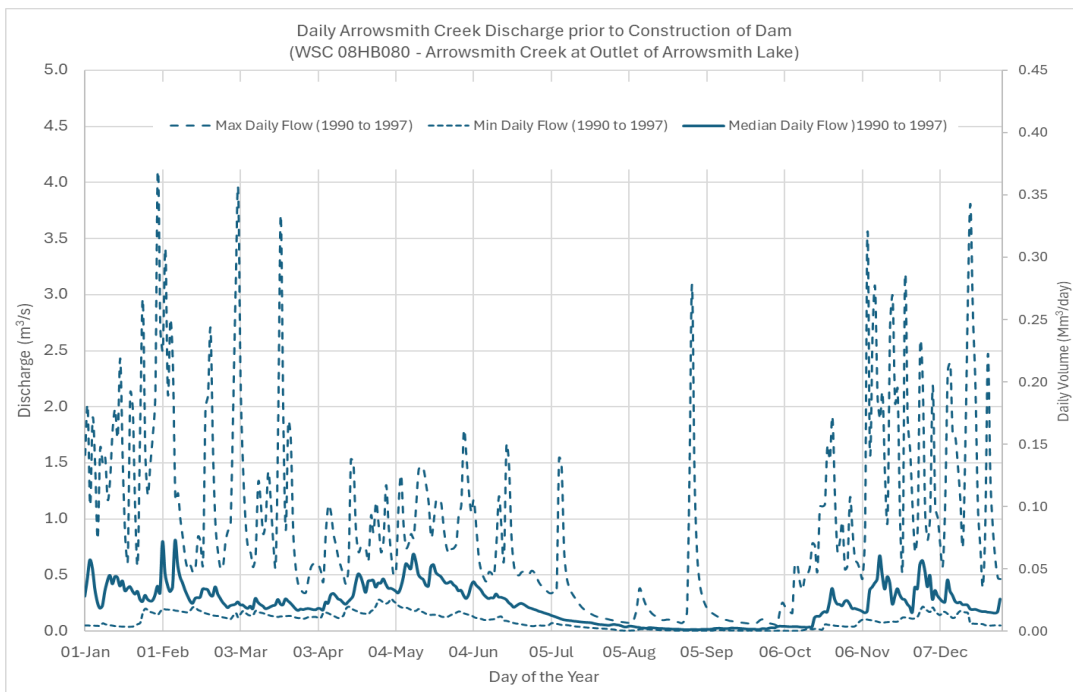


Figure 6-4: Daily Flow Records for Arrowsmith Creek prior to Dam Construction (1990 to 1997)

The daily flow hydrograph for Arrowsmith Creek shows that prior to construction of the dam, the seasonal inflow to Arrowsmith Lake was dominated by both winter/fall rainfall as well as spring snowmelt. In addition, it is important to note the relative magnitude of the flows in the Englishman River which are between 10 to 20 times larger than the flow in Arrowsmith Creek. This is an important consideration in the reliability of the Arrowsmith Dam Reservoir to be able to sustain Environmental Flow Needs (EFN) in the Englishman River, supply community water needs, as well as the ability to refill the reservoir during the fall, winter, and spring runoff.

## Arrowsmith Reservoir and Dam Operation

Arrowsmith Reservoir and Dam are operated to achieve two goals:

1. Supplement natural baseflow along 30 km of the Englishman River between the reservoir and the raw water intake to support EFN in the river and withdrawals of water for community use at the ERWS WTP raw water intake.
2. Maintain EFN in the Englishman River, especially along 4.5 km of channel downstream of the ERWS WTP to minimize negative impacts to fish and other aquatic species.

The normal operation of the reservoir is premised on:

- The Arrowsmith Dam Reservoir refilling over the fall and winter months and being full on June 1.
- Flow being released through the LLOs to maintain EFN downstream of the raw water intake. The flow release from the reservoir is achieved using a combination of the high LLO and the low LLO (siphon).

Despite these objectives, as discussed earlier in Section 2.1 there are limitations of the siphon outlet capacity, which limit the ability to maintain sufficient discharge to support EFN when lake levels are below 810.5 m. This is equal to the remaining storage volume in the reservoir being less than 2 Mm<sup>3</sup>. Therefore, during years with longer dry periods when more water is released from storage to maintain EFN and community water supply needs, the capacity of the siphon at lower reservoir levels can limit the ability to maintain EFN later in the season.

Figure 6-5 and Figure 6-6 show recorded Arrowsmith Dam Reservoir water level and Englishman River flow hydrographs, respectively. The Arrowsmith Dam Reservoir water level hydrographs are based on recorded data provided by the City for the period from 2007 to 2025. The Englishman River flow hydrograph show data recorded at the Englishman River near Parksville WSC gauge (08HB002) located at the Highway 19 A bridge. The flow hydrograph also includes estimated natural baseflows calculated by subtracting the flow release from the Arrowsmith Dam Reservoir from the recorded river flow, thus is a representation of the flow that would be expected in the river without operation of the dam.

The Arrowsmith Dam Reservoir water level hydrographs show how median water levels in the reservoir were higher in the period from 2007 to 2015 compared to 2016 to 2025. Comparing the daily median water levels between the two periods indicates that water levels are starting to drop in the reservoir about 2 weeks earlier on average over the 2016 to 2025 period compared to the earlier period. In addition, this is result of having to start releasing water from the reservoir to supplement flows in the Englishman River due to drop in natural flow in the river earlier in the year. This earlier drop in flow in the Englishman River and thus the need to release flow from Arrowsmith Dam Reservoir over a longer period is shown in Figure 6-6. The average length of the operating period, when water is being released from Arrowsmith Dam Reservoir during the June to October operating season, has increased from 84 days during the 2007 to 2015 period to 109 days or about three weeks longer on average in the period from 2016 to 2025.

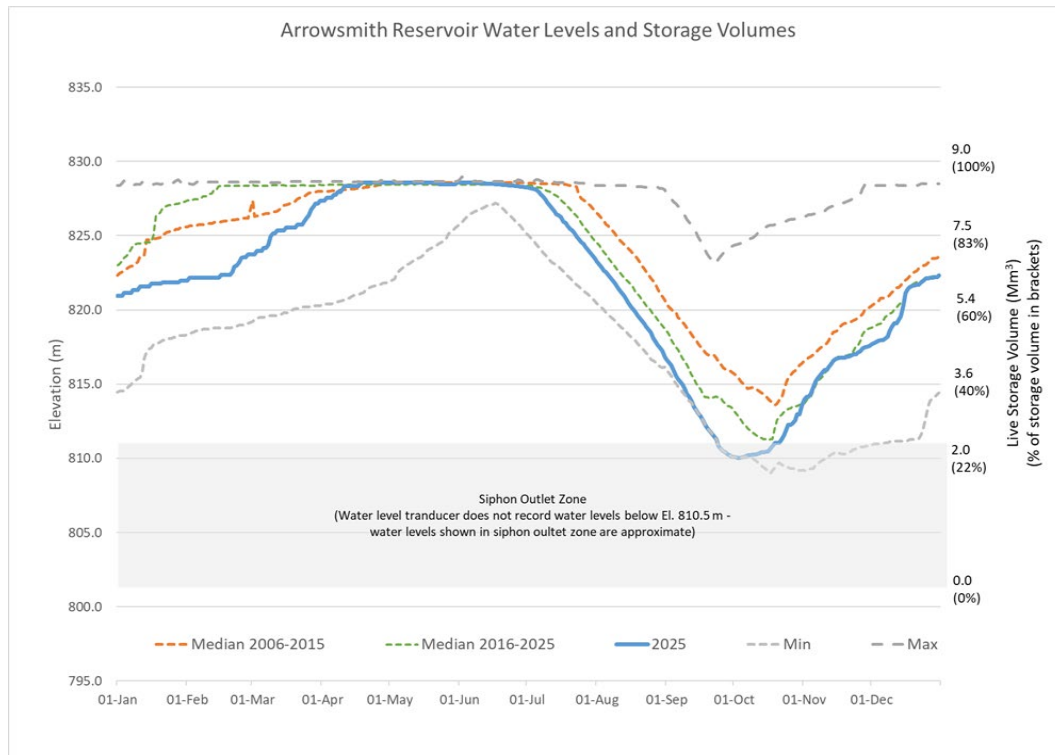


Figure 6-5: Median Arrowsmith Dam Reservoir Water Levels Over Time

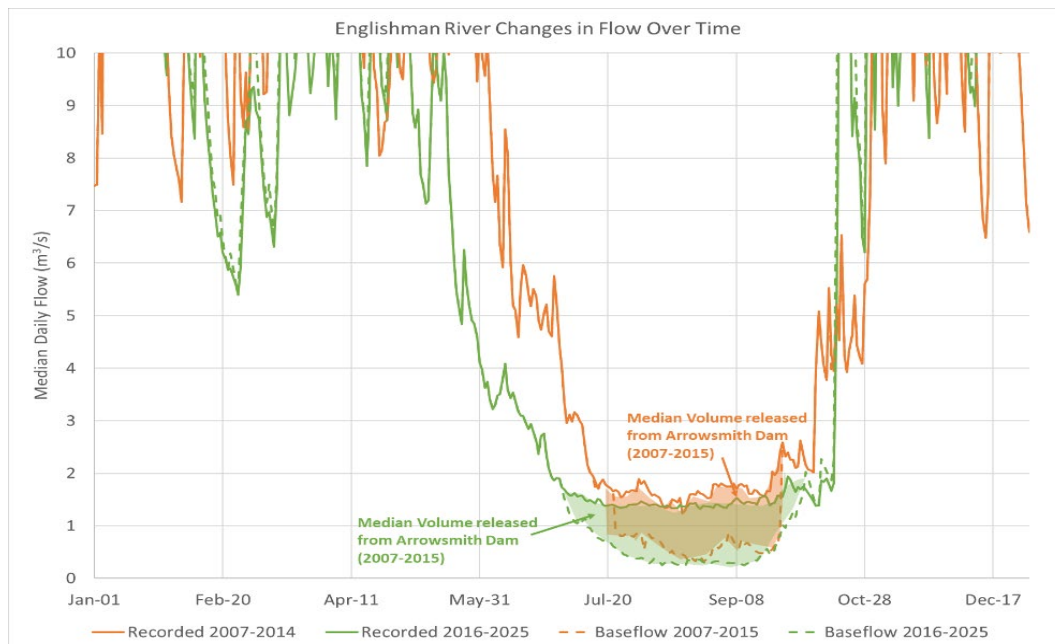
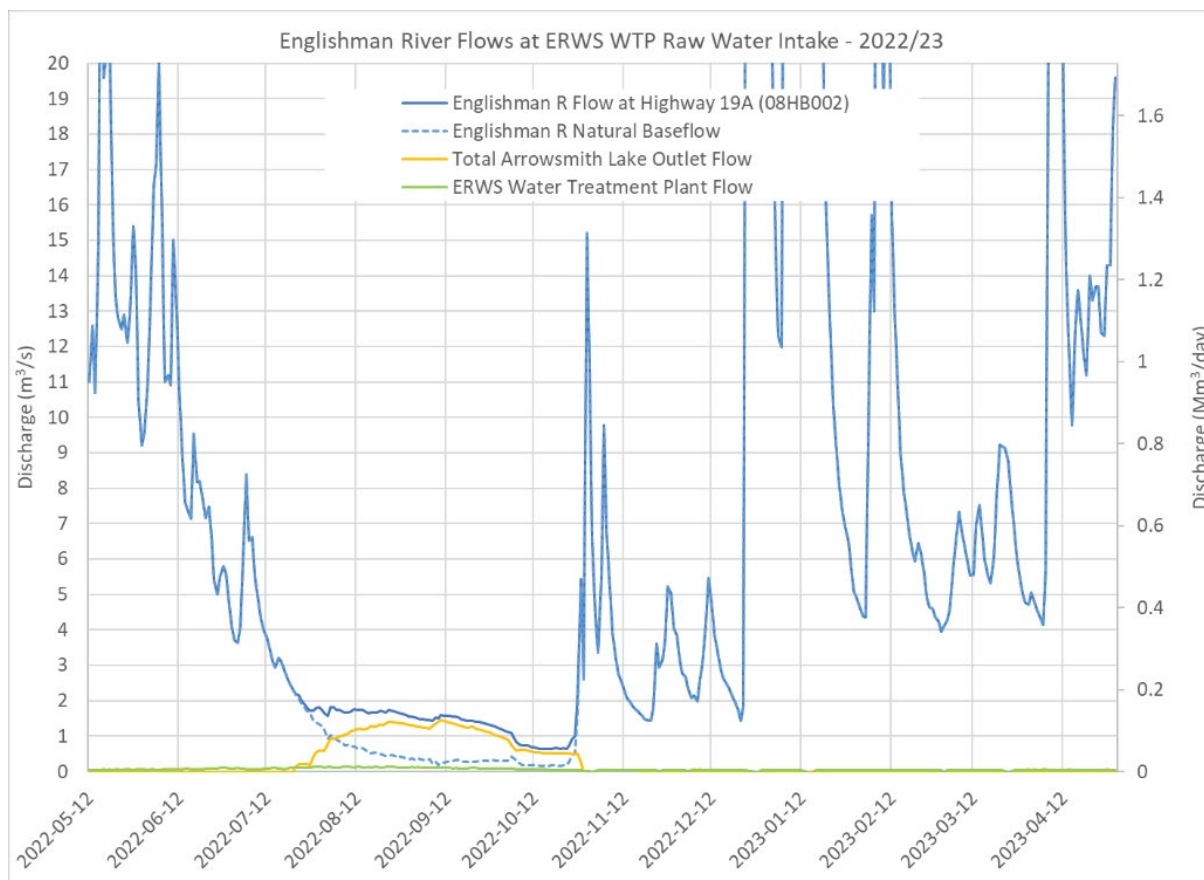


Figure 6-6: Englishman River Flows and Arrowsmith Dam Reservoir Flow Releases Over Time

The summer of 2022 was one of the driest and longest on record with the operating period lasting 120 days between July 22 and November 2. The dry fall that year resulted in reservoir levels dropping below El. 810 m and into the siphon zone. This resulted in reduction in the flow rate that could be released from Arrowsmith Dam Reservoir due to the lower capacity of lower siphon outlet compared to the higher gravity outlet and thus reduction in flow in the Englishman River later in the season (see Figure 6-7).

Instrumentation at the dam is unable to record water levels below El. 810 m, therefore water levels below El 810 m are estimated based on volume of water released from the dam. City staff estimated that reservoir level dropped to a minimum elevation of 809.15 m on November 2. At this level, there is approximately 1.8 Mm<sup>3</sup> of storage remaining or about 20% of the total storage in the dam. However, as described previously, not all of this storage may be accessible due to the potential for cavitation of the syphon.

The operation period during the summer of 2022 is an example of a year when both the EFN and community withdrawal targets were not met due to the capacity of the siphon. Despite there being about 20% of the available storage remaining at the end of the operating period, the EFN and community withdrawal targets were not met and thus 2022 would not be considered a reliable year in calculation of reliability as discussed further in the following section.



**Figure 6-7: Englishman River Flow at ERWS WTP Raw Water Intake for Long Dry Operating Season (2022/23)**

## Historical Surface Water Reliability

Operation of the Arrowsmith Dam Reservoir was simulated using an optimization/mass balance approach which optimizes reservoir operation to satisfy the EFN and withdrawal at the raw water intake. Inputs to the model include historical and future inflows into the reservoir, baseflows in the Englishman River downstream of the Arrowsmith Dam, a temporal distribution of raw water intake withdrawals, and allowances for EFN. Detailed information on the modeling approach is included in Appendix E.

The simulation was carried out using Arrowsmith Dam Reservoir inflows based on the historical climate period between 1981 to 2010. This period was selected because climate projections typically are reported as a change from this standard baseline period as well as the ability to use spatially distributed historical climate data, available up to 2012, that is representative of the distribution of rainfall and temperature across the entire watershed. Using historical data to drive the simulation, provides means for comparing the simulated results with observed historical conditions.

The results of the simulation were used to estimate the historical reliability of the Arrowsmith Dam Reservoir to support both community withdrawals and EFN. Reliability is a measure of how often flow releases from Arrowsmith Dam can maintain both community withdrawals and EFN over the entire operating period, which is defined as when water is being released from Arrowsmith Dam during the June to October operating season. It is represented as a percentage of the number of years over the 30-year simulation period that both community raw water withdrawals and EFN can be supported.

During operation of the Arrowsmith Dam Reservoir, flow releases are not continuously adjusted to meet EFN and community water supply needs. The time lag for the flow to travel from Arrowsmith Dam Reservoir to the ERWS WTP raw water intake makes it challenging to exactly match releases to meet EFN and community withdrawals. The flow releases from Arrowsmith Dam are adjusted incrementally based on the operators' judgement, past experience and precautionary approach given to maintain flows near the EFN target. These operational limitations result that on average a slightly higher volume of flow is usually released from Arrowsmith Dam than what the reservoir simulation model calculates assuming exact operation. Therefore, the simulation assumes a minimum target flow in the Englishman River downstream of the intake of 1.05 m<sup>3</sup>/s to account for the operational limitations in maintaining the agreed interim EFN of 1.0 m<sup>3</sup>/s.

Community raw water withdrawals from the Englishman River are based on simulated current community water demands, adjusted to account for ground water withdrawals, over the baseline period. The simulated water demand time series does not include the influence of implementation of Stage 4 watering restrictions in the historical withdrawal record. Therefore, the calculated system reliability is a measure of how often the storage at in the Arrowsmith Dam Reservoir can support community water withdrawals and the EFN, without the approximate 10% reduction in peak demand resulting from Stage 4 watering restrictions.

In addition to reliability, the storage deficit for each operating period was calculated which is the total volume difference between the volume of water that could be released, based on the hydraulic constraint of the LLOs and the volume that would be required to be released to meet the EFN and community raw water withdrawal. The maximum deficit is the largest total volume difference simulated over the thirty-year period.

The results of the analysis indicate that the existing system, under the simulated baseline climate conditions from 1981 to 2010, could support EFN and community withdrawals without implementing Stage 4 watering restrictions about 21 years out of 30 (or a reliability of about 70%) with a maximum storage deficit of about 1.9 Mm<sup>3</sup>. For the 2020s, reliability was estimated to be about 60% (18 years out of 30) for the status quo condition.

A review of the results indicates that the primary driver of reliability is the volume of water required to maintain EFN and the limited capacity of the low LLO (siphon) to support both community withdrawals and EFN when reservoir levels drop below 2 Mm<sup>3</sup> of storage.

Figure 6-8 shows the relative magnitude of monthly volumes of water flowing in the Englishman River over a typical operation season. The volumes shown in the graph comprise of:

- Withdrawals at the ERWS WTP.
- Other water users withdrawals assumed to be at the licensed withdrawal limits.
- The release from Arrowsmith Dam Reservoir to support EFN.
- The natural baseflow in the river, which is an indication of the amount of flow that would be in the river if the dam was not operational.

This shows that about half of the total volume of water flowing in the river is released from Arrowsmith Dam Reservoir to support EFN while about 10% of the total volume is released to support community withdrawals over the same period.

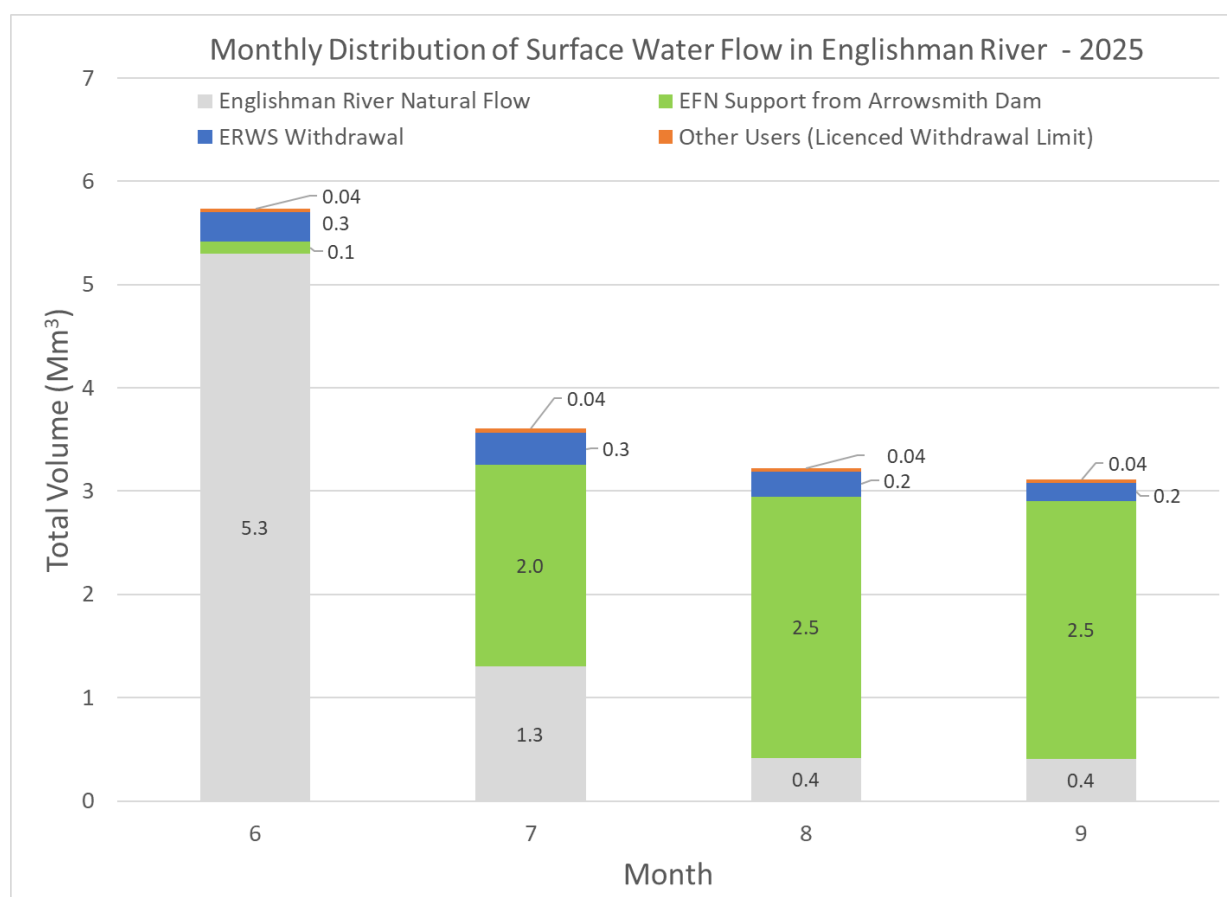


Figure 6-8: Monthly Volume for Englishman River flow during the 2025 Reservoir Operating Period



A review of records provided by the City indicates that Stage 4 watering restrictions were implemented in five of the eleven years from 2015 to 2025 (equivalent to a 55% reliability), with four of the years occurring in the last five years (2022 to 2025) of this period and the fifth occurring in 2015. The reliability results from the simulated baseline period indicate that the current system would meet the 97% reliability target if Stage 4 watering restrictions were implemented between 3 to 4 times on average over a 10-year period. The slightly higher frequency that Stage 4 watering restrictions are implemented by the City compared to the simulation results is attributed to a combination of changing climate conditions over the past 15 years and the changing requirements of the Arrowsmith Dam Reservoir Operating Orders to implement drought management during periods of lower flows in the Englishman River.

### 6.3 Groundwater Availability and Supply

Summary information for the City's groundwater use and available supply is provided in the following sections; more detailed information is provided in Appendix C.

#### Groundwater Level Trends

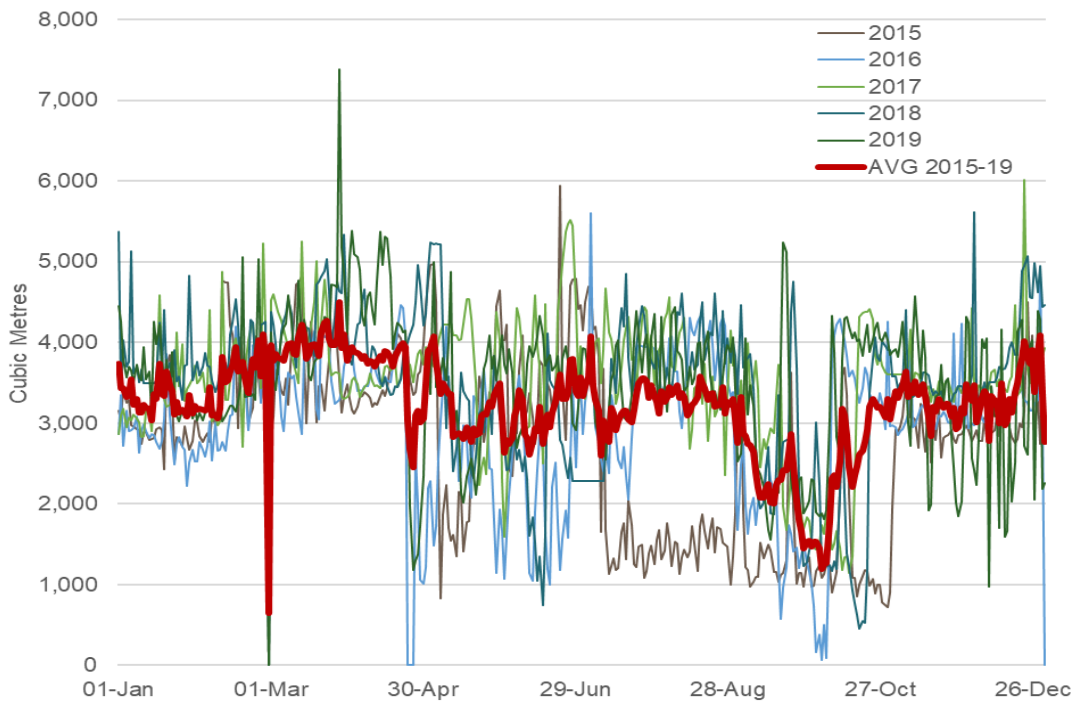
The City's 16 active WSWs are located within Aquifer 216. Groundwater level data for the City's WSWs was reviewed for short-term and long-term periods to assess the threshold for sustainable operations for both the Railway Station and Springwood Well Fields and inform current and future water supply potential. Groundwater levels were compared against each WSW's top of screen elevation and calculated as 70% of available head elevation to assess overuse. Exceedance of the 70% threshold is not recommended for extended periods of time but is expected during peak demand periods.

Short term (2022 - 2024) groundwater level trends are shown in Appendix A of the Waterline Task 2 report (Appendix C of this report). It was noted that several of the Railway Station and Springwood WSWs routinely exceeded the 70% threshold limit throughout the monitoring periods and particularly during peak demand periods in the summer months. Also, when offline, water levels at non-pumped WSWs returned to static levels but still exhibited pumping-like fluctuations, suggesting hydraulic connection between WSWs within each well field. Operation of WSWs with water levels below the 70% of available head threshold limit is not abnormal for short durations during peak demand.

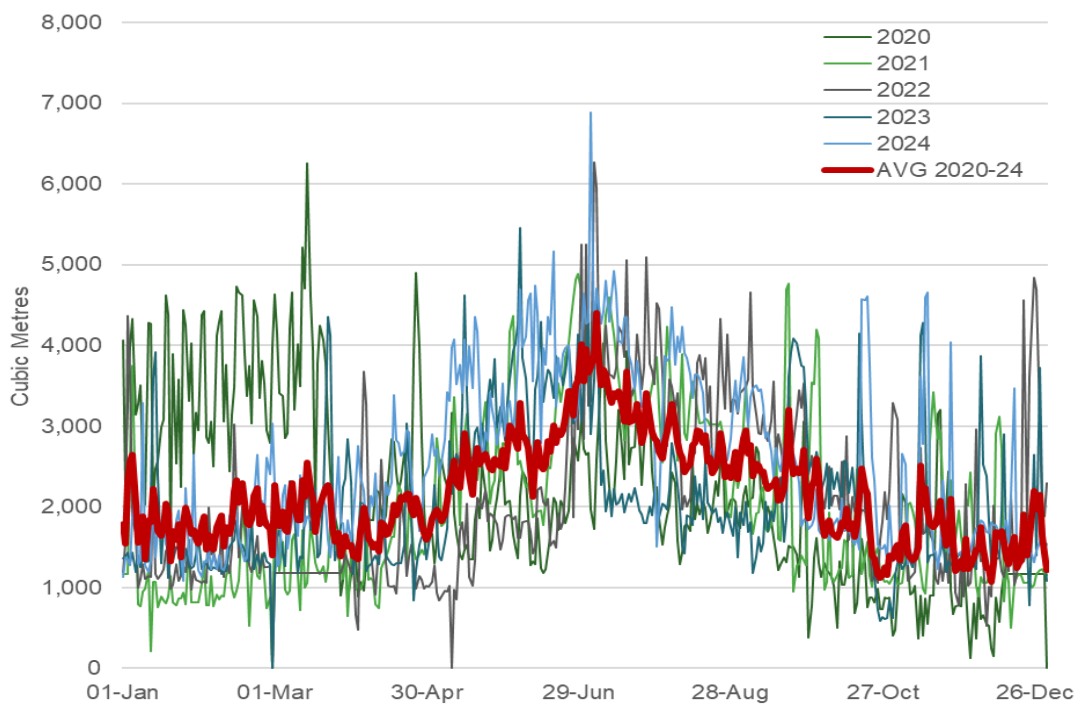
Long term (2012 - 2024) groundwater level trends are shown in Appendix B of the Waterline Task 2 report (Appendix C of this report). Seasonal recharge/use patterns are similar at all WSWs, with the highest annual groundwater levels in the wetter months and the lowest annual groundwater levels in the drier months. None of the WSWs exhibited decreasing groundwater level trends over the monitoring period. Decreasing trends were only observed during high water use years and only for short durations. Generally, the WSWs exhibited increasing or stable groundwater level trends for the monitoring period.

A review of the total daily withdrawal rates from 2015 - 2019 compared with 2020 - 2024 is shown in Figures 6-9 and 6-10. There is a notable reduction in groundwater diversion after the ERWS upgrades entered service in 2020. It is also apparent that the withdrawal rates vary widely day-to-day.

In summary, seasonal groundwater levels in Aquifer 216 return to the same maximum elevation and an overall decreasing trend is not apparent, indicating both short-term and long-term sustainable groundwater withdrawal near both the Railway Station and Springwood Well Fields.



**Figure 6-9: City of Parksville Daily Total Groundwater Withdrawals 2015 - 2019**



**Figure 6-10: City of Parksville Daily Total Groundwater Withdrawals 2020 - 2024**

## Groundwater Use Assessment

The long-term water use data was compiled for both the Railway Station and Springwood Well Fields and is summarized in Table 6-1 and shown graphically in Appendix C of the Waterline Task 2 report (Appendix C of this report).

Table 6-1 compares well field existing licence application diversion volumes and the average use for each of the last three years (2022, 2023, and 2024), as well as the last five-year (2020 - 2024) and 10-year period (2015 - 2024).

**Table 6-1: Groundwater Availability and Use**

| Location              | Existing Use Groundwater Licence Application Diversion Volume (m <sup>3</sup> /year) | Total Use (m <sup>3</sup> /year) |                |                |                |                 |
|-----------------------|--------------------------------------------------------------------------------------|----------------------------------|----------------|----------------|----------------|-----------------|
|                       |                                                                                      | 2022                             | 2023           | 2024           | 5-Year Average | 10-Year Average |
| Railway Station Wells | 595,820                                                                              | 360,771                          | 348,164        | 434,799        | 369,702        | 426,424         |
| Springwood Wells      | 608,002                                                                              | 400,403                          | 411,071        | 492,520        | 408,387        | 514,958         |
| <b>Total</b>          | <b>1,203,822</b>                                                                     | <b>761,174</b>                   | <b>759,235</b> | <b>927,319</b> | <b>778,089</b> | <b>941,382</b>  |

Total groundwater use for 2022 and 2023 was close to the 5-year average while the total groundwater use for 2024 was closer to the 10-year average.

Groundwater use is approximately 22 - 35% lower than the licence application diversion volume of 1.2 Mm<sup>3</sup>. The estimated total annual well yield volume from the original construction reports for the Railway Station and Springwood Wells combined is close to 4 Mm<sup>3</sup> but does not consider well interference and cumulative drawdown.

Further assessment of the annual and summer diversion volumes shows that more groundwater use is occurring during peak water demand periods from June 1 to September 30 each year as per Table 6-2.

In the last two years (2023 and 2024), summer diversion (four months or 33% of the year) accounted for 42 - 46% of the total annual groundwater diversion from the well fields. In addition, seasonal groundwater use in the last two years increased by 9 to 13%. However, the overall groundwater diversion volume for the year is relatively consistent with past years.

**Table 6-2: Groundwater Annual and Summer Diversion Volumes**

| Location              | 2023                                           |                                                          |                                                    | 2024                                           |                                                          |                                                    |
|-----------------------|------------------------------------------------|----------------------------------------------------------|----------------------------------------------------|------------------------------------------------|----------------------------------------------------------|----------------------------------------------------|
|                       | Annual Diversion Volume (m <sup>3</sup> /year) | Summer Diversion Volume (Jun-Sep) (m <sup>3</sup> /year) | Summer Diversion as Percentage of Annual Diversion | Annual Diversion Volume (m <sup>3</sup> /year) | Summer Diversion Volume (Jun-Sep) (m <sup>3</sup> /year) | Summer Diversion as Percentage of Annual Diversion |
| Railway Station Wells | 348,164                                        | 142,422                                                  | 41%                                                | 434,799                                        | 203,855                                                  | 47%                                                |
| Springwood Wells      | 411,071                                        | 174,511                                                  | 42%                                                | 492,520                                        | 219,765                                                  | 45%                                                |
| Total                 | 759,235                                        | 316,933                                                  | 42%                                                | 927,319                                        | 423,620                                                  | 46%                                                |

Based on the foregoing, it can be concluded that Aquifer 216 is a sustainable water source for current withdrawal and system operation. Further information on the status of the current groundwater supply is provided in the Task 3 – Groundwater Supply Resilience Planning (Waterline, September 25, 2025) report in Appendix D.

Additional groundwater numerical modelling is required to confirm that the full licence application diversion volume can be achieved without negative impacts to adjacent users and the receiving environment. In comparing the licence application volume to the 10-year average use, an additional 729 m<sup>3</sup>/day can be extracted from the active WSWs under the current application amount. This additional diversion is significant for future groundwater supply planning, as it constitutes an increase in current groundwater use by 21%.

## Groundwater Quality

Parksville's performance monitoring program at active WSWs, which includes collection groundwater levels and groundwater use data via their Supervisory Control and Data Acquisition (SCADA) system and sampling of raw groundwater from select WSWs annually, indicates that Railway Station and Springwood WSWs are currently in good condition and are providing high quality water. Although groundwater is "moderately hard" to "very hard", total dissolved solids (TDS) concentrations are low, indicating the water source is fresh and are showing no signs of saltwater intrusion; the closest WSW is approximately 1.7 km from the ocean (i.e., Parksville Bay).

## 6.4 Intake and Water Treatment

The existing capacities for the intake, pump station and WTP were assessed against the existing and future estimates for maximum day water demands. For this analysis it is assumed that the Parksville well diversion rates remain constant in future years and there are no significant changes to the water conservation and demand management programs.

By the 2050s, the WTP is assessed to be undersized, and by the 2070s the Raw Water and High Lift Pump Stations are assessed to be undersized.

**Table 6-3: Intake and WTP System Capacities Versus Existing (2024) and Future Best Estimate MDD (2030s, 2050s, 2075)**

| Facility                     | Nominal Existing Capacity (MLD) | ERWS MDD Excluding Supply from Parksville and Nanoose Wells (MLD) |       |       |      |
|------------------------------|---------------------------------|-------------------------------------------------------------------|-------|-------|------|
|                              |                                 | 2024                                                              | 2030s | 2050s | 2075 |
| Intake Screen and Weir       | 48                              | 11.6                                                              | 13.4  | 17.9  | 24.2 |
| Raw Water Pump Station       | 19                              |                                                                   |       |       |      |
| Raw Water Supply Main to WTP | 48                              |                                                                   |       |       |      |
| Water Treatment Plant        | 16                              |                                                                   |       |       |      |
| High Lift Pump Station       | 19                              |                                                                   |       |       |      |

## 6.5 Transmission System

The existing capacities for the transmission system were assessed against the existing and future estimates of maximum day water demands as discussed below and shown in Table 6-4.

The City's hydraulic water model was used to assess the transmission system. The water model was developed by GeoAdvice Engineering Inc. for the Water Utility System Master Plan (September 2024). The MDD was adjusted (i.e., scaled up) to match the MDD demands for Parksville and NBP WSA for 2024 and the future demand scenarios to determine how much flow was directed west (i.e., towards Springwood Reservoir #4) vs. east towards Industrial/Top Bridge Reservoir. It is assumed that the City's well diversion rates remain constant in future years while the NBP system withdrawal is increased to its sustainable capacity when demands exceed it. It is also assumed that each distribution system has sufficient peak hour balancing and fire storage and therefore the transmission system is only required to supply MDD. As shown, all of the existing infrastructure has sufficient capacity for existing and future MDD estimates.

**Table 6-4: Transmission System Capacities Versus Existing (2024) and Future MDD (2030s, 2050s, 2070s)**

| Facility                                                                                                                                                           | Existing Capacity (MLD) | ERWS Transmission Requirement (MLD) |       |            |            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------------------|-------|------------|------------|
|                                                                                                                                                                    |                         | 2024                                | 2030s | 2050s High | 2070s High |
| ERWS Treated Water Supply Main from WTP to Diversion Point (700 mm dia. HDPE DR 11)                                                                                | 48                      | 11.6                                | 15.8  | 23.9       | 29.7       |
| ERWS Treated Water Supply Main to Industrial Reservoir (450 mm dia. HDPE DR varies, 11-17)                                                                         | 22                      | 2.5                                 | 4.7   | 7.9        | 9.9        |
| ERWS Treated Water Supply Main to Springwood Reservoir (600 mm dia. HDPE DR varies, 11-17)                                                                         | 38                      | 9.1                                 | 11.2  | 15.9       | 19.8       |
| Transmission/Distribution Main from Industrial/Top Bridge Reservoir to Nanoose Bay Peninsula Pump Station (350 & 300 mm dia. ductile iron, pressure class unknown) | 12                      | 3.7                                 | 4.2   | 6.1        | 7.1        |
| Nanoose Bay Peninsula Pump Station (Craig Bay 2)                                                                                                                   | 7.4                     |                                     |       |            |            |

## 7. Future Water System Review

### 7.1 Impacts of Climate Change

In the most recent Assessment Report 6 (AR6), the International Panel on Climate Change (IPCC) has stated that global climate records and modelling indicate warming of the global climate system is unequivocal (IPCC, 2023). Evidence of the warming can be found in increased observed temperatures, widespread melting of snow and ice, and increased sea levels. A review of past trends and future climate projections for the region has been performed in order to better understand impacts to water supply and options for adaptation to these changes in the study area. Climate change impacts on the water system were assessed over three 30-year time periods:

- A 2020s time horizon representing from 2011 to 2040
- A 2050s time horizon representing from 2041 to 2070
- A 2080s time horizon representing from 2071 to 2100

#### Regional Projected Climate Change

Climate projections completed for the RDN by the Pacific Climate Impacts Consortium (PCIC) indicate warmer temperatures can be expected year-round with wetter winters and drier summers on average (PCIC, 2023a). Projections<sup>3</sup> indicate average summer daytime temperatures increasing between 2.3 °C to 5.4 °C by the 2050s and increasing between 4.2 °C to 8.9 °C by the 2080s. Summer precipitation is expected to decrease between 0% to 27% by 2050s and decrease between 5% to 38% by the 2080s. Winter rainfall is projected to increase by between 24% to 54% by 2050s and by between 40% to 77% by the 2080s. The projected changes are from the 1981 to 2010 baseline period.

The increased summer temperatures will increase the growing season length. Under baseline climate conditions the growing season was approximately 275 days and is projected to increase by 26 days to 70 days by the 2050s and increase by 59 days to 85 days by the 2080s. Decreased summer precipitation is expected to increase dry periods. The median dry spell length for the baseline period is 24 days and is projected to change by between -2 days to +11 days by the 2050s and between +2 days to +20 days by the 2080s. The combination of longer growing season and generally longer dry spell lengths are expected to both increase seasonal irrigation demand while at the same time reducing flow in the Englishman River and inflow to Arrowsmith Dam Reservoir during the summer period. Therefore, under future climate conditions, community water demand is expected to increase while summer water availability in the Englishman River is expected to decrease, thus increasing reliance on Arrowsmith Dam Reservoir storage to support both EFN and community water withdrawal.

Winter daytime low temperatures are projected to increase between 2.3 °C to 5.4 °C by the 2050s and between 4.2 °C to 8.9 °C by the 2080s which will result in fewer days with temperatures falling below zero. The increased temperatures and higher projected rainfall amounts indicate that, on average, the amount of snowfall and accumulation across the Englishman River watershed and Arrowsmith Dam Reservoir watersheds are expected to decrease. It is likely that only the highest elevation areas within the watershed will continue to accumulate snow reliably. Maps showing the annual frost days for the historical baseline and 2050s periods are shown in Figure 7-1, which indicates that only the highest elevation areas will have longer periods of nights below freezing.

<sup>3</sup> The range of values represent the 10<sup>th</sup> percentile to 90<sup>th</sup> percentile values across the range of the ensemble of nine downscaled global circulation model (GCM) results selected by PCIC and are representative of a high greenhouse gas emissions projection based on the Shared Socioeconomic Pathway 5=8.5 (SSP585) emissions scenario. The changes are from the 1981 to 2010 historical reference period.



## Climate Change Impacts on Water Demand and Water Supply

An ensemble of climate models were used to understand climate change impacts on water demand and water supply.

Weekly precipitation and temperature datasets (1950-2100) downscaled or converted to a finer spatial resolution from six global circulation models (GCM), with two Shared Socioeconomic Pathway (SSP) scenarios each, from the 6th Coupled Model Intercomparison Project (CMIP6) were used in the analysis. The six GCM models are representative of the range of projected future climate change conditions in British Columbia and are included as part of PCICs regional climate data subsets of the CMIP6 ensemble (Sobie, Ouali, Curry, & Zwiers, 2024). The GCMs were downscaled by PCIC to be more representative of local conditions, refine the influence of topography on climate results and improve the distribution of extreme conditions (Werner & Cannon, 2016). The climate data from the selected downscaled GCMs was further bias-corrected to improve the fit with the local recorded historical data using a percentile mapping approach as discussed in Appendix E.

The SSPs selected for analysis come from the IPCC AR6 and are:

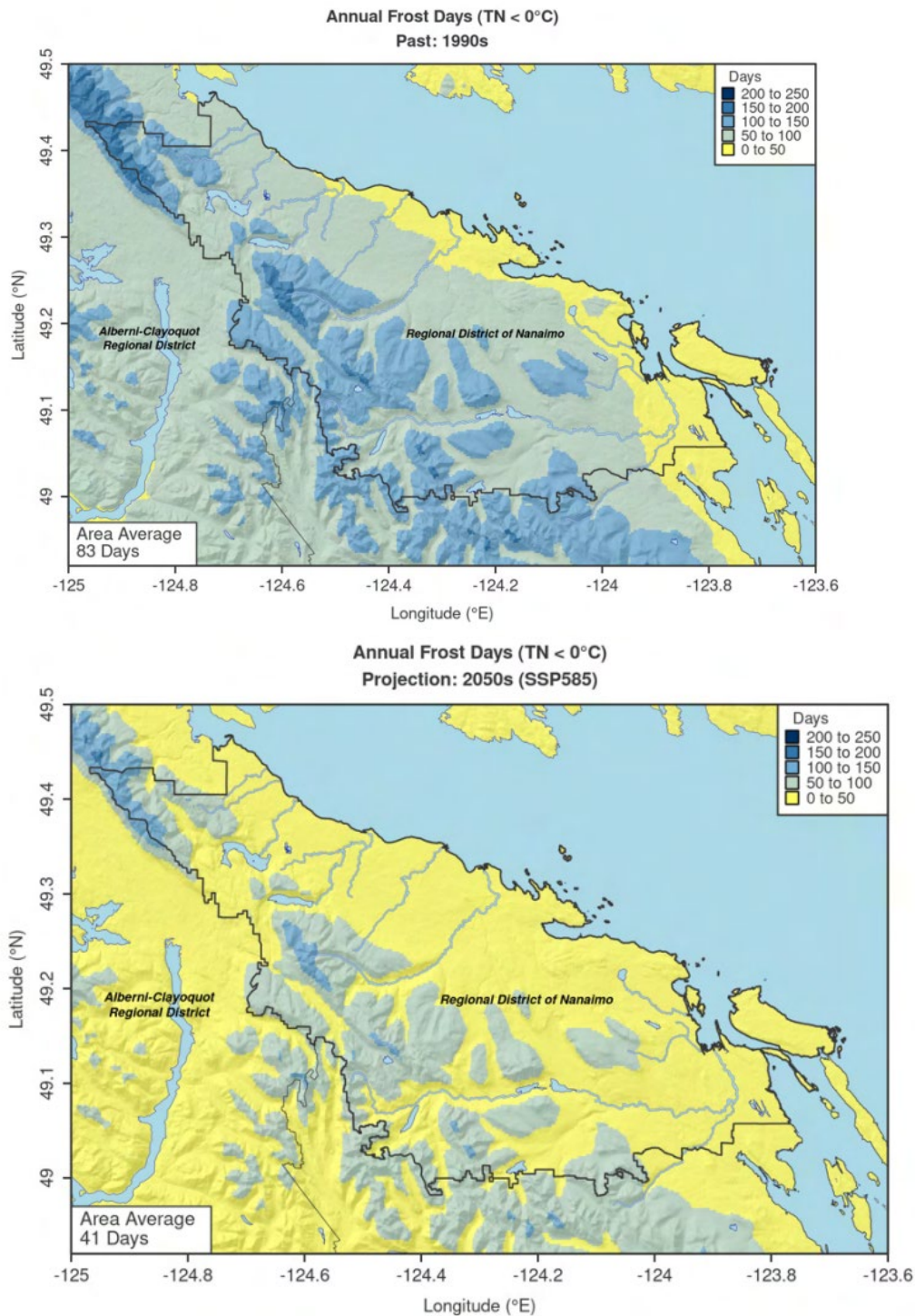
- SSP2, which represents a “middle of the road” future greenhouse gas (GHG) emission scenario that sees development continue as is.
- SSP5, which represents a high fossil fuel development GHG scenario (IPCC, 2021).

A distributed hydrological model of the Englishman River watershed, calibrated to recorded flow data available for the Englishman River and Arrowsmith Creek, was used to understand the spatial and temporal distribution of flow across the watershed for the historical baseline period as well as to project how projected changes in climate could impact the distribution of flow. Further details on the model calibration performance is included in Appendix E.

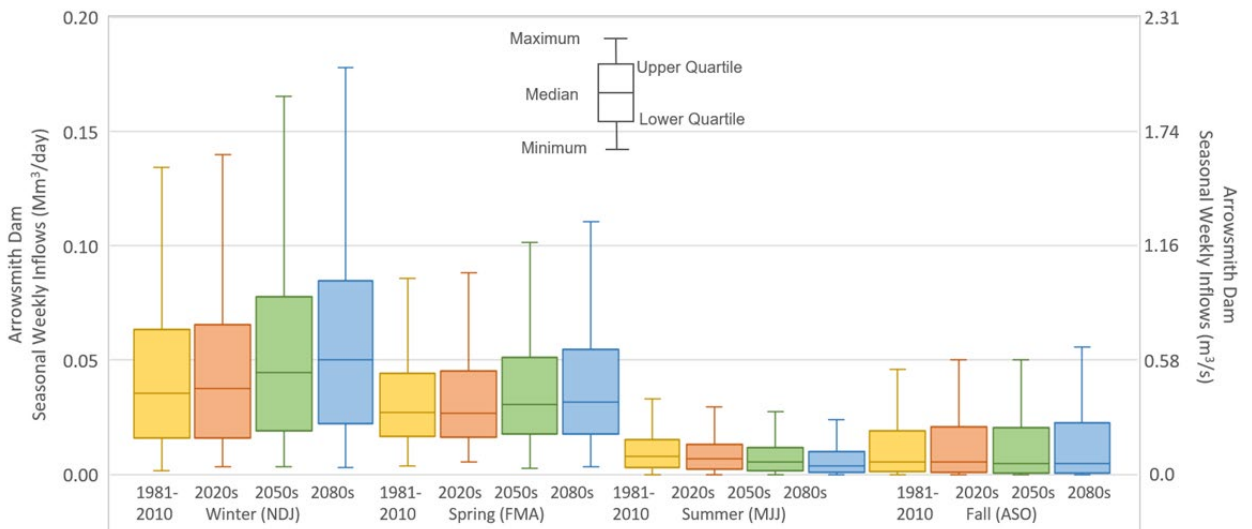
Results of the hydrologic model showing changes in flow from the baseline period for both Arrowsmith Dam Reservoir inflow and Englishman River flow are shown in Figure 7-2 and Figure 7-3, respectively. The projected continuous weekly flow simulations from the hydrological model were used as inputs for the potential yield and storage analysis.

The projected streamflow under future climate generally aligns with the observed streamflow trends. The model results show a decrease in late-spring and early summer (May, June, July) period flow in both Arrowsmith Dam Reservoir inflow and Englishman River. The projections indicate that by the 2080s, the median flow in the watersheds will be roughly equal to the lower quartile flow under current (2020s) conditions. In other words, the average low flow conditions in the future will be equivalent to the low flow conditions that occur roughly once in every four years under current climate conditions.

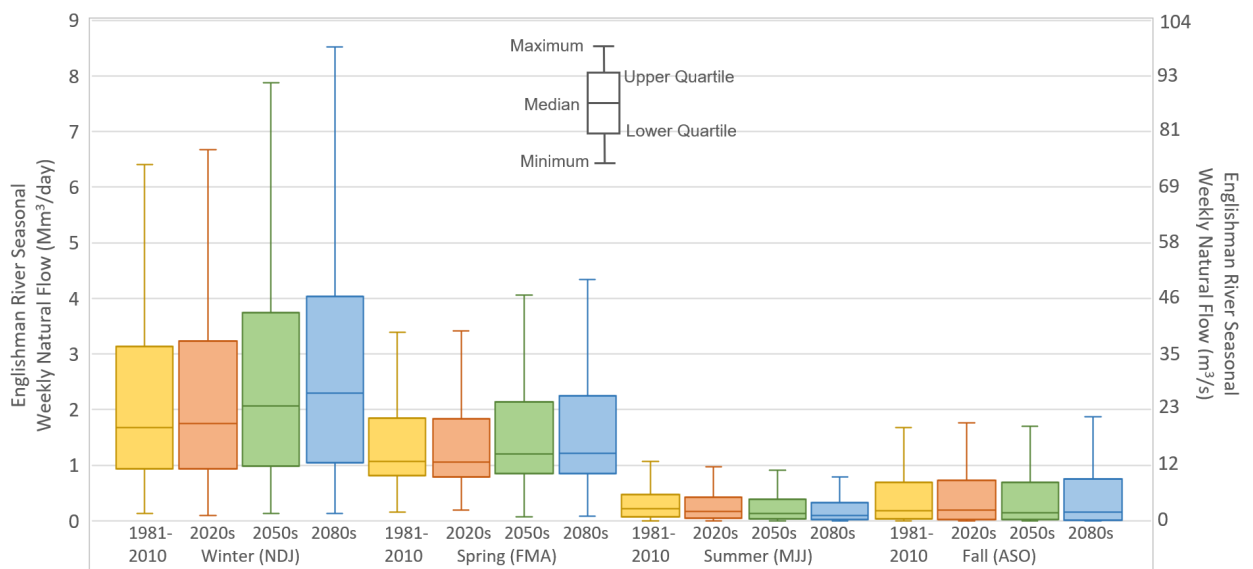
The inflows under projected climate condition are expected to increase in late fall/early winter (November, December, January) and in later winter/early spring (February, March, and April). It is likely that most of the change in winter volume will occur during relatively short high intensity storm events with potentially longer drier spells between the events. This trend can be seen in the comparison of historical recorded flows presented previously in Figure 6-3. In addition, the results also show that variability in fall and winter inflow are likely to increase, as indicated by the wider range of the bar and whisker plots. This increase in variability may increase the potential for year over year drought conditions which could have an impact on future reliability as discussed further in the following section.



**Figure 7-1: Annual Frost Days Across the RDN for Historical Baseline and 2050s Periods**  
Source: *Climate Projections for Regional District of Nanaimo, PCIC, 2023*



**Figure 7-2: Historical and Future Seasonal Weekly Inflows to the Arrowsmith Dam Reservoir**



**Figure 7-3: Historical and Future Seasonal Weekly Baseflow of the Englishman River Basin**

## 7.2 Projected Water Supply Reliability

The reliability of water supply was evaluated using projected inflows and demands accounting for climate change for four periods including a baseline period (1981 to 2010), the 2020s, 2050s, and 2080s. The reliability of Arrowsmith Dam Reservoir storage was calculated using the “delta-shift” method. This method involves first calculating the projected change in reliability between the modelled baseline period and the future periods. Then future reliability is calculated by adding the projected future changes in reliability to the reliability calculated for baseline period (1981 to 20210) based on historical recorded climate data. The projected maximum storage deficits were calculated using the same technique.

The historical and projected reliability for the water supply system and maximum volume deficits for Arrowsmith Dam Reservoir as a water supply source are included in Table 7-1. The reliability of water supply is calculated considering meeting EFN for the Englishman River as well as the contribution of both surface water and groundwater supply for two scenarios: a scenario with current (2025) groundwater withdrawal rates and a scenario with groundwater withdrawals increased to the maximum licensed amount.

The results show a decreasing trend in modelled water supply reliability and increasing trend in modelled maximum storage volume deficit over time. The modelled reliability using current ground water withdrawals drop by about half by the 2080s from 70% under baseline (1981 to 2010) climate conditions to 33% by the 2080s using the median change obtained from modelling the ensemble of projections. The modelled maximum storage deficit assuming current ground water withdrawal rates more than doubles between the baseline value of 1.9 Mm<sup>3</sup> to 4.9 Mm<sup>3</sup> by the 2050s when using the median change obtained from modelling of the ensemble of models. The results also show an increasing range of uncertainty over time with some of the model results showing very low reliability (3%) by the 2080s.

Increasing groundwater withdrawals to the maximum licenced amount results in an increase in water supply reliability from 70% to 73% under the baseline climate, equivalent to a reliability of 22 years out of 30 years with increased groundwater supply compared to 21 years out of 30 years for current groundwater withdrawal rates. For the 2020s, the modelled reliability of water supply with ground water withdrawals increased is only slightly less the modelled reliability for under baseline (1981 to 2010) conditions with groundwater withdrawals at the current rate.

The potential for bias in the reliability modelling was investigated by comparing the modelled reliability and maximum storage deficit obtained when using historical climate data as an input and the climate model data as an input. It was found that the results for the baseline period using the climate model data yield a higher system reliability and lower storage deficit volume. For example, the modelled reliability using historical recorded data for the 1981 to 2010 baseline period is 70% while the modelled reliability using downscaled climate model data ranges from 73% to 83%.

Due to this potential bias, a more detailed review of the climate model data was conducted. It was found that, although the climate data derived from the GCMs matches the overall statistics of the historical climate data, it may not be generating the same inter-annual variability which can drive the likelihood of subsequential dry years. The likelihood and magnitude of subsequential dry years, especially dry winter periods which limit the ability of the Arrowsmith Dam Reservoir to refill, is one of the main drivers of reliability for the Arrowsmith Dam Reservoir and therefore the reliability o support EFN and community withdrawals. As the inter-annual variability is a limitation within the GCM results, it can not be readily accounted for in the analysis and/or quantified with regards to the uncertainty. Therefore, it is important to consider this limitation when interpreting the future reliability results.

The water system reliability projections and maximum volume deficits developed in this study use the “delta method” and therefore, the projections are partly derived from the historical record and partly from the climate model data and are therefore not fully impacted by potential bias in the climate model data.

Despite these limitations, the projections provided are considered a suitable basis for planning purposes. To try to account for the uncertainty in inter-annual variability, additional storage options analysis is based on the 75<sup>th</sup> percentile value of the range of maximum storage deficit results from the ensemble of models, as discussed further in the following section.

Further detailed analysis to account for the limitations in inter-annual variability in the climate model data, potentially using updated GCM projections in future, should be carried out as part of detailed planning and design for the selected storage option in future phases of implementation of the plan.



Table 7-1: Water Supply System Historical and Projected Reliability and Maximum Storage Deficit

| Scenario                                                                                                                                                                                                                                                                                        | Baseline (1980-2010)                  |                    |                                        | 2020s (2010-2039)                     |                     |                                        | 2050s (2041-2070)                     |                     |                                        | 2080s (2071-2100)                     |                    |                                        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|--------------------|----------------------------------------|---------------------------------------|---------------------|----------------------------------------|---------------------------------------|---------------------|----------------------------------------|---------------------------------------|--------------------|----------------------------------------|
|                                                                                                                                                                                                                                                                                                 | Reliability<br>(# out of<br>30 years) | Reliability<br>(%) | Max. Annual<br>Volume Deficit<br>(Mm³) | Reliability<br>(# out of<br>30 years) | Reliability<br>(%)  | Max. Annual<br>Volume Deficit<br>(Mm³) | Reliability<br>(# out of<br>30 years) | Reliability<br>(%)  | Max. Annual<br>Volume Deficit<br>(Mm³) | Reliability<br>(# out of<br>30 years) | Reliability<br>(%) | Max. Annual<br>Volume Deficit<br>(Mm³) |
| Status Quo<br>(Ground Water<br>Withdrawal at Current<br>2025 Rate)                                                                                                                                                                                                                              | 21                                    | 70%                | 1.9                                    | 18<br>(14 to 22)                      | 60%<br>(47% to 73%) | 2.2<br>(1.2 to 5.5)                    | 11<br>(2 to 15)                       | 37%<br>(7% to 50%)  | 4.0<br>(3.3 to 5.9)                    | 10<br>(1 to 18)                       | 33%<br>(3% to 60%) | 4.9<br>(1.5 to 6.4)                    |
| Status Quo<br>(Ground Water<br>Withdrawal at Licence<br>Maximum)                                                                                                                                                                                                                                | 22                                    | 73%                | 1.5                                    | 20<br>(14 to 24)                      | 67%<br>(47% to 80%) | 2.0<br>(1.0 to 5.2)                    | 13<br>(3 to 15)                       | 43%<br>(10% to 50%) | 3.7<br>(3.0 to 5.6)                    | 12<br>(2 to 19)                       | 38%<br>(7% to 63%) | 4.7<br>(1.2 to 6.1)                    |
| Note:<br>Values in brackets provide range of projected reliability and max annual storage deficit based on ensemble of six downscaled global circulation models (GCMs) using two shared social pathway (SSP2-4.5 and SSP5-8.5) greenhouse gas emissions scenarios (12 combinations of GCM/SSP). |                                       |                    |                                        |                                       |                     |                                        |                                       |                     |                                        |                                       |                    |                                        |



## 7.3 Surface Water Storage Options

### Surface Water Storage Option Locations

Five potential locations for additional surface water storage have been evaluated including Shelton Lake, Healy Lake, an unnamed tributary to the South Englishman River, Moriarty Creek and Fish Tail Lake. In addition, increasing the hydraulic capacity of the LLO at Arrowsmith Dam Reservoir was also considered to help improve reliability. The locations were selected based on desktop review of topography in the Englishman River watershed to find locations for surface water reservoirs which optimize storage volume compared to the height and length of dams. These are typically located near outlets of existing lakes and low-lying flat areas where higher volume of storage can be achieved for incremental depth in storage. Due to potential impacts to river habitat, no dam locations were considered along the mainstem of the Englishman River or any of the major tributaries. These locations are similar to those identified in the 1987 Englishman River study (Chatwin, 1987). No field visits or site investigations to the dam locations were carried out as part of the scope of this study. The locations of the surface water storage options are shown in Figure 7-4.

### Additional Storage Options Water Balance

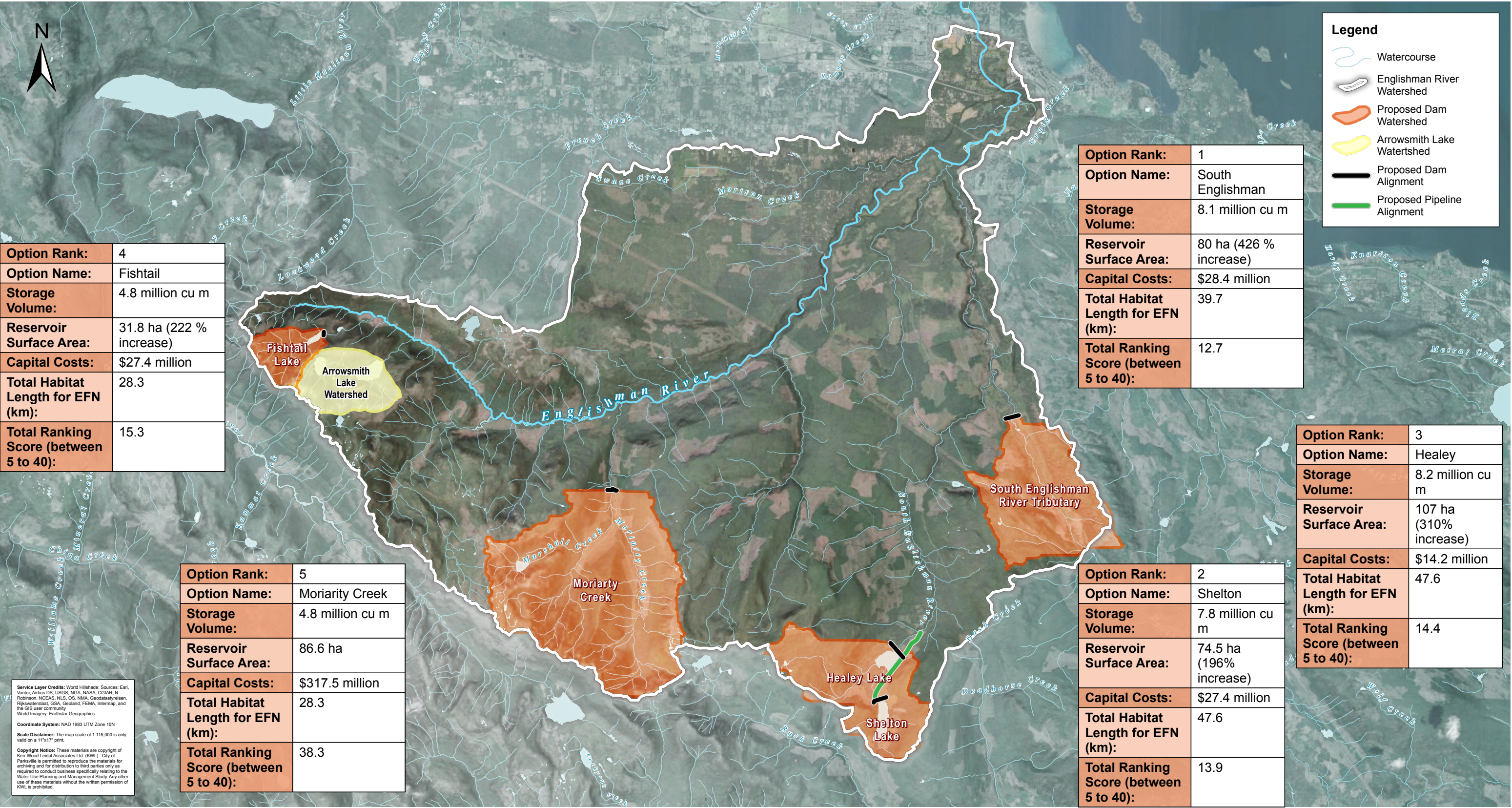
Water balance analyses, similar to the Arrowsmith Dam Reservoir reliability assessment, were carried out to calculate the additional storage volumes required to meet 97% reliability target for maintaining EFN and community water withdrawals. The analysis is based on inflow at the selected surface water storage locations and community withdrawals including impacts of projected climate change to the 2050s period (2041 to 2070). For this initial review of options, the water balance analysis was carried out for each surface water storage location separately assuming that only one location would be selected for future development of additional surface water storage. Further detailed analysis, beyond the scope of this study, is required to confirm if development of two or more sources may be more beneficial.

### Environmental Flow Needs – Englishman and South Englishman Rivers

The additional storage analysis assumes Environmental Flow Needs (EFN) of 1.0 m<sup>3</sup>/s for the Englishman River downstream of the ERWS raw water intake. Similar to the Arrowsmith Dam Reservoir reliability analysis, operational limitations in maintaining the Englishman River EFN from the Arrowsmith Dam Reservoir and the other proposed surface water storage options were accounted for by assuming the average daily minimum flow of 1.05 m<sup>3</sup>/s in the Englishman River in the water balance analysis.

An EFN for the South Englishman River was estimated as part of a seasonal water storage study carried out by KWL for the BC Conservation Foundation in 2011. The 2011 study assumed an EFN of 0.275 m<sup>3</sup>/s which is 10% of the estimated Mean Annual Discharge (MAD) for the South Englishman River. Current provincial EFN policy identifies that streams with monthly flow less than 10% MAD are highly sensitive and that storage be required to mitigate potential negative impacts (MFLNRO, 2022). Therefore, the 2011 estimate for EFN has been adopted as the target for carrying out initial evaluation of the additional storage required for the water supply storage options located within the South Englishman River at Shelton Lake, Healy Lake and the South Englishman River tributary. The water balance analysis carried out for additional surface water storage in the South Englishman River assumes EFN flow would be released from the reservoirs to meet minimum EFN flow of 0.275 m<sup>3</sup>/s upstream of the confluence of the South Englishman River and Englishman River. Table 7-2 summarizes the channel lengths of fish habitat supported by EFN for each option. Further detailed assessment, beyond the scope of this study, is required to confirm the EFN for South Englishman River.







**Table 7-2: Fish Habitat Lengths Supported by EFN for Additional Surface Water Storage Options**

| Fish Habitat Lengths (km) supported by EFN |            |          |                      |
|--------------------------------------------|------------|----------|----------------------|
| Storage Option                             | Anadromous | Resident | Total Habitat Length |
| Existing Arrowsmith Dam                    | 16.5       | 11.8     | 28.3                 |
| South Englishman River Tributary           | 26.8       | 12.9     | 39.7                 |
| Shelton Lake                               | 25.8       | 21.8     | 47.6                 |
| Healey Lake                                | 25.8       | 21.8     | 47.6                 |
| Fishtail Lake                              | 16.5       | 11.8     | 28.3                 |
| Moriarty Creek                             | 16.5       | 11.8     | 28.3                 |

### Additional Surface Water Storage Options Water Balance

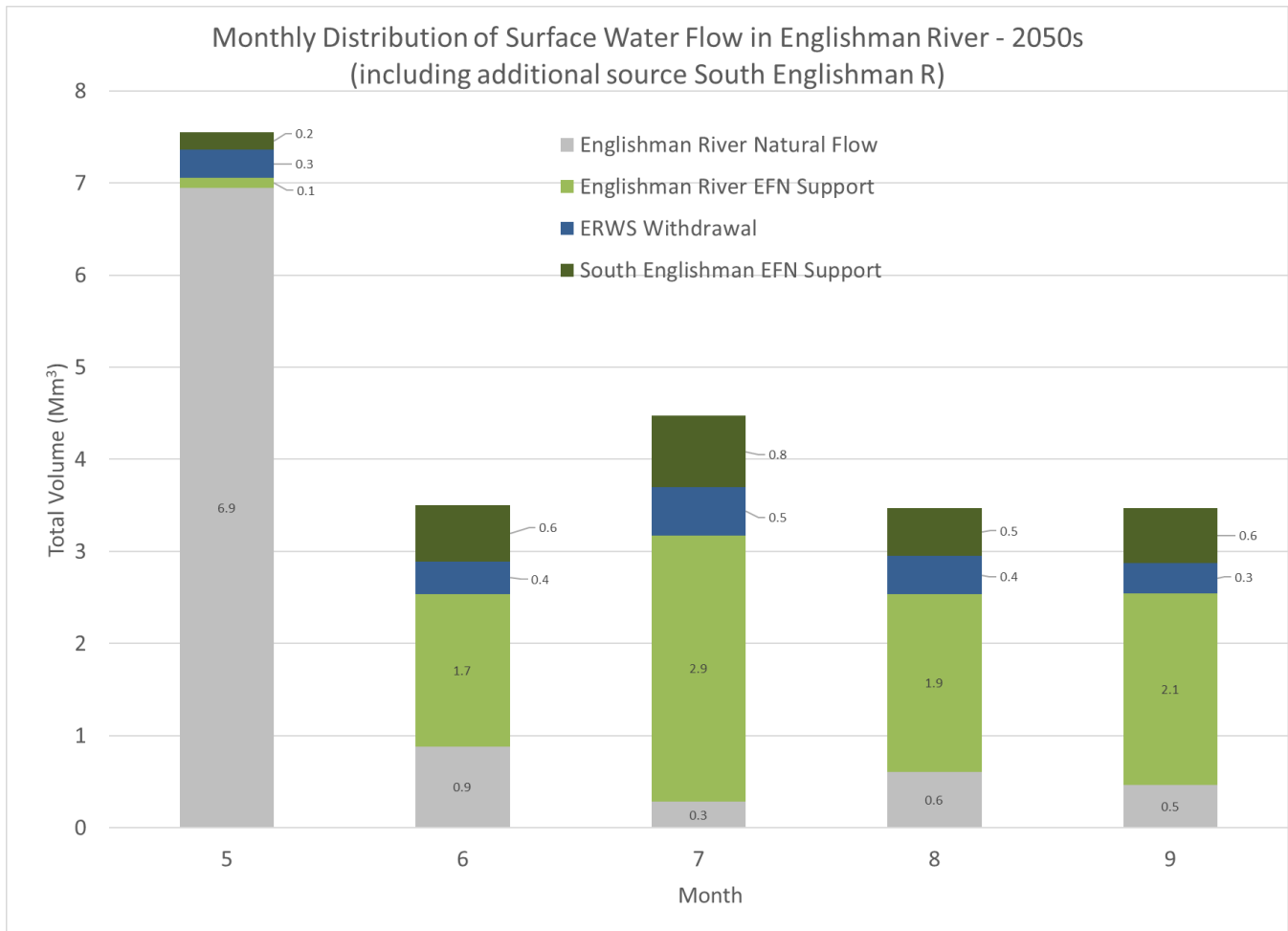
The results of the water balance analyses for additional surface water storage options are summarized in Table 7-3.

**Table 7-3: Reliable Storage Volumes for Additional Surface Water Storage Options**

| Surface Water Storage Option Location | Environmental Flow Needs (m <sup>3</sup> /s – Mm <sup>3</sup> /day in brackets) |                        | Additional Storage for 97% Reliability Target (Mm <sup>3</sup> ) |                                                                                  |
|---------------------------------------|---------------------------------------------------------------------------------|------------------------|------------------------------------------------------------------|----------------------------------------------------------------------------------|
|                                       | Englishman River below Intake                                                   | South Englishman River | Baseline Period (1981 to 2010)                                   | 2050s Period (25 <sup>th</sup> to 75 <sup>th</sup> Percentile Range in Brackets) |
| South Englishman River Tributary      | 1.0 (0.086)                                                                     | 0.275 (0.024)          | 3.9                                                              | 7.2 (6.7 to 8.1)                                                                 |
| Shelton Lake                          | 1.0 (0.086)                                                                     | 0.275 (0.024)          | 3.9                                                              | 7.2 (6.7 to 7.8)                                                                 |
| Healey Lake                           | 1.0 (0.086)                                                                     | 0.275 (0.024)          | 3.9                                                              | 7.2 (6.7 to 8.2)                                                                 |
| Fishtail Lake                         | 1.0 (0.086)                                                                     | N/A                    | 1.5                                                              | 4.0 (3.6 to 4.8)                                                                 |
| Moriarty Creek                        | 1.0 (0.086)                                                                     | N/A                    | 1.5                                                              | 4.0 (3.6 to 4.8)                                                                 |

The results above assume that the EFN for Englishman River is supported by releases from Arrowsmith Dam Reservoir as well as the proposed Fishtail Lake or Moriarty Creek reservoirs. The EFN for South Englishman River is assumed to be supported by releases from proposed South Englishman River Tributary, Shelton Lake or Healey Lake reservoirs. The results indicate that additional storage to meet the 97% reliability target at Shelton Lake, Healey Lake or South Englishman tributary locations are higher than those for Fishtail Lake and Moriarty Lake. This difference is due to the additional storage required to support the EFN for South Englishman River. Monthly distribution of the components of surface water flow in the Englishman River projected for the 2050s, including release from additional storage in South Englishman River is included in Figure 7-5.

It should be noted that due to relatively small size of the Shelton Lake watershed, the limited inflow to the lake limits the ability for Shelton Lake to refill during dry winter periods. This is indicated by the smaller additional storage at the 75th percentile for Shelton Lake location being smaller than those for South Englishman River Tributary and Healey Lake.



**Figure 7-5: Monthly Distribution of Englishman River Flow for 2050s – Including Releases from Additional Storage in South Englishman River**

## Surface Water Storage Option Descriptions

The following sections describe each of the surface water storage options. Detailed plans of each option including watershed areas, approximate dam locations and reservoir surface areas are shown in Figure 7-6 to Figure 7-10.

### Shelton Lake and Healy Lake

Shelton Lake and Healy Lake are located near the headwaters of the South Englishman River near the southern boundary of the Englishman River watershed at elevation of 550 m and 530 m, respectively. The lakes have total watershed areas of 3.1 km<sup>2</sup> and 11.4 km<sup>2</sup> for Shelton Lake and Healy Lake, respectively. The total watershed area for Healy Lake includes the Shelton Lake watershed.

When analyzed together, the required total storage volume for Shelton Lake and Healey Lake is 7.2 Mm<sup>3</sup>, for the 2050s climate condition and community withdrawals. This volume assumes perfect reservoir operation where the amount of water released from the reservoir exactly matches the volume required to support the EFN target as well as the withdrawal.

The results also show that the limited size of the watershed area of Shelton Lake and therefore the limited inflow limits the potential to store water at the lake. This finding is similar to that found in 2011; however, the combined watershed of Shelton Lake and Healey Lake is large enough to have sufficient inflow to refill storage at Healey Lake.

To impound additional storage at Healey Lake or Shelton Lake would require a dam with an earthfill embankment and spillway structure. To impound approximately 8 Mm<sup>3</sup>, equal to 75<sup>th</sup> percentile of the range of storage volumes calculated from the ensemble of model results, it is estimated that the dams at either Shelton Lake or Healey Lake would be about 15 m high by 370 m long and 12 m high by 235 m long, respectively. This would result in a reservoir surface area of 107 ha for Healey Lake, about three times the size of the current lake. For Shelton Lake, the reservoir area would be 74.5 ha which is about twice the size of the current lake.

Both Shelton Lake and Healey Lake have reasonable construction vehicle access via existing private logging roads from the Nanaimo River estuary to the south.

### South Englishman River Tributary

A location for a surface water storage reservoir was identified on a tributary to the South Englishman River near the eastern boundary of the Englishman River watershed at elevation 280 m. At the location of the potential dam, the watershed has an area of 12.9 km<sup>2</sup>. The potential reservoir would flood an existing wetland area located about 1.3 km upstream of the confluence of the tributary with the South Englishman River.

A storage analysis, using the assumed target EFN of 0.275 m<sup>3</sup>/s for the South Englishman River, was carried out and the results indicate that a reservoir at this location would require a storage capacity of 8.1 Mm<sup>3</sup> to support both the EFN for the South Englishman River, and supplement the Englishman River EFN and community withdrawals from the Englishman River.

A dam having an earthfill embankment 14 m high by 440 m long would be required at this location to impound 8.1 Mm<sup>3</sup>. The reservoir would have a surface area of about 80 ha, more than four times the size of the existing wetland area.

There is good access to the site via existing private logging roads from Northwest Bay Road near Parksville.

## Moriarty Creek

A dam across Moriarty Creek could be constructed to create additional surface water storage. The watershed at the proposed dam location is 28.3 km<sup>2</sup> at about an existing ground elevation of about 450 m.

There is no lake at this location and due to the steep valley walls, a significant dam would be required to impound the additional surface water storage volume required. An earthfill dam having a height of 48 m and a length of 340 m would be required to impound 4.8 Mm<sup>3</sup> of water. This would result in a reservoir with a surface area of 86.6 ha.

It has been assumed that flow release from a reservoir at Moriarty Creek to maintain EFN in the mainstem of the Englishman River would be greater than any flow releases required for the lower reaches of Moriarty Creek. Therefore, no additional storage for EFN flows in Moriarty Creek are included in the analysis.

There is good access to this site via existing private logging roads.

## Fishtail Lake

Fishtail Lake is located in the watershed of an unnamed tributary to the Englishman River immediately to the west of Arrowsmith Dam Reservoir. The watershed to the outlet of Fishtail Lake has an area of 2.9 km<sup>2</sup> and the elevation of the lake is 1,000 m.

The flow releases from a reservoir at Fishtail Lake to support EFN flows in the Englishman River are greater than EFN for the tributary downstream of Fishtail Lake. Therefore, the analysis assumes that no additional EFN would be necessary in addition to the current EFN for the Englishman River. Based on this, the total required storage at Fishtail Lake would be 4.8 Mm<sup>3</sup> to support the Englishman River EFN and future community water supply. A 20 m high by 130 m long concrete gravity dam would be required to impound the required storage. This would result in a reservoir having a surface area of 31.8 ha, about twice the size of the existing lake.

There is no vehicle access to Fishtail Lake. An access road would need to be constructed across the steep terrain below the lake to gain access to the site.

## Summary of Surface Water Source Options

Table 7-4 summarizes the analysis results for the surface water source options. The table includes the watershed area, mean annual runoff and target reservoir volume required to support EFN and community water withdrawals for each of the surface water storage options. As discussed above, the target reservoir volume for Shelton Lake, Healy Lake and the South Englishman River tributary includes supplemental storage volume to support EFN for the South Englishman River. The mean annual runoff and target reservoir volume provides an indication of the water yield available to refill the reservoir on average. For example, the target storage for Shelton Lake is greater than the mean annual runoff volume from the watershed. This indicates that the ability for a reservoir at Shelton Lake to be refilled each year by the inflow is marginal and thus would have to be carefully managed to maintain EFN and support community water withdrawals during the dry season.

It should be noted that construction of fully man-made storage is not considered to be economically feasible due to the volumes required. For example, a 3 m deep pond would have to have an area of 160 ha to hold 4.8 Mm<sup>3</sup>. This is roughly equivalent to a 3 m deep pond covering about 220 soccer fields or the equivalent of volume of about 1,920 Olympic-sized swimming pools.

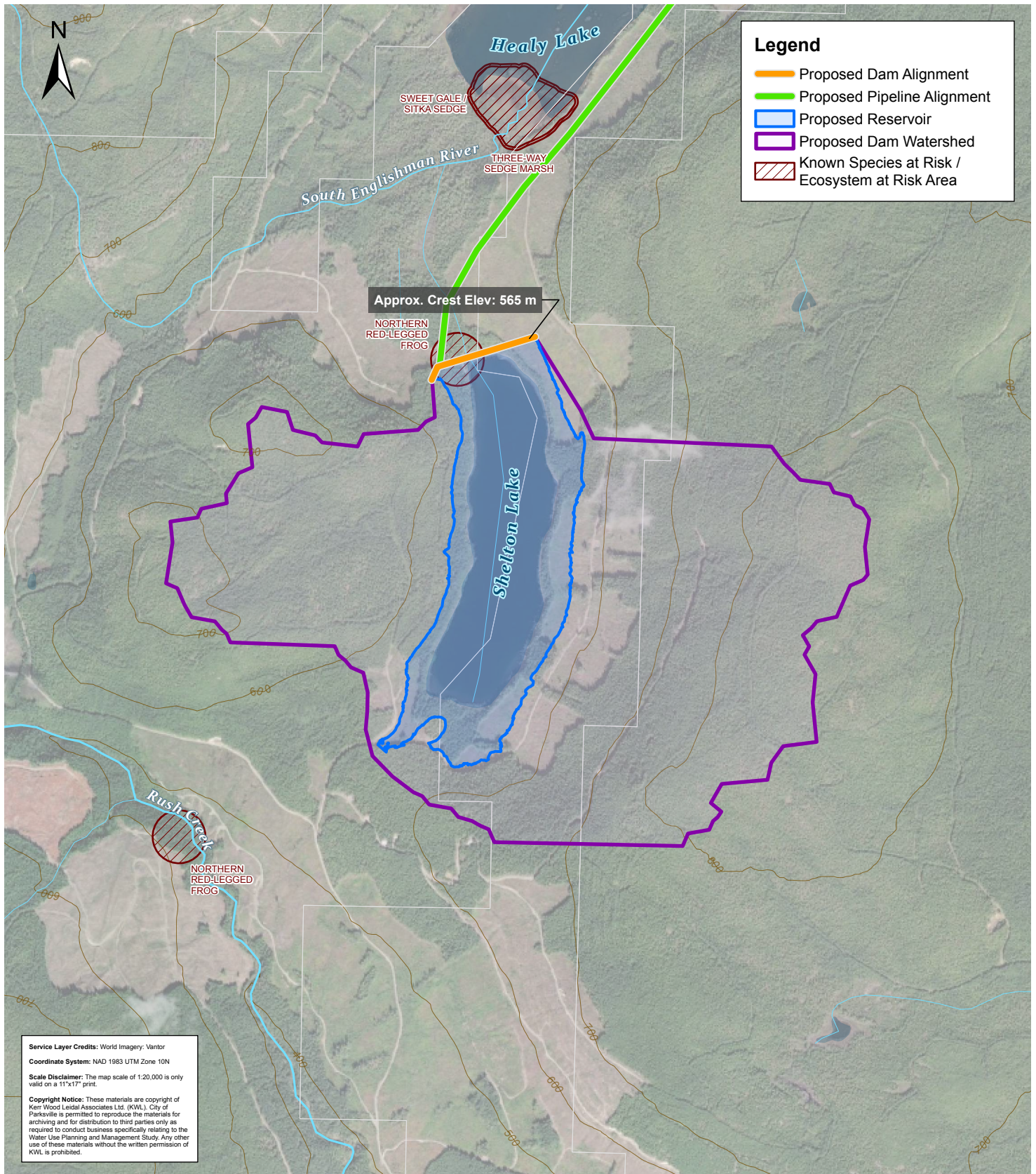


**Table 7-4: Summary of Surface Water Storage Options**

| Surface Water Storage Option                                                                                                                                                                                                    | Watershed Area (km <sup>2</sup> ) | Proposed Dam Dimensions (Height x Length) | Proposed Reservoir Surface Area (ha) | Mean Annual Runoff (Mm <sup>3</sup> ) |                      |                      | Target Reservoir Volume (Mm <sup>3</sup> ) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-------------------------------------------|--------------------------------------|---------------------------------------|----------------------|----------------------|--------------------------------------------|
|                                                                                                                                                                                                                                 |                                   |                                           |                                      | Baseline (1981 to 2010)               | 2050s (2041 to 2070) | 2080s (2041 to 2070) |                                            |
| South Englishman River Tributary                                                                                                                                                                                                | 12.9                              | 14 m x 440 m                              | 61.2                                 | 17.7                                  | 19.8                 | 20.2                 | 8.1                                        |
| Shelton Lake                                                                                                                                                                                                                    | 3.1                               | 15 m x 370 m                              | 36.4                                 | 4.4                                   | 5.0                  | 5.1                  | 7.8                                        |
| Healy Lake                                                                                                                                                                                                                      | 11.4 <sup>2</sup>                 | 12 m x 235 m                              | 72.5                                 | 18.5                                  | 21.2                 | 21.6                 | 8.2                                        |
| Fishtail Lake                                                                                                                                                                                                                   | 2.9                               | 20 m x 130 m                              | 17.5                                 | 5.1                                   | 5.6                  | 5.7                  | 4.8                                        |
| Moriarty Creek                                                                                                                                                                                                                  | 28.3                              | 48 m x 340 m                              | 86.6                                 | 50.1                                  | 55.7                 | 56.8                 | 4.8                                        |
| Notes:<br>1. Projected mean annual runoff for 2050s and 2080s period is the median value across the range of climate change model ensemble results.<br>2. Healy Lake watershed area includes the area upstream of Shelton Lake. |                                   |                                           |                                      |                                       |                      |                      |                                            |

# City of Parksville

## Water Use Planning and Management Study



Project No. 2248.018  
 Date June 2026  
 Scale 1:20,000

0 200 400 800 Metres

## Surface Water Storage Option - Shelton Lake

Figure 7-6

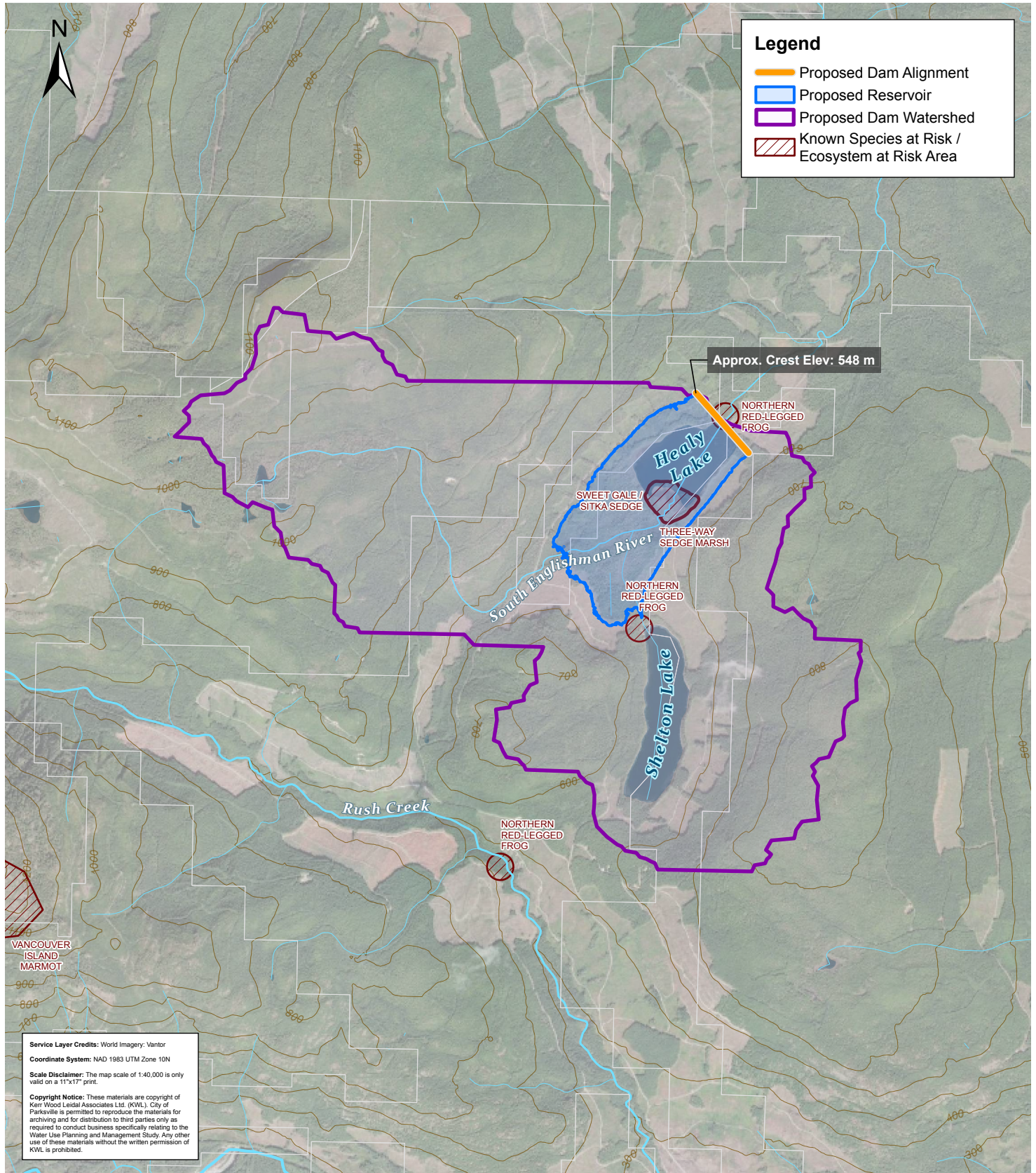


## City of Parksville

### Water Use Planning and Management Study



**KERR WOOD LEIDAL**  
consulting engineers



Project No. 2248.018

Date June 2026

Scale 1:40,000

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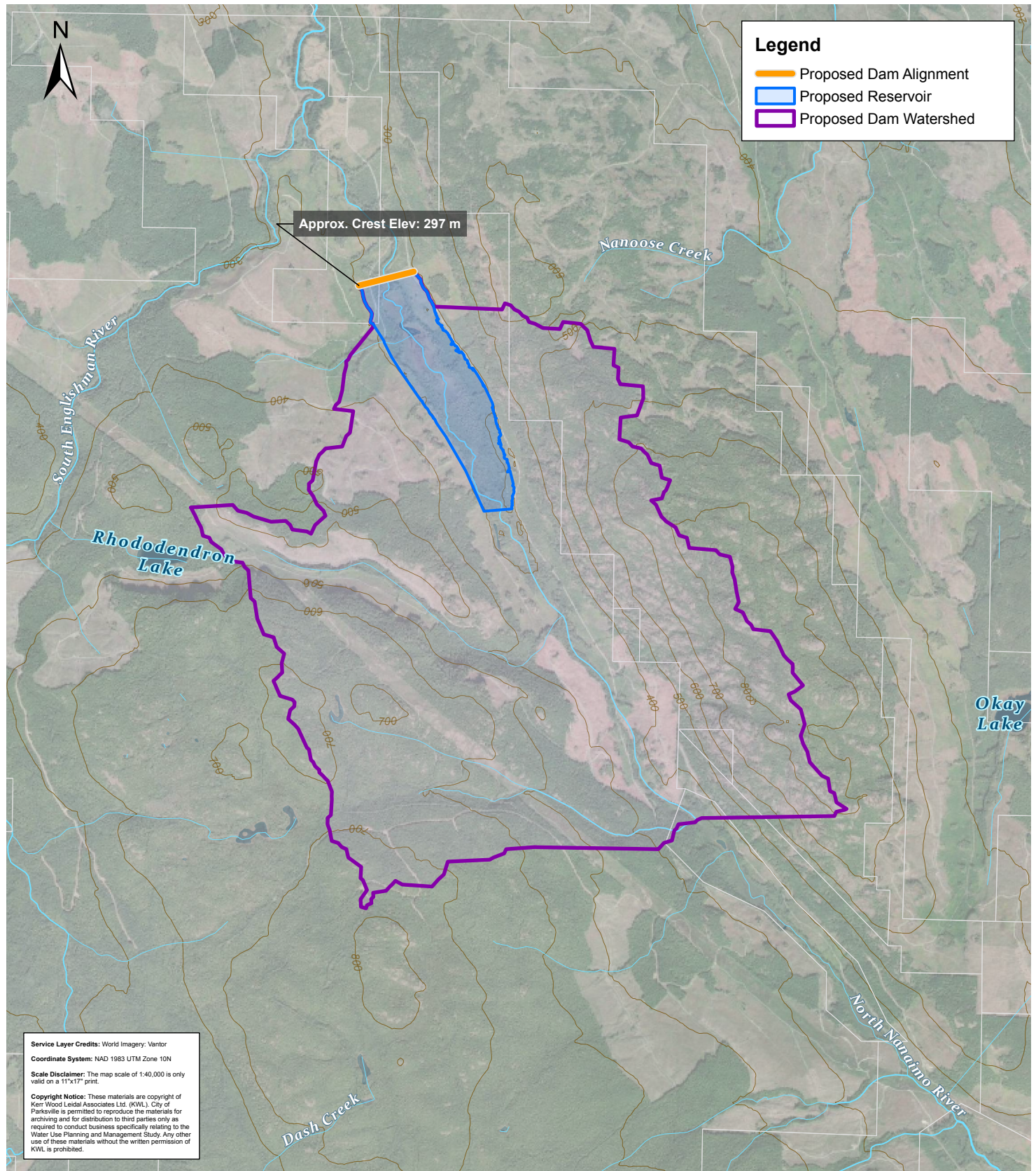
## Surface Water Storage Option - Healey Lake

Figure 7-7



# City of Parksville

## Water Use Planning and Management Study



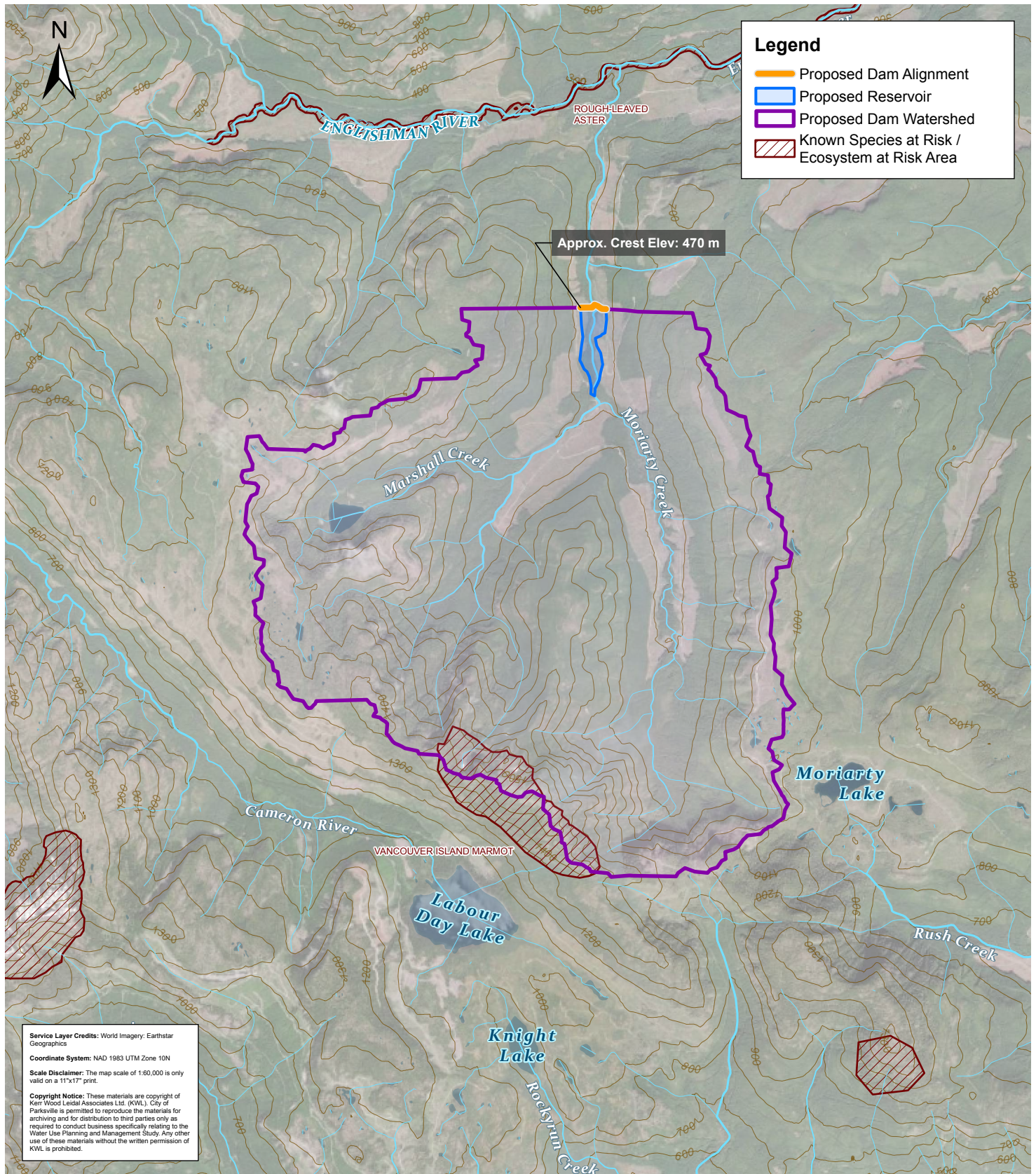
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## Surface Water Storage Option - South Englishman River Tributary

Figure 7-8



# City of Parksville Water Use Planning and Management Study



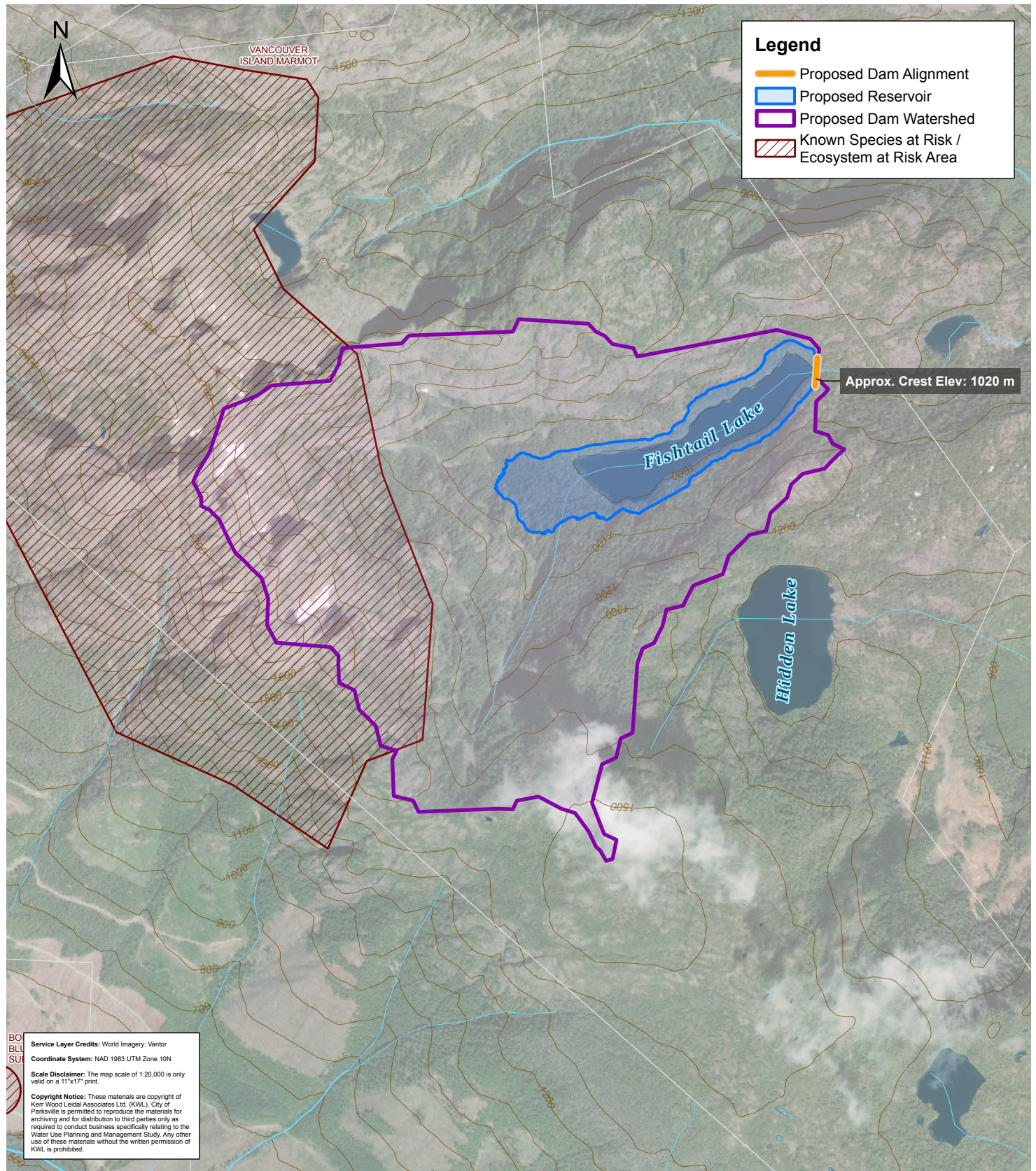
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## Surface Water Storage Option - Moriarty Creek

Figure 7-9



# City of Parksville Water Use Planning and Management Study



Project No. 2248.018

Date June 2026

Scale 1:20,000

0 200 400 800 Metres

## Surface Water Storage Option - Fishtail Lake

Figure 7-10



## Arrowsmith Dam Reservoir Supply Improvements

A detailed review of the potential to improve reliability for Arrowsmith Dam Reservoir was carried out by making use of the current storage below the existing High Level (Gravity) LLO through improving capacity of the Low Level (Siphon) LLO through pumping. As there is no power at the dam currently, this option would require electricity for pumping be supplied either using temporary portable pumps (likely propane powered to reduce risk to water quality) or as part of construction of small hydro-electric facility at the dam, discussed further in Section 8.

This option was analyzed by updating the water balance model by removing hydraulic limitations imposed by the LLO lake level vs outflow relationship. The results of the analysis indicate that under baseline conditions, removing the hydraulic constraint of the lower LLO improves modelled reliability for the baseline period from 70% (21 out of 30 years) to 83% (25 out of 30 years) with a maximum storage deficit of 1.3 Mm<sup>3</sup> assuming community demand is supplemented by current groundwater withdrawal rates.

Alternatively, the storage at Arrowsmith Dam Reservoir could be increased to store an additional 3.3 Mm<sup>3</sup> of water above the siphon level by raising the dam crest by approximately 5 m.

However, the results of the analysis indicate that reliability of water supply is governed by the volume of inflow from the watershed above the reservoir rather than the volume of storage available at Arrowsmith Dam Reservoir. This indicates that upgrades to Arrowsmith Dam Reservoir alone, whether by increasing storage volume or through other improvements, will not meet the target reliability goals. Therefore, further analysis of upgrade options for Arrowsmith Dam were not carried out.

## 7.4 Initial Comparison of Surface Storage Options

A multi-criteria evaluation approach was used for an initial comparison of surface storage options. This approach helps in decision making when there are variables of many types. Unlike a cost-benefit analysis, multi-criteria analysis allows for comparison across variables that are both quantitative as well as qualitative.

The evaluation process involves four steps as outlined in the following sections.

### Step 1 – Initial Screening of Options

As discussed previously, upgrading Arrowsmith Dam Reservoir and alternative storage options would not provide sufficient storage to meet reliability targets. Reliability analysis of the five storage locations confirmed that they do meet the reliability targets and are thus considered in options analysis. The initial analysis only considers each option individually and does not include options where additional storage is provided at multiple locations across the watershed.

### Step 2 – Identify Decision Attributes

Five key attributes were identified for consideration in the decision.

1. Capital Costs
2. Construction Risks
3. Land Impacts
4. Environmental Benefits/Environmental Flow Needs
5. Environmental Impacts/Regulatory Risks

Selection of these attributes should be refined in future phases of work with input from First Nations and stakeholders. For example, additional or alternative decision attributes could be identified and selected which reflect further discussion with First Nations, Provincial and Federal Regulators and local stakeholders.

The following sections describe each of these attributes and how they were evaluated. All attributes are equally weighted and have been calculated on a scale of 1 to 5, with 1 having the most benefit/least risk/lowest costs and 5 having the least benefit/highest risk/most cost.

### **Attribute 1 – Capital Costs**

Capital cost estimates for each of the storage options were prepared. These comparative cost estimates (Class 5) include construction, engineering and environmental approvals, insurance and bonding and a contingency. Dam construction costs were estimated based on estimates of the volumes of embankment fill or concrete multiplied by unit costs from other similar projects. The unit costs are based on total construction costs for dams divided by either the embankment fill volume or the concrete volume and include mobilization and demobilization, clearing, foundation preparation, embankment fill, finish grading, appurtenant structures and instrumentation. A fixed cost was added for spillway construction. For Fishtail Lake, the cost estimate also includes estimated costs for construction of an access road. No cost for land purchase and/or clearing of the reservoir is included for all the options.

A 40% contingency was added to the construction cost while engineering, environmental and insurance/bonding were added to the cost estimate as a percentage of the construction cost including contingency. The cost estimates are based on limited site information and feasibility level design and as such are suitable for options comparison and long-term capital planning. Further refinement of cost estimates will be required as the plans and design are refined. A copy of the cost estimates for each of the sites and assumptions used is included in Appendix H. For scoring, the capital costs for each option are divided by the capital cost for the least cost option and then factored between a value of 1 to 5 with a value of 5 having the highest cost.

### **Attribute 2 – Construction Risks**

Construction risks consider the level of understanding of design constraints and conditions at each of the sites. For example, initial geotechnical site evaluation was carried out for Shelton Lake as part of previous storage analysis. However, the same level of information is not available at the other sites. Another example of construction risk is the requirement for access for Fishtail Lake, requiring construction in steep terrain. For evaluation, construction risks are assigned a value between 1 to 5 based on qualitative judgment of the level of certainty in the feasibility of construction.

### **Attribute 3 – Land Impacts**

All of the sites, except for Fishtail Lake, are located on and would result in inundation of privately owned forest lands. This may result in the loss of productive forest land and wetlands. The additional inundated area for each of the reservoir options was calculated. To evaluate land impacts, the scoring is based on the relative value of the inundated land calculated using assessed land values from BC Assessment. For Forestry Lands, the assessed value is calculated considering access, terrain and productivity but may not be reflective of the market value of the land. The scoring value is the relative calculated value with the lowest value of impacted land having a value of 1, the highest value being assigned a value of 5 and the other values assigned a value between 1 to 5 based on their relative values.

Fishtail Lake is located within the RDN's Mount Arrowsmith Massif Regional Park. Construction of the access road and the dam may have impacts on the park. Some of these impacts may be inundation of park land and riparian habitats at Fishtail Lake as well as improved vehicle access into the park. A detailed review of the potential impacts to the park is outside the scope of this assessment. For Fishtail Lake, the value of the land was calculated using the BC Assessment value for Forestry Lands to provide

consistent land valuation relative to the other options. In this way, the relative potential land impact could be compared to the other options.

#### **Attribute 4 – Environmental Benefits/Environmental Flow Needs**

The sites located in the South Englishman River watershed include an allowance in the storage volume for improved baseflow conditions in the South Englishman River. Therefore, this improvement needs to be considered in the evaluation. Scoring for environmental benefits is based on the total length of river reach with augmented baseflow compared to the length of river reach with augmented baseflow under the current condition. For scoring, the option with the longest reach of augmented base flow is assigned a value of 5 with the shortest reach a value of 1 with the other options distributed between 1 to 5 based on their relative lengths.

#### **Attribute 5 – Environmental Impacts/Regulatory Risks**

Potential negative environmental impacts and associated regulatory risks also need to be considered in decision making. A qualitative score between 1 to 5 was assigned. The key considerations in scoring are the presence of any species at risk or sensitive ecosystems, the potential for species at risk or sensitive ecosystems, and the level of regulatory complexity such as requirements for BC Environmental Assessment.

Figure 7-11 shows the fish habitat distributions and species at risk/ecosystems at risk areas mapped by the province used in evaluating environmental benefits and risks.

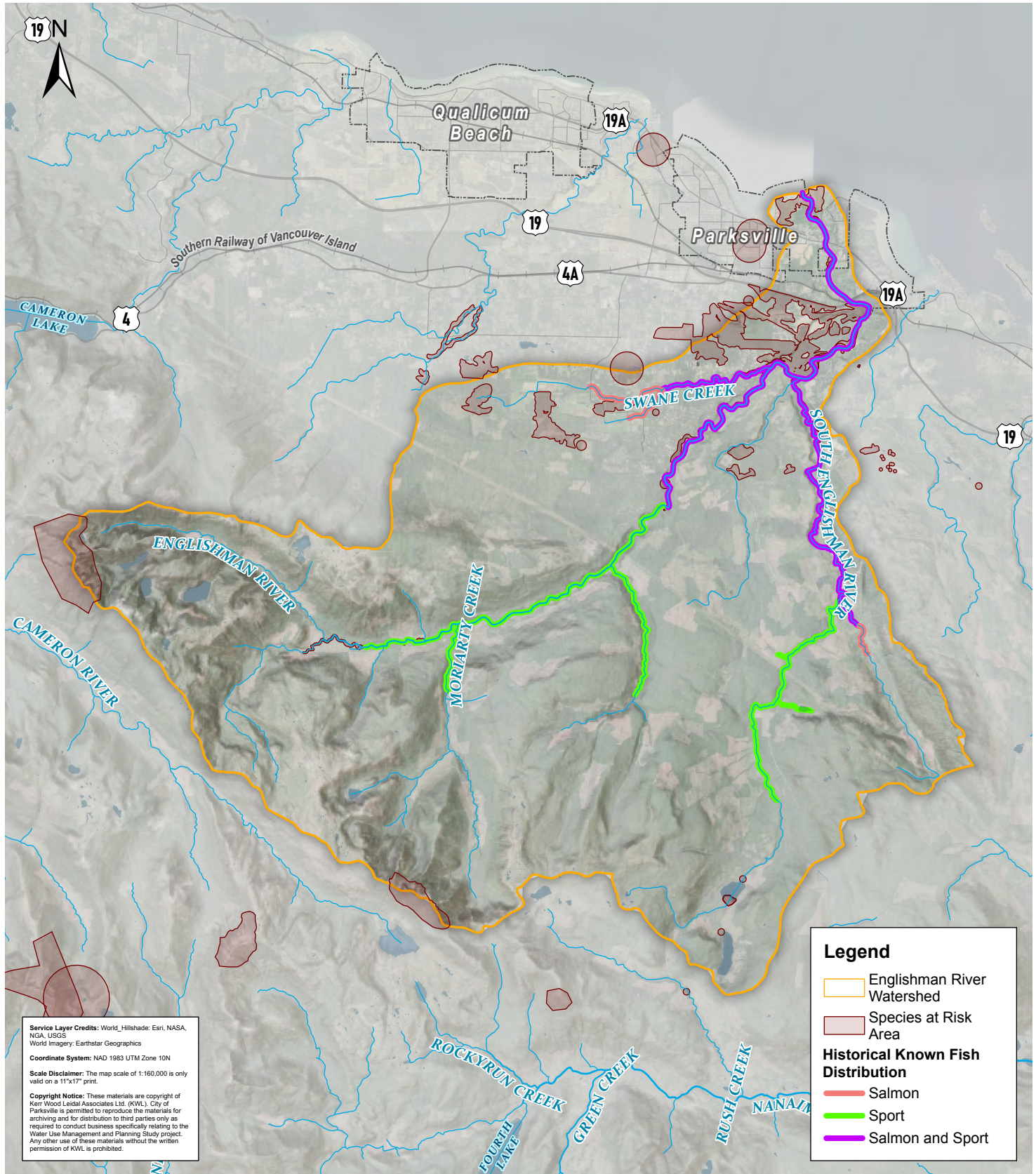


## City of Parksville

### Water Use Planning and Management Study



**KERR WOOD LEIDAL**  
consulting engineers



Project No. 2248.018

Date June 2026

Scale 1:160,000

0 1 2 4 Kilometres

## Englishman River Watershed Habitat Features

Figure 7-11

### **Step 3 – Weighting**

For this initial analysis, no relative weighting was applied. Assigning weighting requires understanding of the relative value or importance of the indices for the City, First Nations and the broader community. An understanding of the relative importance should be incorporated as part of a future structured decision-making process to help select the preferred option.

### **Step 4 – Scoring and Ranking**

The scoring and ranking of the five potential storage locations is summarized in Table 7-5. The table also includes commentary on the rationale for scoring.

## **Summary of Surface Water Storage Options Evaluation**

The initial options analysis indicates that due to the high capital cost, the Moriarty Creek option could be removed from further assessment. However, the remaining four options all have potential benefits and drawbacks with no single option being a clear front runner. Although Healey Lake has the lowest estimated project costs at about half the cost of the other options, other considerations such as environmental and permitting risks associated with species at risk at the site increase the overall indices score and thus the overall rank value is similar to the other projects.

The initial analysis indicates that the South Englishman River Tributary site ranked the highest of the options. However, further investigation of site conditions and environmental field surveys to assess potential for ecosystems at risk or species at risk at the site will be required.

Table 7 5: Surface Water Storage Alternatives Multi-Criteria Options Analysis

| Rank | Name                             | Required Storage Volume (Mm³) | Reservoir Surface Area (ha) | Inundated Land Area <sup>1</sup> (ha) | Capital Cost <sup>2</sup> (Million\$) | Relative Land Value <sup>3</sup> | O&M Cost (\$1,000/ year) | Total Habitat Length (km) | Project Costs | Construction Challenge | Operational Risk | Land Impacts | Environment Benefits/EFN Improvement | Environment Impacts/ Regulatory Risks | Total Ranking Score (Range from 5 to 30) | Comments                                                                                                                                                                                                                                                                            |
|------|----------------------------------|-------------------------------|-----------------------------|---------------------------------------|---------------------------------------|----------------------------------|--------------------------|---------------------------|---------------|------------------------|------------------|--------------|--------------------------------------|---------------------------------------|------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | South Englishman River Tributary | 8.1                           | 80                          | 61.2                                  | \$28.4                                | 0.8                              | \$250                    | 39.7                      | 2.0           | 2                      | 1                | 2.3          | 1                                    | 4                                     | 12.7                                     | Storage will inundate a wetland area and although no species at risk are mapped. There is a high potential for species at risk to be present.                                                                                                                                       |
| 2    | Shelton Lake                     | 7.8                           | 74.5                        | 36.4                                  | \$27.4                                | 0.7                              | \$250                    | 47.6                      | 1.9           | 1                      | 5                | 2.0          | 1                                    | 3                                     | 13.7                                     | Note Provincial ecosystem at risk identified within Healey Lake and high potential for others. There are limits to inflow for this site that limit ability to refill reservoir. Option may not be able to fully support EFN in South Englishman River due to limited inflow.        |
| 3    | Healey Lake                      | 8.2                           | 107                         | 72.5                                  | \$14.2                                | 1.5                              | \$250                    | 47.6                      | 1.0           | 2                      | 1                | 4.4          | 1                                    | 5                                     | 14.4                                     | Note Provincial ecosystem at risk identified within Healey Lake and high potential for others. Provides storage to support EFN in both South Englishman R and Englishman River.                                                                                                     |
| 4    | Fishtail Lake                    | 4.8                           | 31.8                        | 17.5                                  | \$23.8                                | 0.8                              | \$250                    | 28.3                      | 1.7           | 5                      | 2                | 2.4          | 2                                    | 2                                     | 15.0                                     | Assumes no EFN flow release requirements for the tributary between Fishtail and mainstem Englishman River. Construction access/on-going maintenance access is challenging. Located within Arrowsmith Masif Regional Park. Dam > 15 m high will require BC Environmental Assessment. |
| 5    | Moriarity Creek                  | 4.8                           | 86.6                        | 86.6                                  | \$317.5                               | 1.3                              | \$500                    | 28.3                      | 22.4          | 4                      | 3                | 3.9          | 2                                    | 3                                     | 38.3                                     | Moriarty Creek is relatively steep tributary stream to Englishman River without natural lake resulting in large dam to impound storage.                                                                                                                                             |

Notes:

1. Inundated Land area is the additional surface area of proposed reservoir beyond existing natural water body surface area.

2. Capital costs include construction only. They do not include costs to compensate for land value/lost timber harvesting potential.

3. Relative land values are intended to be comparative based on Assessed Land Values for Managed Timberlands. Value shows normalized with the average having a value of 1.0.



## 7.5 Additional Groundwater Potential

Previous analyses on the impact of climate change on long-term groundwater conditions (WSP 2023) have been conducted to understand current and future aquifer stress. The findings show that during the summer dry season, unconsolidated aquifers across the Englishman River watershed (i.e., Aquifers 216 and 209) have very high stress ratings predominantly due to high water withdrawal by municipalities and private users. There are some exceptions, such as Aquifer 1252, Aquifer 221 and Aquifer 219, which have lower stress levels due to lower water usage (WSP, 2023; Golder, 2020).

Bedrock aquifers in the Englishman River watershed (i.e., Aquifers 220, 214 and 212) are generally considered to have lower stress levels (WSP, 2023; Golder, 2020); however, these aquifers are highly variable, having complex flow paths and sources of recharge, assigning one risk rating can be inherently difficult or misleading.

Aquifer 216, which is the source of the City's groundwater supply, was assigned a "very high" stress rating by WSP (2023) indicating that additional groundwater development potential is considered limited and there is the possibility of reduced groundwater availability in the future. Despite this finding, the current groundwater diversion rates appear to be sustainable and could potentially be increased. However, additional modelling is required to confirm whether the rates can be increased to the licence application diversion volume without negative impacts to adjacent users and the aquifer.

### Optimizing Operation of Parksville's Water Supply Wells and Aquifer 216

For continued safe operation of both the Railway Station and Springwood Well Fields, Parksville should continue detailed monitoring of groundwater diversion rates, groundwater levels, and water chemistry from the WSWs. As a monitoring program is already being implemented to provide ongoing assessment of aquifer and well conditions, the data should be reviewed regularly, to determine if well maintenance is needed, confirming that the WSWs are operating efficiently. Enhancements to the current performance monitoring of the Railway Station and Springwood Well Fields include increased frequency for calibration of the SCADA system data, ongoing review of groundwater level and water use data to monitor changes in operational groundwater levels, and increased frequency of water quality sampling and analysis. Historical data has already been compiled and is available for quick comparison with new groundwater level, use and chemistry data, for assessment of well conditions and operations.

As part of efforts to optimize the well performance and obtain a more realistic understanding of well capacities and well interference, Parksville could conduct a series of well tests and maintenance programs in the short- to medium-term. This would include performing step rate pumping tests for individual WSWs to assess well efficiency combined with analysis of the pumping responses using modeling software to review potential well field interference and impacts to adjacent users and other Parksville WSWs as well review as potential well rehabilitation efforts.

Opportunities for enhancing groundwater supply from Aquifer 216 could be undertaken using the RDN's French Creek FEEFLOW 3D groundwater model developed by WSP. Parksville could run a variety of tailored model updates and water use scenarios for Aquifer 216 to get a better understanding of the well field capacities based on suggested improvements and known data gaps in the model.

Model updates would include an improved water budget calculation for Aquifer 216 by verifying groundwater use for domestic, agricultural and other uses based on the licence data and land use tracking. The updated model could inform how the Aquifer 216 stress rating changes for varying groundwater diversion volumes from Parksville's well fields (i.e., 5-year and 10-year averages and the licence application amount) given that the current model is calibrated for the 2021 annual average diversion volume and does not consider the 10-year average diversion volume or the maximum licence



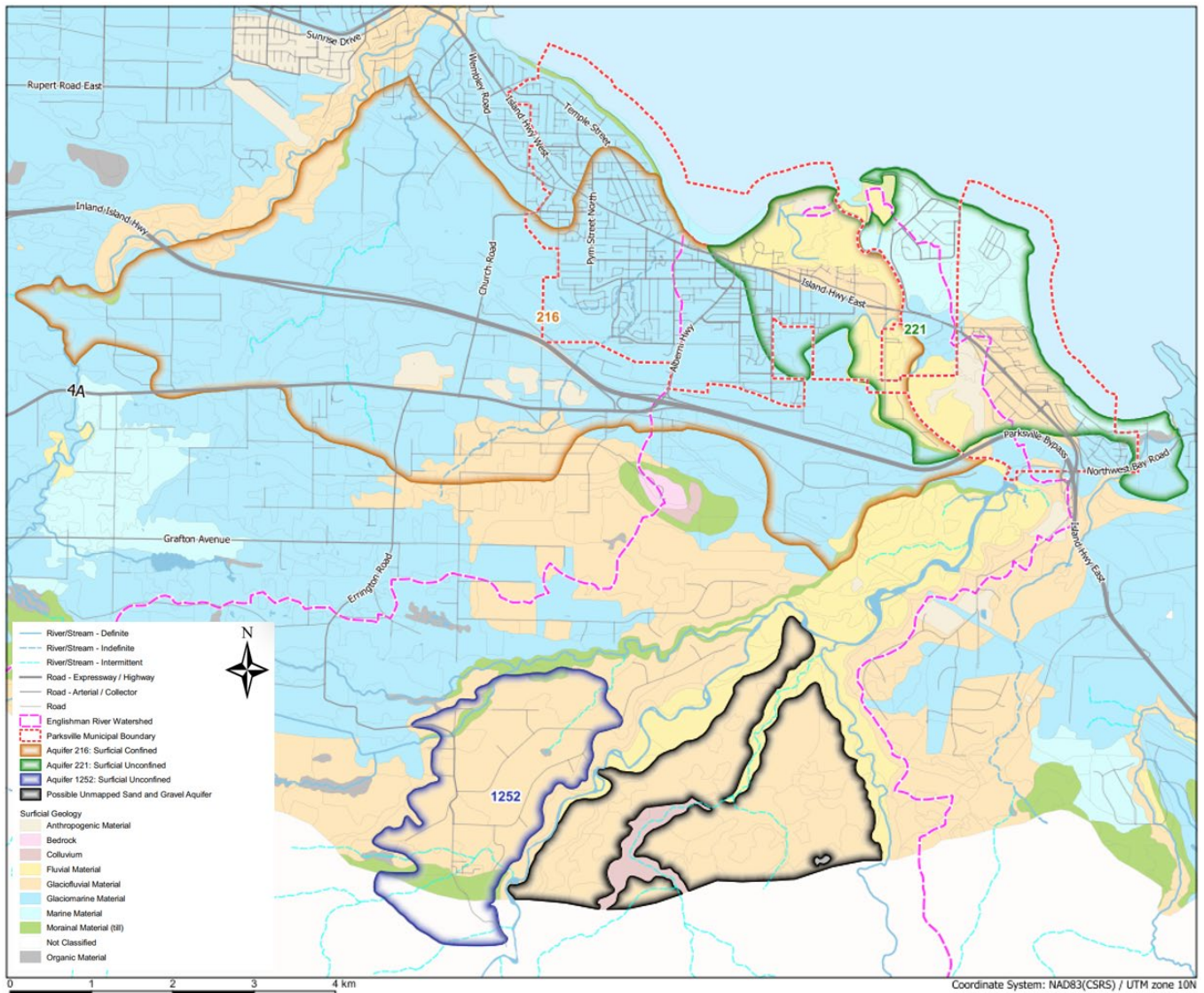
volume. Results from the assessment of aquifer stress would help confirm future reliance on groundwater as a sustainable water supply.

The updated model could also be used to assess how the Aquifer 216 stress rating responds to changes in groundwater diversion by adjacent users and what happens if existing groundwater use is repurposed for municipal water supply or existing users cease operations.

## **New Groundwater Sources in the Englishman River Watershed**

There are several groundwater sources available near Parksville in the Englishman River watershed; however, only groundwater sources with low to moderate aquifer stress ratings and aquifers with reliable productivity should be targeted for new development in the medium-term. Consideration should also be given to unmapped groundwater sources in undeveloped areas. Options for such groundwater sources are highlighted on Figure 7-12 and include:

- Aquifer 221 (unconsolidated, unconfined), within Parksville's municipal boundary.
- Aquifer 1252 (unconsolidated, unconfined), located south of Parksville.
- An unmapped sand and gravel aquifer in the South Englishman River sub-watershed.



**Figure 7-12: New Groundwater Source Options in the Englishman River**

A preliminary source evaluation and ranking by Waterline and is shown in Table 3 of Appendix D.

The evaluation categories include data availability (including all publicly available data), groundwater supply and environmental risk, groundwater quality, infrastructure requirements, and regulatory requirements. Each category was weighted and grades assigned based on how each source met the evaluation category criteria to develop an overall probability score with the highest score representing the best probability for a new groundwater source.

Results of the preliminary evaluation of groundwater source options in the Englishman River watershed indicate the probability of developing the unmapped sand and gravel aquifer in the South Englishman River sub-watershed is “unlikely”. Although the unconsolidated sediment (fluvial and glaciofluvial) has a high groundwater supply potential, low vulnerability from existing development, and groundwater chemistry is considered “fresh”, there are no groundwater wells completed in the immediate area to assess groundwater characteristics or water supply development. The water supply infrastructure requirements needed to connect new WSWs to Parksville’s existing water system would be substantial given the distance to the nearest point of connection. Parksville would also need to invest substantial time and resources towards meeting the necessary regulatory requirements (e.g., multiple different land use authorizations may be required and determination of hydraulic connection with the Englishman River and/or its tributaries would be required).

Groundwater development for Aquifer 221 or Aquifer 1252 is “possible”. Despite some risks related to incomplete modelling, aquifer vulnerability, potential impacts to adjacent groundwater users and probable hydraulic connection with surface water, both aquifers have proven water supply potential. While groundwater source development of either aquifer would require well drilling and testing, a large investment would be needed to connect Aquifer 1252 with Parksville infrastructure. The probability of successfully developing Aquifer 1252 is higher than Aquifer 221, as the perceived regulatory requirements for assessing environmental impacts would be less stringent (e.g., Aquifer 1252 is situated in an area of less land development with less potential for contamination from current land use practices) and the likelihood of obtaining regulatory authorizations could be easier (e.g., licensing for Aquifer 1252 would not involve assessment of potential saltwater intrusion).

Prior to finalizing the groundwater source evaluation to provide a more realistic assessment of groundwater availability there are data gaps to be resolved that include numerical modelling for Aquifer 221 and 1252 to complete the assessment of groundwater-surface water interaction and consider the full aquifer extent. Characterization of the groundwater quality for all three groundwater source options is also needed.

## Summary of Groundwater Source Options

Opportunities to optimize the existing groundwater supply and new source development as discussed above, are summarized in Waterline’s Groundwater Supply Execution Plan provided in Table 4 of Appendix D. Details for execution, timelines and costs (Class D) are also provided.

The key recommendations for the Parksville’s existing well performance monitoring program include:

- Measuring manual groundwater levels at each WSW (e.g., semi-annually) to calibrate Parksville’s SCADA system data.
- Collecting groundwater samples from active WSWs at a greater frequency (e.g., semi-annual sampling) to better understand seasonal changes in water quality and identify changes in well condition (e.g., well fouling).

In addition, there are opportunities to optimize the groundwater supply and initiate updates to the groundwater modelling for Aquifer 216 to verify current and future use predictions.

For the new source development the following tasks are identified:

- To better predict stress for Aquifer 221 and Aquifer 1252, the Leapfrog geology model, which is the basis for the groundwater numerical models, will need to be updated. Model calibration and sensitivity analysis are required.
- To assess the groundwater quality of Aquifer 221, Aquifer 1252 and the Unmapped Sand and Gravel Aquifer in the South Englishman River Sub-watershed, three water quality samples should be collected from each groundwater source. If sample collection points (wells) are unavailable, analogue well locations can be selected.
- Drilling and testing a new well will be required for assessment of aquifer characteristics and determination of well capacity.
- Authorizations for groundwater use may need to be obtained from multiple levels of government (local, provincial, federal) and from private landowners. Technical assessment(s) will be required to support the Water Sustainability Act water licensing process.
- Designing, permitting and constructing water system infrastructure to connect new WSW(s) to Parksville's current water distribution system would be multi-disciplinary.

Parksville should also assess if ongoing groundwater supply investigations by the RDN near the Englishman River watershed (e.g., aquifer storage and recovery in Nanoose) can be beneficial to the community water supply.

## 7.6 Watershed Management Considerations

A majority of the land base across the Englishman River lies within privately owned forestry lands with a smaller proportion of rural residential and agricultural lands in the lower watershed. Activities on these lands do have potential to increase risk to both water quantity and water quality in the Englishman River.

Activities in the watershed are regulated to limit risks to water quantity and water quality through a range of federal and provincial acts including:

- Federal Fisheries Act
- Water Sustainability Act
- Drinking Water Protection Act

These acts provide federal and provincial government ability to manage and permit a broad range of activities as they relate to water. However, these acts and regulations do not necessarily take into account specific local concerns or help identify areas or activities that may be at higher risk.

Water utilities, such as the City and AWS, do not have jurisdiction to govern land use and activities in the source watershed. However, there are opportunities to influence land use decisions and stewardship by industry and society in the watershed through on-going engagement. It is most often through community led discussions with a broad range of interests where opportunities to limit risks to water quantity and water quality are identified and where partnerships are formed to help address them.

The RDNs Drinking Water and Watershed Protection Program (DWWPP) is a regional service that helps the community protect the region's water resources. At its core, the DWWPP provides a venue for community led collaboration to learn more about water in the region, use this information to improve land use decisions and help communities protect the environment.



The City and AWS should consider leveraging RDN's DWWPP to help meet specific watershed protection needs in the Englishman River as they relate to community water supply and EFN, this includes:

- Robust monitoring, analysis, and communication of source water quality trends in the Englishman River upstream of the raw water intake and for Aquifer 216.
- Increase collaboration with forest industry/Mosaic, Province, First Nations, land trust NGOs, agriculture to reduce source water risks and achieve synergy.
- Continue to improve water information in the watershed to support science-based decision making and to improve awareness and communication of water and watershed related issues.
- Enable more water-centric planning and policy in land management.

### **Groundwater to Surface Water Interaction**

Protecting and enhancing wetlands and the riparian areas within the Englishman River Watershed would provide benefits in terms of ecological function for the watershed to protect water quality, habitat and shallow groundwater recharge to maintain baseflows. A ground water-surface water interaction study of the Englishman River was completed by GW Solutions in 2012. This study characterized ground water aquifers along the Englishman River and quantified the flux between groundwater and the Englishman River during summer low flow periods. At the time, GW solutions concluded that about 30% of the summer baseflow on average, assumed to be 1.0 m<sup>3</sup>/s, in the Englishman River is supplied through groundwater along the lower 16 km of the river channel. A follow up study by GW Solutions in 2012 concluded that an additional 50% of baseflow on average was expected to be flowing from bedrock aquifers in the upper reaches of the river.

The baseflow estimates by GW Solutions compares with our estimate for an extreme dry year of about 46% of the 1.0 m<sup>3</sup>/s EFN being supplied by baseflow in the Englishman River with the remaining coming from flow releases from Arrowsmith Dam. These results show the importance of maintaining groundwater flow into the Englishman River during low flow periods and how protection or enhancement of groundwater would add resilience to any future water supply to improve or maintain reliability of the system under future climate change conditions.

## **7.7 Intake and Water Treatment System Improvements**

Although the existing ERWS Intake and WTP system have capacity for current water demands, there are limitations on providing future water demands without system improvements. Timing for implementation of improvements depends on whether groundwater use can be increased and how successful new water demand management programs are.

At present the ERWS capacity is limited by the Raw Water Pump Station (19 MLD), WTP (16 MLD) and High Lift Pump Station (19 MLD). The Intake Screen and Weir (48 MLD) and Raw Water Supply Main to the WTP (48 MLD) will not constrain water supply capacity in the foreseeable future.

Under the status quo scenario, the WTP may need to be upgraded by 2037 if the water demand is close to the high forecast uncertainty margin. Furthermore, the Raw Water Pump Station and High Lift Pump Station would need to be upgraded by 2043.

Cost estimates to upgrade the WTP and raw water pump station were prepared based on the final pre-design report cost estimates (CH2M HILL, 2014) as well as the earlier concept planning report (AE, 2011) inflated to 2025 dollars using BC Stats Consumer Price Index. These costs are indicative only and further analysis is needed to refine the estimates based on actual existing infrastructure and proposed upgrades.

**Table 7-6: ERWS Facility Improvements**

| Facility               | Nominal Existing Capacity (MLD) | Ultimate Expanded Capacity Needed for Status Quo Scenario (MLD) | Initial Upgrade Year (status quo) | Project Cost (millions) | Source                                                                   |
|------------------------|---------------------------------|-----------------------------------------------------------------|-----------------------------------|-------------------------|--------------------------------------------------------------------------|
| Water Treatment Plant  | 16                              | 29.7                                                            | 2037                              | \$5.5                   | Cost based on original Phase 2 (2035 - 2050) WTP upgrade in \$2025       |
| Raw Water Pump Station | 19                              | 29.7                                                            | 2043                              | \$1.6                   | Cost based on approx. 56% of raw water pump station total cost in \$2025 |
| High Lift Pump Station | 19                              | 29.7                                                            | 2043                              | \$1.6                   | Assumed to be same at raw water pump station costs                       |

Note: Cost inflation based on CPI index for BC

## 7.8 Transmission System Improvements

As shown in Table 6-4 the existing ERWS Transmission System components have sufficient capacity for the future demand estimates.

## 7.9 Future Water System Recommendations

An initial review and evaluation of potential water supply sources within the Englishman River watershed that will increase the overall water system reliability and meet future water demands was completed. Review of existing and new groundwater sources as well as optimization potential of the current well systems was also undertaken. Initial recommendations for timing of the WTP and transmission system capacity upgrades to meet future demands under the status quo scenario are also provided.

The initial multi-criteria analysis indicates that a new dam and reservoir on the South Englishman Tributary is the top ranked option; however, there are three other surface water storage options (Shelton Lake, Healy Lake and Fishtail Lake) that appear to be viable. Although there are potential improvements that can be made at Arrowsmith Dam to optimize the current reservoir and access to the lower storage volume, there is not enough inflow from the watershed to warrant increasing the storage in attempts to meet the target reliability goals. In addition, a potential storage site at Moriarty Creek was assessed and deemed not feasible due to significantly higher construction cost than the other sites given there is no natural lake on the creek at present.

Ultimately, further assessment is needed for each of the four surface water storage options to better quantify the risks associated with environmental impacts, construction challenges, operational requirements and land costs. Once further site assessment is completed, a structured decision-making process is proposed to determine the relative value or importance of the criteria for the City, First Nations and the broader community in efforts to refine the recommendations on how best to proceed.

In conjunction with a new surface water supply, it is recommended that the City further assesses how best to optimize the performance of the existing groundwater diversion rates within the current licence amounts for wells drawing on Aquifer 216. Prior hydrogeological modelling studies have indicated that

Aquifer 216 is already deemed to be under “high stress” such that additional groundwater modelling is needed to review any operational changes and refine the model assumptions. Ideally, groundwater pumping rates could be increased during the operating period to alleviate the reliance on surface water during the summer months; however, pumping rates would need to be increased gradually and drawdown would need to be monitored carefully on all wells to ensure the aquifer remains stable.

Further investigation of new groundwater sources is also recommended with the focus on Aquifer 221, Aquifer 1252 and the Unmapped Sand and Gravel Aquifer in the South Englishman River Sub-watershed. There are challenges associated with each option that include well development potential, groundwater quality, aquifer stress, infrastructure needed for connectivity to the distribution network and permitting/authorization to use the water.

As for the ERWS WTP, intake and transmission system infrastructure, the existing system hydraulic capacity is limited by the Raw Water Pump Station, WTP and High Lift Pump Station which all require increased capacity in the future to accommodate water demands under the status quo scenario.

## 8. Water Conservation and Demand Management

### 8.1 Introduction

Water conservation and demand management are important tools for managing water demands to address constraints in water supply in the region. As demonstrated in Section 7, the reliability of existing groundwater and surface water sources is relatively low, especially during peak summer periods when water demand is highest.

Climate change is expected to increase the frequency and severity of seasonal and long-term droughts, placing additional stress on both drinking water supplies and the environmental river flows. The City has implemented the highest level of water restrictions (Stage 4) four times in the past five years (from 2021 - 2025). These restrictions reflect the increasing frequency and severity of drought conditions and the limited capacity of the water system. Reducing water waste and managing peak demand through water conservation and demand management can play a role in extending the life of existing infrastructure, deferring costly capital upgrades, and maintaining aquatic ecosystems in local watersheds.

### 8.2 Background

The City's conservation planning is integrated into various municipal strategies, including the Official Community Plan and the Parks, Trails, and Open Space Master Plan. These plans emphasize the importance of preserving natural resources, promoting sustainable practices, and enhancing community awareness about water conservation. The City's water conservation programs are overseen by the Utilities Division of the City's Operations Department. This department is responsible for implementing and enforcing water conservation measures. This includes monitoring water usage, identifying high users, issuing special watering permits, and ensuring compliance with the conservation bylaw.

The City collaborates with RDN to align conservation efforts for the Englishman River and Nanoose Bay Water Service Areas and share resources. This partnership allows for shared resources and consistent messaging across jurisdictions.

A key initiative is the Drinking Water and Watershed Protection (DWWP) Action Plan, a service of the RDN. The DWWP service was established following expression of public support by referendum in 2008 the program launched in 2009 to address the need for better water information to inform local decisions and the need to coordinate across jurisdictions. Parksville joined the service in 2011 with the updated to RDN Bylaw 1556 that saw a parcel tax request contribution from all RFDN member municipalities as well as Electoral Areas. This made the RDN the first regional district in British Columbia to establish a dedicated service focused on protecting water at the watershed scale. The original plan outlined objectives such as increasing public awareness of water resources, supporting education, enhancing monitoring and scientific research, and informing policy and planning.

The updated DWWP Action Plan 2.0 (2020 - 2030) builds on the original framework and includes a range of conservation-related actions. These include public outreach on water use efficiency, support for innovative water policy, community-based engagement, rebate programs. The Action Plan includes extensive community-engaged watershed monitoring programs, including the surface water quality assessments through the Community Watershed Morning Network, and groundwater level seasonal reporting and long-term trends through the Volunteer Observation Well Network.



In parallel, the RDN commissioned the Water Conservation Plan (WCP) in 2013, to assess trends in demand and non-revenue water across its nine WSAs. The plan set two key targets:

1. Reduce average residential water use by 33% between 2004 and 2018.
2. Maintain maximum monthly water production at or below 2004 levels until 2018.

A 2018 assessment found that average daily use per connection had steadily declined from 2004 to 2017, and that maximum monthly production remained below the 2004 benchmark from 2011 to 2017. Building on this progress, the 2020 - 2030 WCP introduced a renewed suite of measures, data-driven targets, and implementation strategies. Its goals include:

- Reducing per capita water consumption year-round.
- Lowering peak summer water demand to improve drought resilience.
- Supporting WSAs and residents with above-average water use.
- Improving understanding and management of non-revenue water.
- Supporting RDN's asset management program.
- Fostering a water stewardship ethic.

Actions are organized around five themes:

1. **Reduce Outdoor Water Use:** enhanced incentives and regulations to reduce irrigation
2. **Commercial, Institutional and Multi-Family Pilot Project:** support non-residential customers in managing water use.
3. **Review Water Service Rates to Optimize Conservation-Oriented:** ensure rate structures promote conservation.
4. **Improve Water Use Accounting and Management of Non-Revenue Water:** strengthen data and reduce system losses.
5. **Continue Team WaterSmart Outreach Implementation:** promote indoor efficiency, youth education, and stewardship.

The 2020 WCP also prescribes specific percentage-based reduction targets for residential consumption, peak season demand, and non-revenue water that the RDN would work towards. These were selected based on the RDN WSAs trajectory and comparable provincial, national, and global benchmarks. The 2020 WCP builds on the Team WaterSmart program, the 2013 WCP, and the DWWP framework. It emphasizes helping residents use water more efficiently and equipping the RDN to make informed decisions about water management.

The 2020 WCP identifies the following targets:

#### Target 1: Residential Consumption

- Reduce average day single family residential consumption by 15% to 275 L/ca/day by 2030, benchmarked against 323 LCD in 2018/19.

#### Target 2: Peak Season Demand

- Maintain maximum month average day total water production at or below the July 2018 daily average.

### Target 3: Non-Revenue Water

- Quantified target to be established as an early implementation priority. A water audit was to be completed in 2020.

These targets apply to the nine RDN WSAs, which includes Nanoose Bay Peninsula WSA. While the City would not be included in these targets, they are aligned with the recommendations in this Study.

## 8.3 Current Initiatives

The City and RDN coordinate water conservation efforts through a regional partnership framework that ensures conservation levels are tailored to the specific needs of the region while also supporting environmental flow needs. The water conservation framework was established by consensus between regional water purveyors so everyone could see themselves and their systems' unique requirements in the framework. Its purpose is to provide a communication approach to reduce confusion among residents about watering restriction stages. The framework is updated periodically based on changing needs and input from all participating water purveyors.

Current water conservation efforts are focused on managing outdoor demand through seasonal irrigation restrictions and public education. These current programs include measures evaluated in this section such as rebates for irrigation efficiency upgrades and soil amendments. Full details of these initiatives are provided in Appendix F.

## 8.4 Recommended Demand Management Strategies

The following section outlines the new and ongoing activities proposed to meet the City's water demand management objectives, with a focus on managing peak demands. The measures place strong emphasis on the highest water users, management of seasonal demand, and water use efficiency improvements in the municipal and ICI sectors. While the measures discussed in this section focus on Parksville, the analysis and recommendations are also generally applicable to Nanoose Bay.

The forecasted water savings will be used to explore whether and how demand management measures could play a role in water system planning in terms of delaying, or even reducing the need for, infrastructure investment.

The region's water system is under increasing pressure from community growth, aging infrastructure, and relatively low water supply reliability exacerbated by climate change. With at least a 50% annual probability of implementing Stage 3 or 4 water restrictions, the City would benefit greatly from improving system reliability and reducing discretionary water use, particularly during the summer peak. The reliability of the surface water source (Englishman River) is almost entirely governed by environmental flow needs which are largely out of the City's control. However, effective water demand management in combination with effective use of groundwater has the potential to reduce the impacts of low surface water source reliability until it can be improved through a major capital project or through other means.

Effective demand management also strengthens the City's and RDN's negotiating position with senior government to limit the hardship experienced during drought conditions. A strong track record of effective stewardship of water resources will also likely aid the City and RDN in obtaining regulatory approvals for a major project to increase surface water supply capacity.

Water demand management strategies will be based on the following approaches:

- Introducing audit/technical support programs focused on high users and seasonal use.
- Expanding program availability beyond the single-family residential (SFR) sector.

- Using data to both recruit participants and monitor program effectiveness.
- Using pilots to test methods and refine approaches based on quantitative results.
- Expanding outreach and education to both specific user groups and across the service area.
- Introducing two-way communication with customers, providing more opportunities for residents to engage in conversations about water conservation, ask questions, and provide feedback.

To address both operational efficiency and customer-side conservation, the proposed programs are organized into two categories:

1. **Management Measures:** Operational measures that improve the City's ability to manage water effectively, such as rate reform, metering upgrades, and better management of municipal irrigation systems.
2. **Targeted Demand Reduction:** Programs that directly engage high-use customers and outdoor water users to reduce consumption through audits, education, and behavioral change.

This structure ensures that the City strengthens its internal management systems while also addressing the most significant and discretionary areas of demand.

## Management Measures

These management measures are foundational actions which focus on improving how the City manages its own water system from pricing and metering to municipal irrigation and are essential to enabling long-term conservation success.

### Rate Reform

Parksville currently uses an inclining block rate structure; however, the fifth-tier declines in unit price, which sends a counterproductive pricing signal to the highest water users. In addition, the sewer rate structure includes a high fixed fee that covers up to 100 m<sup>3</sup>, with only a modest volumetric charge beyond that.

Together, these structures do not encourage water conservation because they reduce the marginal cost of high water use. Further, the rate structure disproportionately impacts lower-use customers who may be subsidizing the highest users, and fails to reflect the true cost of high peak demands which cause the greatest system stress.

A reformed rate structure should consider these revisions:

- Eliminate the fifth tier.
- Reinforce the price signal in the upper tiers to reflect the true cost of peak demand and discretionary use.
- Introduce fully volumetric sewer rates, or at minimum, reduce the fixed portion and increase the variable component.
- Ensure that both water and sewer pricing structures support equity, conservation, and long-term financial sustainability.

These changes will align the City's pricing with best practices in water demand management and provide a stronger foundation for future conservation programs.

## AMI Business Case

Parksville's current metering system is fully built out but limited by infrequent meter reads of typically only twice per year. This low read rate restricts the City's ability to manage system loss, detect leaks, understand usage patterns, and engage with customers in a timely and meaningful way. As meters reach the end of their service life, Parksville has a strategic opportunity to begin transitioning to Automated Meter Infrastructure (AMI).

Recommended actions for implementation of an AMI program are as follows.

- Undertake a formal business case analysis for AMI, including:
  - A cost-benefit assessment of full vs. partial deployment.
  - Evaluation of meter and communication technologies.
  - Assessment of data management and staffing needs.
  - Evaluation of optional leak detection capabilities including acoustic and other sensors on some Meter endpoints.
  - Review of funding options and grant eligibility.
- Install AMI-ready meters as part of the regular meter replacement cycle.
- Ensure that all new construction is AMI ready.
- Develop a phased AMI implementation plan, including:
  - Back-end system upgrades (e.g., billing, data analytics).
  - Communications infrastructure (e.g., fixed network or cellular).
  - Staff training and customer engagement strategies.

Benefits for customers include:

- **Early leak detection:** Customers can be alerted to continuous flow or abnormal usage within days, not months.
- **Usage transparency:** Hourly or daily data allows customers to track their own consumption, set alerts and adjust behavior.
- **Improved billing accuracy:** Reduces estimated bills and billing disputes.
- **Empowered conservation:** Real-time feedback supports voluntary reductions and participation in incentive programs.

Utility-side benefits of the program include:

- **Leak detection and system loss reduction:** High-resolution data helps identify leaks in both customer plumbing and City infrastructure.
- **Targeted communication:** Enables automated, proactive outreach to high users, seasonal irrigators, or accounts with unusual patterns.
- **Improved planning:** Supports demand forecasting, peak demand analysis, asset management and infrastructure sizing.



- **Enforcement of watering restrictions:** Hourly data can be used to verify compliance with time-of-day or day-of-week watering rules.
- **Operational efficiency:** Reduces staff time spent on manual reads, re-reads, leak alerting, and billing corrections.

AMI deployment can be phased over 5 - 10 years, starting with municipal accounts, high-use ICI, and MFR accounts; followed by areas known to have high leakage or minimum overnight flow rates; and new developments where AMI-ready meters can be installed from the outset. Back-end accounting and administrative systems (billing, customer portal, analytics) should be scoped and budgeted early to avoid delays once meter data becomes available.

This phased approach to AMI deployment will improve operational efficiency and provide the data needed to support targeted conservation programs.

### Water loss Control

The City currently responds to reported system leaks on a reactive basis. While this may help maintain losses within a manageable range, there is significant potential to expand and systematize this work with the objective of reducing water loss.

The program could explore the use of acoustic monitoring, pressure management and district metered areas (DMAs) to isolate and monitor specific parts of the system. These tools are particularly effective in identifying slow leaks and reducing background losses.

Based on industry benchmarks, proactive leak detection and repair can reduce real losses by 10 - 30%, depending on system condition and response time. For the City, this could translate to savings of at least 30 ML per year, along with improved service reliability and reduced risk of infrastructure failure.

To strengthen water loss management, the following actions are recommended:

- Incorporating water loss reduction targets into the Asset Management Plan and prioritizing renewal of high-risk infrastructure.
- Improving accounting by conducting an AWWA M36 water audit and potentially conducting a night flow analysis and adding additional system metering as needed.
- Evaluating the feasibility of DMAs or pressure zones to isolate and monitor high-loss zones.
- Acoustic surveys of high-risk zones every 2 years, prioritized based on DMA night flow analysis, pipe age, material, and break history, with consideration of transitioning to a fixed acoustic monitoring network integrated with AMI for continuous leak detection.
- Integration of leak detection data with the City's GIS and asset management systems.
- Development of a leak response protocol, including prioritization criteria and repair timelines.
- Assessing the potential for AMI to support real-time loss detection and pressure optimization.

Reducing water loss is one of the most effective conservation strategies available and an opportunity for the City to demonstrate shared responsibility for water conservation with its customers – i.e., ensuring that municipal systems are efficient and well-managed as residents are asked to conserve. Continued investment in monitoring, detection, and renewal will support both financial sustainability and source protection.

## **Estimated Results of New Water Management Measures**

Annual water savings for the proposed water management measures after 10 years is estimated to be 60 ML/year (3% of total water supply flow) with contributions as follows:

- 30 ML/year reduction in non-revenue water (10% of non-revenue, 1.5% of total) resulting from improved water loss detection with AMI network, water system audits, and targeted loss reduction efforts.
- 20 ML/year reduction in residential base demand (1% of total) resulting from improved leak notification and response.
- 10 ML/year reduction in residential seasonal demand (1.5% of seasonal demand, 0.5% of total) resulting from a more conservation-oriented water rate scale (including elimination of declining top rate block).

The total estimated cost for the water management enhancement program over 10 years is \$1 M (\$0.1 M/year).

## **Targeted Demand Reduction**

While residential water use in the City is already relatively efficient – with a base demand of 156 L/capita/day, lower than many other Island communities – the City’s overall demand profile is heavily influenced by non-residential and seasonal outdoor use, with consumption in the summer months more than double that of the winter. The residential sector accounts for a smaller share of total demand than in comparable communities, and most single-family homes are already performing well. In contrast, the ICI sector and municipal irrigation represent significant opportunities for targeted water use reductions.

Outdoor irrigation is the most discretionary and variable component of demand. Much of this is concentrated in:

- Large resorts and recreational properties with expansive lawns and landscaping.
- Commercial strips where irrigation practices vary widely.
- City-owned properties such as the waterpark, Parksville Community Park, and skatepark – all among the highest seasonal users.

In addition, some municipal and ICI properties show signs of leakage or inefficient systems, such as sports fields with unusually low base use. The top 20 ICI accounts represent 15% of total demand and nearly half of ICI seasonal use, yet meters are only read twice per year, which limits the City’s ability to detect issues or engage with users.

To address these challenges, the City could implement a suite of targeted irrigation programs and a dedicated ICI water management strategy, supported by improved metering, data analysis, and pricing signals. These programs are designed to reduce peak water demand, improve system reliability, and ensure that the City leads by example.

## Municipal Landscape and Irrigation Asset Renewal and Efficiency Improvements

Municipal irrigation is one of the most visible and controllable components of the City's water demand. The City's own properties, including the waterpark, Parksville Community Park, and irrigated lawn area at the skate park, are among the highest seasonal users in the system. Collectively, City-managed irrigated parkland is estimated to cover an area of about 15 ha and use approximately 82,000 m<sup>3</sup>/year, and in some cases, the City appears to be using three times more water per acre than necessary based on first principles review of watering requirements and weather.

Implementing municipal landscape and irrigation asset renewal and efficiency improvements presents both a challenge and an opportunity. Some considerations for implementation include:

- **Leadership by example:** As with leadership in leakage reduction, by improving its own irrigation practices, the City can significantly reduce demand while also setting the standard for the community.

Residents and businesses are more likely to adopt conservation practices when they see the City doing the same.

- **Public visibility:** Parks and civic spaces are high-profile areas where efficient irrigation can demonstrate best practices.
- **Quantifiable savings:** Reducing municipal irrigation to efficient benchmarks could reduce use by about one-third after 10 years or roughly 30 ML/year equivalent to the entire seasonal demand of some ICI properties.

A ten-year program of prioritized parks landscape and irrigation asset renewal that could be undertaken would include the following components. Estimated costs and water savings are provided.

1. Complete an efficiency review and asset renewal plan for an estimated cost of \$0.2 M.
2. Undertake asset renewal to replace aging irrigation infrastructure and upgrades to meet modern irrigation standards:
  - a. Estimated cost of \$0.4 M/ha for irrigation renewal.
  - b. Target 1 ha/year of irrigation renewal saving 2 ML/year (200 mm/yr of irrigation).
3. Initiate landscape transformation to replace high-water-use turf with climate appropriate alternatives where feasible:
  - a. Estimated cost of \$4 M/ha on average for landscape transformation.
  - b. Target 0.25 ha/year landscape transformation saving 1 ML/yr (400 mm/yr of irrigation).
4. Benchmark and monitor water use per hectare across all City properties to identify outliers and inefficiencies as well as track progress over time.
5. Pilot and showcase efficient landscaping and irrigation practices in Parksville Community Park and other high-traffic civic spaces.
6. Train City staff in irrigation best practices for seasonal scheduling adjustments, monitoring of soil moisture, and leak detection and repair.

## Estimated Results for Municipal Landscape Improvements

Broader benefits that can be realized from the landscape and irrigation improvements include:

- **Supporting enforcement:** Demonstrating compliance with watering restrictions builds credibility when enforcing them among residents.
- **Improving system reliability:** Reducing peak municipal demand frees up capacity during critical summer periods.
- **Building internal capacity:** City staff gain hands-on experience with technologies and practices that can inform broader conservation programs.

Municipal irrigation is not just a demand management measure; it is a leadership opportunity. By improving its own practices, the City can reduce demand, improve reliability, and inspire the community to follow suit.

The estimated water savings and program costs over 10 years as well as an estimate of the park irrigation system asset renewal include:

- Annual water savings after 10 years of 30 ML/year
- Total cost \$14.2 M (\$1.4 M/year)
- Assets renewed for 12.5 ha of irrigated parkland (83% of estimated total)

## Outdoor Water Use Measures

The measures discussed in this section are intended to complement and build on initiatives that are covered by the DWWP service. DWWP offers residential irrigation check-ups to high water users across the region, runs periodic campaigns of targeted mail-outs to these residential high-water users (that include information on "WaterSmart gardening and irrigation practices), develops seasonal campaigns under the regional "Team WaterSmart" brand, and provides an extensive program of water stewardship rebates that include irrigation and soil improvements, rainwater harvesting systems.

### Single-Family Residential (SFR) Irrigation Reduction Program

While the City's residential water use is relatively efficient overall, it still accounts for 73% of seasonal use and there is a subset of high-use households that drive a disproportionate share of seasonal demand. In 2024, 59 residential accounts reached the top tier of water use, and 46 of these were single-family homes. These properties are likely to have large, irrigated landscapes, automatic sprinkler systems, and limited awareness of efficient watering practices.

This proposed irrigation reduction program is designed to target the highest residential users, particularly those with seasonal irrigation peaks, and provide them with the tools, information, and incentives to reduce outdoor water use.

The program objectives include reducing peak summer demand from high-use SFR properties, promoting efficient irrigation practices and landscaping choices; and building awareness of the City's conservation goals and watering regulations.



To achieve the SFR irrigation program goals the following actions are recommended.

1. Targeted Outreach and Engagement:
  - a. Use meter data to identify top-tier residential users, especially those with sharp summer increases.
  - b. Send personalized communications offering free irrigation assessments, tips on efficient watering schedules and system maintenance, and information on available rebates or incentives.
2. Irrigation Assessments and Rebates:
  - a. Offer on-site irrigation assessments for high-use properties, focusing on irrigation controller settings and scheduling, system leaks or overspray, and landscape type and soil conditions.
  - b. Provide rebates for smart irrigation controllers, drip irrigation systems, and turf replacement with drought-tolerant landscaping.
3. Education and Behavior Change:
  - a. Deliver seasonal campaigns focused on “watering smarter” (i.e. early morning or evening only 1 - 2 times per week), understanding the City’s watering restrictions and the benefits of planting native and low-water-use plants.
  - b. Highlight success stories from local residents who have reduced their use.
4. Compliance and Monitoring:
  - a. Use more frequent meter reads (or AMI data, as it becomes available) to monitor high-use accounts during restriction periods, support enforcement of watering regulations, and provide feedback to participants on their progress.

A 15 - 25% reduction in outdoor use is achievable among top-tier SFR accounts through improved scheduling, system upgrades, and landscape changes. These savings help reduce peak day demand and delay the need for more restrictive measures.

### **Watering Restrictions Review**

The City’s current watering restrictions are a key tool for managing water peak demand but may not be fully aligned with best practices or optimized to best serve the City’s needs for reducing demands during a drought, or for reducing seasonal total and peak demands in other years.

A review and amendment process similar to what Metro Vancouver has done over the past 20 years would be expected to lead to reduced total seasonal demand. Based on that work, an estimated 10% reduction in total seasonal water use would likely be achievable for the City, and substantial reductions in MDD and PHD.

Recommended actions for the watering restrictions review include:

- Align restriction stages with actual system conditions (e.g., reservoir levels, streamflow, forecasted demand).
- Benchmark against Metro Vancouver and other regional leaders to identify opportunities for improvement.
- Strengthen enforcement mechanisms, including:
  - Clear communication of restriction stages and expectations.
  - Use of AMI or frequent meter reads to detect non-compliance.
  - Consideration of fines or surcharges for repeated violations.

- Improve public communication, using:
  - Real-time signage in parks and public spaces.
  - Online dashboards showing current restriction stage and rationale.
  - Seasonal campaigns to reinforce messaging.
  - Ensure that restrictions are timely, effective, and well-understood by all user groups.

### **Pilot Landscape Transformation Incentive Program**

The DWWP Water Stewardship Rebate program already incorporates several elements that can serve as a foundation for a landscape transformation program. There are opportunities for adapting and updating these existing rebate programs within a pilot landscape transformation program that builds on the current DWWP measures with additional incentives.

Eligible customers for a landscape transformation incentive program could include residential, multi-family, and ICI users. While watering restrictions and outreach can reduce use temporarily, long-term reductions in peak demand require structural changes to the landscape itself to build a more resilient, climate-adapted community. The objective for the program is to provide technical and financial support for replacing turf or other water intensive landscaping with drought-tolerant landscapes.

Landscape transformation programs may include:

- Rebates for efficient irrigation technologies
- Free distribution of mulch
- Turf removal and replacement
- Water-wise re-landscaping
- Customer site audits

Similar programs in other jurisdictions have demonstrated strong water savings and public support. Alliance for Water Efficiency's (AWE) evaluation of customer motivations for, and effectiveness of, landscape transformation (Alliance for Water Efficiency, 2019) revealed that people are open to transforming their landscapes and want to be smart water users. With support from water providers, government agencies, irrigation industry players, and landscape professionals, one can achieve beautiful, water-efficient landscapes they can feel proud of.

The average participant savings for single family customers across programs analyzed by the AWE, ranged from a 7 per cent reduction in water use (City of Guelph<sup>4</sup>) up to 39 per cent. Higher participant water savings were associated with higher levels of pre-participation mean use and with higher amounts of turf replaced, with average annual savings of 30 - 60 m<sup>3</sup> per 100 m<sup>2</sup> of turf removed. The programs successfully reduced peak demand and the savings achieved not only persisted after the first year, they increased in time indicating that implementation costs could be recouped over time.

The City can pilot a Landscape Transformation Incentive Program, modeled on successful "cash for grass" and xeriscape rebate programs across North America. The program would offer financial incentives to customers who replace high-water-use turf with low-water-use alternatives, such as:

- Native or climate-appropriate plantings
- Mulch or permeable hardscape
- Edible gardens with drip irrigation

<sup>4</sup> The City of Guelph was the only participating utility that did not offer financial incentives. Its program was focused on outreach and support.

The program could start with a budget of \$150 k/year, of which \$100 - 130 k/year would be applied to customer incentives (the balance being staffing and expense costs). This budget allocation could fund up to 30 projects at \$5 k/each or more smaller projects. Rebates could be structured as a dollar amount per square metre of turf removed or as a percentage of project costs. As the program progresses, the City should evaluate which approach works best, drawing on customer feedback and program performance data to refine incentive design and maximize participation and savings.

Eligibility requirements could include:

- Removing at least 10 m<sup>2</sup> of turf
- Installing qualifying low-water-use landscaping
- Including efficient irrigation (e.g., drip, timers, rain sensors)
- Maintaining for a minimum of 3 years

This program would complement existing soil amendment and irrigation efficiency rebates and could be piloted in areas or with customers that have high outdoor use. Participants would be required to submit a pre-application with photos and a site plan and receive approval before beginning work. Post-installation inspections would be conducted to verify completion.

The new program could look for inspiration from best practices in leading North American jurisdictions, such as the [Town of Okotoks](#) highly popular Xeriscape program, the long standing Healthy Landscapes Program delivered by [City of Guelph](#) or [Region of Peel](#)'s Fusion Landscaping® training in Southern Ontario.

### **Monitoring and Evaluation**

As a pilot, the program should include a robust monitoring and evaluation component to assess its effectiveness and inform future scaling. Existing meter data can be used to track changes in water use at participating properties, comparing pre- and post-conversion summer consumption. Temporary data loggers for selected properties should be considered as they would greatly improve resolution and accuracy compared with the limited number of water meter reads available with the current metering technology. These devices can provide hourly or daily consumption data, allowing for more precise attribution of savings to landscape changes. This approach is particularly useful for evaluating peak demand impacts.

Key performance indicators include:

- Total area of turf removed
- Estimated and actual water savings (m<sup>3</sup>/property)
- Change in peak day and seasonal use
- Customer satisfaction and reported behaviour change

Results would be used to refine program design, eligibility criteria, and incentive levels.

### **Education and Support**

In addition to financial incentives, landscape transformation requires education, inspiration, and technical support. To ensure success, the City could develop a suite of educational materials and outreach tools, including:

- A "Water-Wise Landscaping" guide tailored to the City's climate and soils
- Native plant gardening workshops
- Sample plant lists and design templates
- How-to videos on irrigation retrofits and soil preparation
- A dedicated webpage with application forms, FAQs, and before/after photos
- Signage and branding: Offer "water-wise yard" signs to build social norming

Staff or contractors could be available to provide one-on-one support during the application and installation process. The City may also partner with local nurseries, landscapers, master gardeners, or community groups to promote the program and offer discounts or co-branded events. Through coordination with RDN, this measure could be positioned as a regionally delivered suite of programs under the DWWP to leverage established partnerships and brand recognition.

### **Estimated Results for Outdoor Water Use Measures**

Estimated water savings and program costs over 10 years for implementing changes to the current outdoor watering restrictions and initiating new single family irrigation and the pilot landscape transformation incentive program include:

- Annual water savings after 10 years 50 ML/year
- Total cost \$1.5 M (\$0.15 M/year)

It is recommended that the City continue to participate in existing RDN programs for irrigation upgrades and soil improvements.

## **ICI and Water Efficient Design**

### **ICI High-Use Program**

The ICI sector in the City is a major contributor to both base and seasonal demand accounting for 25 and 20% of total use respectively, with a high concentration of use in a relatively small number of accounts. The top 20 ICI users alone account for approximately 15% of total system water demand and nearly 80% of ICI seasonal use. With an almost 100,000 m<sup>3</sup> of ICI outdoor use annually this sector is a key driver of peak summer demand. Much of this use is concentrated in resorts, commercial strips, and recreational properties with large irrigated areas, ornamental landscaping, and in some cases, inefficient or aging irrigation systems.

Key characteristics of ICI outdoor use in the City are as follows:

- Large resorts and hotels with expansive lawns, gardens, and pools.
- Commercial strips where irrigation practices vary widely.
- Recreational properties such as RV parks and sports fields, some of which show signs of leakage or overwatering.

Despite being fully metered, most ICI accounts are only read twice per year, limiting the City's ability to detect leaks, monitor irrigation patterns, or engage with users in a timely way. In addition to more frequent meter readings, conducting water audits can uncover significant savings by detecting leaks and highlighting inefficiencies in processes such as cooling, irrigation, and sanitation.

However, audits alone rarely lead to implementation. A review of Best Management Practices for water efficiency in the ICI sector indicates that without financial or technical support, many businesses fail to act on audit recommendations due to cost constraints and competing operational priorities (Maddaus Water Management Inc., 2022). In fact, measures with payback periods of only a few months to two years are often deemed financially unfeasible. The report recommends a multifaceted approach: staff training combined with well-funded incentives, including pay-for-performance models, along with partnerships with committed customers and pilot studies to validate implementation strategies and program design.



The objectives for the ICI targeted programs would be to reduce peak seasonal demand from ICI users and identify and address leaks and inefficiencies in both indoor and outdoor systems.

Recommended actions for the ICI programs include:

1. Conducting targeted water audits for the top ICI accounts, focusing on:
  - a. Outdoor irrigation scheduling and system efficiency.
  - b. Irrigation scheduling and controller settings.
  - c. System design and maintenance.
  - d. Landscape type and plant selection.
  - e. Indoor end uses such as once-through cooling, laundry, washrooms, and kitchen operations.
  - f. Leak detection, especially in older or seasonal infrastructure (e.g., RV parks).
  - g. Provide follow-up support and technical guidance to help users implement recommendations.
2. Increasing meter reading frequency for large ICI accounts from biannual to monthly or quarterly to enable better leak detection and consider prioritizing ICI accounts for AMI implementation.
3. Engagement and capacity building for landscape contractors, property managers, and resort operators through:
  - a. Workshops and training sessions.
  - b. Recognition or certification programs for efficient properties.
  - c. Technical resources and case studies.
4. Coordinating with the City's education and outreach efforts to amplify messaging and support behavior change.
5. Contracting audit delivery to external specialists to reduce staff burden and ensure technical quality.
6. Providing performance incentives and/or developing a recognition / certification program for ICI customers who implement efficiency upgrades.

A few implementation considerations that will aid to yield better results include:

- Starting with the top five ICI accounts, which represent the highest-impact targets.
- Using AMI-ready meters and more frequent reads to build a data-driven understanding of seasonal use.
- Coordinating with the broader ICI Water Management Program (see next section) to address both indoor and outdoor use holistically.

### Incentivizing Water Efficient Design

To ensure that new development aligns with long-term water supply constraints and conservation goals, the City can explore integrating water-efficient design principles into the planning and approval process for new construction. Many of these recommendations can also apply to major renovation projects.

Core principles for water efficient design include:

- **Match Water Quality to Use:** Encourage the use of rainwater or greywater for non-potable applications such as irrigation, toilet flushing, and laundry.

- **Design for Efficiency:** Promote compact plumbing layouts, ultra low-flow fixtures, and climate-appropriate landscaping.
- **Plan for Resilience:** Require or incentivize rainwater harvesting systems sized to meet seasonal irrigation needs or indoor non-potable demand.

Several voluntary and incentive-based actions that can encourage water efficiency design include:

- **Connection Fee Discounts:** Explore the possibility of offering reduced Development Cost Charges (DCC) for developments that exceed baseline water efficiency standards.
- **Rainwater-Ready Design Templates:** Develop and promote pre-approved system designs for cisterns, dual plumbing, and irrigation systems.
- **Builder Outreach and Recognition:** Engage local builders and developers through workshops, design guides, and “Water-Wise Home”/“Water-Wise Business” certifications.
- **Enhanced Rebates:** Provide rebates for new homes that install cisterns and integrate indoor non-potable reuse.

Implementing policy changes and updates to design standards are also good options for increasing water efficient design.

- **Development Permit Guidelines:** Include water efficiency (e.g. landscaping, irrigation, and stormwater management) and rainwater harvesting in Development Permit Area (DPA) guidelines.
- **Subdivision Standards:** Require or incentivize water-efficient infrastructure in new subdivisions, including shared cisterns or greywater systems.
- **Plumbing Code Alignment:** Explore amendments or pilot programs that enable safe indoor reuse of rainwater and greywater.

Examples of water efficiency programs from other jurisdictions are provided below.

- [City of Guelph Blue Built Home Program](#): offers certification and rebates for new homes that include water-efficient fixtures and systems, including rainwater harvesting and greywater reuse.
- [San Francisco Non-Potable Water Ordinance](#): requires new buildings over 250,000 sq. ft. to install onsite non-potable water systems, including rainwater harvesting. While not mandatory for single-family homes, the city offers guidelines and incentives for voluntary adoption, especially in multi-unit developments.
- [City of Tucson ordinance](#) mandates that commercial developments provide at least 50% of their irrigation needs with harvested rainwater. It also mandates that all new home construction includes gray water stub-outs at time of building. Stub-outs are sections of drainage pipe installed during construction which allow for convenient and inexpensive redirection of household greywater to the landscape at a later time once the stub-out pipes are connected to the source drain(s).
- New South Wales (NSW), Australia: Under the Building Sustainability Index ([BASIX](#)), all new homes and major remodels must meet water efficiency targets. Most new homes must install a rainwater tank connected to toilets and laundry or demonstrate equivalent water savings. Since 2004, more than 500,000 BASIX-compliant homes are estimated to have saved 12.3 million tonnes of greenhouse gas emissions, and 340 billion litres of drinking water (NSW Government, 2024).

Rainwater harvesting can play a valuable role in supporting the City’s objectives such as reducing peak demand, offsetting some winter water use, lowering per capita consumption, enhancing system resilience, and encouraging sustainable water practices. The City could continue to participate in the RDN cistern program and consider increasing participation through targeted outreach to high use customers identified through the other programs described above. Rain barrels, however, do not make a meaningful impact on reducing consumption due to their small size and the City could consider discontinuing this program.

Where the program can be most impactful is in building rainwater capture, on-site storage, and non-potable plumbing into a site scale redevelopment (see Incentivizing Water Efficient Design Section). The City can, for example, consider waiving the water DCC if a proposed development is designed to reliably add no new water demand through storage and appropriate landscaping.

### **Estimated Results of the ICI and Water Efficiency Design Programs**

Implementation of programs targeting high water use ICI customers and enhancing policy on efficient use of water are anticipated to result in the following water savings and program cost over the 10-year period.

- Annual water savings after 10 years: 50 ML/year
- Total cost \$1.5 M (\$0.15 M/year)

### **Education and Engagement**

Education is a critical enabler of all conservation programs. While infrastructure upgrade incentives, policy and pricing reforms are essential, long-term water conservation success depends on building a culture of water stewardship across all sectors – from homeowners and businesses to contractors and City staff. Without a solid foundation of effective customer engagement, participation in incentive measures will be low and policy and pricing measures will face strong resistance, and the overall program goals will not be achieved.

The region already has a strong base to build from, with universal metering and a relatively efficient residential sector. However, many users – particularly those with high seasonal demand – may not fully understand how their water use compares to others, or how small changes in behavior can lead to significant savings. Education and outreach efforts should be designed to close this gap, using data to target the right users with the right messages at the right time. Potential education and engagement programs are listed below.

**Seasonal Campaigns and Public Messaging:** Seasonal outreach should be timed to coincide with key decision points, such as the start of the irrigation season or the implementation of watering restrictions. Messaging should be clear, consistent, and visible across multiple platforms, including:

- Utility bills and newsletters
- City website and social media
- Signage in parks and public spaces

For example, a spring campaign might focus on “watering smarter” encouraging residents to water early in the morning, only twice per week, and to check for leaks or overspray. A summer campaign could highlight the City’s own efforts to reduce irrigation in parks, reinforcing the message that everyone has a role to play.

**Demonstration Projects in City Parks and Facilities:** To reinforce its leadership role and provide visible examples of best practices, the City could implement demonstration projects in high-profile municipal spaces. These projects can serve as living case studies and educational tools for residents, contractors, and other municipalities. Key features could include:

- Climate-appropriate landscaping that reduces water needs while maintaining aesthetic and recreational value.
- Smart irrigation controllers that adjust watering based on weather and soil conditions.
- Real-time water use monitoring with public dashboards or signage showing how much water is being saved.

These sites, such as Parksville Community Park, the waterpark, and the skatepark are already among the City's highest-use areas and offer ideal platforms for showcasing innovation and commitment to sustainability.

**Engagement with Contractors and Property Managers:** Many of the highest-use properties in the City include multi-family residential (MFR), commercial, and resort sites that rely on landscape contractors or property managers to oversee irrigation. These professionals are key influencers and should be directly engaged through:

- Workshops or training sessions on efficient irrigation practices.
- Coordination with local irrigation associations.
- Recognition programs for contractors who consistently deliver low-water landscapes.
- Technical resources and case studies that demonstrate successful retrofits or upgrades.

By equipping these intermediaries with the right tools and incentives, the region can extend the reach of its conservation programs and ensure that efficiency is built into the design and maintenance of large landscapes.

**Data-Driven Outreach:** Improved metering and analytics can be used to identify accounts with high seasonal use, unusual consumption patterns or consistent top-tier usage allowing the region to move beyond generic messaging and begin delivering personalized, timely communications to critical accounts. For example:

- A homeowner whose summer use spikes could receive a tailored message showing how their irrigation compares to similar properties, along with tips for adjusting their watering schedule.
- A resort operator could be shown how their water use per unit area compares to benchmarks, with an offer for a free audit or consultation.

This kind of targeted engagement is more likely to result in behavior change than broad, one-size-fits-all campaigns. While the region considers upgrades to its meter infrastructure, this targeted outreach may be more limited and more manual. As the data improve, much of this outreach can be automated.

## Implementation and Delivery Options

Delivering effective education and outreach requires more than just good messaging – it requires the right tools, timing, and partnerships. The education program should be designed to evolve alongside its metering and conservation initiatives, with a focus on scalability, visibility, and impact.



Several delivery channels and strategies are recommended:

1. **Utility Bill Inserts and Direct Mail:** Utility bills remain one of the most direct ways to reach customers. As AMI or more frequent meter reads become available, these communications can become more timely and data-driven. Inserts or targeted letters can be used to:
  - Notify high-use accounts of their consumption relative to peers.
  - Promote seasonal campaigns or rebate programs.
  - Provide personalized tips based on usage patterns.
2. **Digital Engagement:** Websites and social media platforms offer low-cost, high-reach channels for seasonal messaging and conservation tips. For example, a “Know Your Zone” campaign could help residents understand when and how much to water, based on their landscape type and lot size. These platforms can be used to:
  - Launch seasonal campaigns like “Water Wise Wednesdays” with weekly tips and reminders.
  - Share short videos demonstrating how to adjust irrigation timers or check for leaks.
  - Host an interactive irrigation calculator where residents can estimate how much water their lawn actually needs.
  - Promote real-time dashboards showing water savings at City parks or during restriction periods.
3. **On-the-Ground Demonstration and Signage:** City parks and facilities offer high-visibility opportunities to showcase best practices. For example, a sign in Parksville Community Park might say: “This garden uses 70% less water than traditional turf. Want to try it at home? Scan here for a free guide.” These installations turn public spaces into living classrooms and reinforce the City’s leadership role.
  - Interpretive signage next to smart irrigation controllers explaining how they work and how much water they save.
  - QR codes in drought-tolerant gardens linking to plant lists and design guides.
  - Live water use displays at the waterpark or skatepark showing real-time consumption and comparisons to previous years.
4. **Workshops and Contractor Engagement:** Workshops hosted by the City or in partnership with local nurseries, irrigation suppliers, or the RDN can help build capacity. Workshops can be offered in spring and early summer, timed with the irrigation season and new rebate launches. These could include:
  - Irrigation bootcamps for landscape contractors, covering efficient scheduling, system audits, and controller programming.
  - Lunch-and-learns for strata councils and property managers on managing irrigation in multi-family developments.
  - Hands-on demos at City parks showing how to retrofit spray heads or install drip systems.
5. **School and Community Partnerships:** Engaging youth and community groups can help build long-term awareness. Partnerships with garden clubs to host tours of low-water landscapes or help maintain demonstration sites. These partnerships can amplify the City’s message and foster a broader culture of stewardship. Opportunities include:
  - School field trips to demonstration gardens, with activities like “find the mulch” or “guess the water use.”
  - Poster contests for elementary students on the theme “Every Drop Counts.”

## Estimated Cost for Education and Engagement Programs

Based on guidance from the Ontario Water Works Association's Water Efficiency Guidebook for Small and Medium-Sized Utilities, utilities are encouraged to allocate 10 - 15% of their total water conservation program budget to public education and outreach efforts. This aligns with broader North American practice, where outreach typically comprises 5 - 15% of conservation budgets, increasing to 20 - 25% during drought or high-priority campaigns (EPA WaterSense, CalWEP).

For the City, it is recommended to budget for approximately 20% of the overall water demand management and conservation program cost to allow for adequate engagement and administration. This equates to \$3.6 M over 10 years or \$0.36 M/year.

## Water Conservation and Demand Management Summary

**Table 8-1: Water Conservation and Demand Management Program Costs and Water Use Reduction**

| Program                                                     | 10-Year Total Estimated Water Use Reduction | 10-Year Total Cost (Annual Average) |
|-------------------------------------------------------------|---------------------------------------------|-------------------------------------|
| Management Measures                                         | 60 ML/year                                  | \$1M (\$0.1M/year)**                |
| Municipal Landscape Improvements                            | 30 ML/year                                  | \$14.2M (\$1.42M/year)*             |
| Outdoor Water Use Measures                                  | 50 ML/year                                  | \$1.5M (\$0.15M/year)               |
| ICI and water efficient design                              | 50 ML/year                                  | \$1.5M (\$0.15M/year)               |
| <b>Subtotal</b>                                             | <b>190 ML/year</b>                          | <b>\$18.2M (1.82M/year)</b>         |
| Engagement and Administration (20% of Subtotal)             |                                             | \$3.6M (\$0.36M/year)               |
| <b>Total</b>                                                | <b>190 ML/year</b>                          | <b>\$21.8M (\$2.18M/year)</b>       |
| * Primarily asset renewal that will be required in any case |                                             |                                     |
| ** Does not include the cost of transitioning to AMI.       |                                             |                                     |

The total estimated water savings that would result from the recommended water conservation and demand management program measures represents 9% of the 2024 total volume supplied to the City distribution system and 11% of 2024 total retail demand. The recommended measures have a larger impact on seasonal demand than base demand: Seasonal demand reduction of 100 ML/yr (15%) and MDD reduction of 2 ML/d (15%) are estimated to be achieved by the programs.

Of the \$21.8 million estimated total estimated program cost, \$14 million is allocated to renewal and upgrades to municipal park assets. The cost for water demand management is \$7.8 million, or \$780,000 per year for the ten-year implementation timeframe.

## 9. Power Generating Potential

KWL assessed the potential for power generation in the Englishman River Watershed area to identify opportunities to offset project costs and capitalize on hydropower generation on the system at locations such as Arrowsmith Dam and the surrounding watershed.

The scope for power generation potential included Arrowsmith Dam Hydropower, a RHAM model assessment of the remainder of the Englishman River watershed and solar potential on the Englishman River Pump Station. Detailed information on the current BC Hydro policy, methodology for the assessment of hydroelectricity generation at Arrowsmith Dam and other potential locations in the watershed are provided in Appendix G.

In summary, the analysis shows a hydroelectric power generation project at Arrowsmith Dam is not economically viable for several factors that include the initial capital cost of infrastructure needed at the dam site, the significant length of powerline from the reservoir to connect with BC Hydro's system, as well as flow to the power generation system only being available during the operating period of the dam typically from April to October each year.

However, it is noted that a hydroelectric project at Arrowsmith Dam would improve the resilience of the drinking water system (and EFN requirements) by improving access to the lower portion of the reservoir storage (i.e. 2,000 m<sup>3</sup> of live storage, improving the reliability of the siphon intake, and improving automation, control, and monitoring of the discharges from Arrowsmith Dam through the proposed hydroelectric project.

RHAM was used to assess the remainder of Englishman River watershed to estimate hydroelectric power generation potential, and the results are shown in Appendix G. In summary, the model results show that potential power project sites could generate approximately 6 to 10 MW; however, the river reaches identified are all located in Steelhead habitat such that the cost and infrastructure needed to maintain fish access makes the projects not feasible.

An assessment of the solar potential for the rooftop of the Englishman River Pumpstation was also undertaken. Although viable, the project was deemed to have limited benefit over the lifetime of the solar infrastructure and was dependent on the current BC Hydro solar incentives. Further analysis could be carried out to consider other water system assets as well as other sites in the community if the City is interested in pursuing this type of power generation technology.

## 10. Financial Analysis

This section describes the financial implications of the potential water supply and demand strategies described in the previous sections. A status quo scenario is not included in this analysis, as it is not considered to be a viable alternative due to the low and declining reliability of the water supply under the status quo scenario. At least one intervention strategy is assumed to be necessary within the next ten years to improve water supply reliability. All costs are stated in 2025 dollars, and are considered to have an uncertainty margin of at least  $\pm 50\%$  based on the available information and the need to rely on assumptions for estimating costs at this stage of planning.

### 10.1 Capital Expenditures

#### Increased Surface Water Supply

The five surface water supply (storage) options range in estimated capital cost from \$14.2 million (Healey Lake) to \$318 million (Moriarty Creek). The Moriarty Creek option is less desirable than each of the other four options as it offers no major benefit over the other four options and has much higher capital and O&M costs. Of the four remaining options, the South Englishman Tributary option has the highest capital cost at \$28.4 million. The initial analysis indicates that the South Englishman River Tributary site is ranked the highest of the options. However, further investigation of site conditions and environmental field surveys to assess potential for ecosystems at risk or species at risk at the site will be required.

For the purpose of financial analysis, the capital expenditure needed to increase surface water storage to achieve adequate supply reliability over the next 50 years is assumed to be \$24 million, which is the average of the four candidate options.

#### Increased Groundwater Supply

Waterline recommends a Groundwater Supply Execution Plan involving a sequence of steps of further investigation, analysis and well development to increase the City's water supply capacity from Aquifer 221 or 1252. The overall cost of the program to develop a new well is estimated to be in the range of \$0.35 to \$0.51 million. This scope does not include the cost of connecting the new well to the existing distribution system, or the potential cost of treatment. Well location and routing to connect either aquifer to the Parksville distribution system is uncertain and would likely involve a distance in the range of 0 (221, best case scenario) to 10 km (1252, likely longest feasible route). Given that both aquifers are unconfined, filtration and disinfection would likely be required. Assuming a cost range of \$1 to \$1.5 million per km for interconnection and \$5 to \$15 million for treatment, the cost of interconnection and treatment of groundwater from Aquifer 221 or 1252 could be in the range of \$5 to \$30 million. A cost of \$20 million is assumed for financial analysis.

The Nanoose Bay groundwater source has an estimated sustainable yield of 3,500 m<sup>3</sup>/day, which is roughly 2,500 m<sup>3</sup>/day more than the current and status quo forecasted use. It is expected that the full 3,500 m<sup>3</sup>/day will be used on maximum day before 2035 and that groundwater will supply 85% of Nanoose Bay Peninsula water use by 2075 (base demand is predicted to be less than 3,500 m<sup>3</sup>/day through 2075).

With oversight by a hydrogeologist is likely feasible to increase groundwater withdrawal from existing City of Parksville wells, particularly during the operational period, at no capital cost. Although some wells exhibited signs of stress between 2015 and 2020, current pumping rates are significantly less than those before 2020 and there is an opportunity to optimize production from the existing wells.

Aquifer storage and recovery is a potentially feasible option that is currently being investigated by RDN. The scope and capital cost of a potential project to develop an aquifer storage and recovery system is unknown and would depend on several factors including aquifer location, storage capacity, recovery efficiency, and water quality impacts of aquifer storage. Environmental and regulatory implications are also currently unknown.

## Demand Management

The recommended ten-year demand management program includes \$14 million in capital asset renewal and upgrades to City owned park and sports field assets to reduce irrigation demands.

## Summary

The range of estimated capital expenditures associated with each potential option is shown in Table 10-1. The estimated costs of the three options are entirely independent; adding or omitting an option has no influence on the estimated cost of the others.

**Table 10-1: Estimated Capital Expenditures**

| Supply or Demand Strategy Option            | Estimated Capital Expenditure (millions) |
|---------------------------------------------|------------------------------------------|
| Increased Surface Water Supply (New Source) | \$24                                     |
| Increased Groundwater Supply (New Source)   | \$20                                     |
| Demand Management                           | \$14                                     |

## 10.2 Operation and Maintenance Expenditures

### Increased Surface Water Supply

Each of the four potentially feasible surface water supply projects has an estimated annual operation and maintenance (O&M) cost of \$0.25 million.

### Increased Groundwater Supply

The O&M costs of a new well, pipeline and treatment for developing a supply from Aquifer 221 or 1252 depend greatly on well depth, sustainable yield and water quality. Pumping and treatment would be the largest determinants of O&M cost. As a placeholder, it is assumed that the annual O&M expense would be \$0.5 million (for comparison, the budget O&M expense for the Englishman River WTP is \$0.8 million).

### Demand Management

The recommended measures, aside from the capital expenditure for municipal landscape renewal and improvements, have an estimated total annual cost of \$0.8 million.

## Summary

The range of estimated new annual operation and maintenance expenditures associated with each potential option is shown in Table 10-2.



**Table 10-2: Estimated New Annual Operation and Maintenance Expenditures**

| Supply or Demand Strategy Option | Estimated Annual O&M Expenditure (millions) |
|----------------------------------|---------------------------------------------|
| Increased Surface Water Supply   | \$0.25                                      |
| Increased Groundwater Supply     | \$0.5                                       |
| Demand Management                | \$0.8                                       |

### 10.3 Funding Sources

The potential strategies could be funded in several ways, though the primary means will be the City's water utility revenues and development cost charges (DCCs). This section includes a discussion on the various funding sources likely available for each strategy.

#### Increased Surface Water or Groundwater Supply

Infrastructure grants are often available to partially fund capital expenditures for drinking water supply and treatment, although the priority for funding projects is generally driven by public health and regulatory compliance needs, and accommodating community growth is a low priority for funding. Given that the need for a water supply project is largely driven by the environmental flow need, a stronger case for grant funding could likely be made on the basis of the major benefit that storage on the Englishman River watershed provides for salmonid spawning and rearing habitat. The best candidate programs to fund a substantial portion of the cost of a water supply project are:

- UBCM Canada Community-Building Fund (CCBF) – Strategic Priorities Fund. This program has an intake every few years (most recently September 2025) and provides up to 100% of eligible expenses to a maximum of \$7 million. Funding is available for planning studies, design and construction projects that UBCM describes as *“either large in scale, regional in impact, or innovative, and that align with the program's objectives of supporting productivity and economic growth, a clean environment, and strong cities and communities”*. The 2025 federal budget bill includes \$27.8 billion over the next 10 years for the CCBF, which will be rebranded as the Community Stream of a new Build Communities Strong Fund.
- Federal-provincial infrastructure grants (currently the Investing in Canada Infrastructure Program). Federal-provincial funding agreements are typically renewed once or twice per decade, and typically provide funding of up to two thirds of eligible local government design and construction project expenditures. The 2025 federal budget bill includes \$17.2 billion new funding for the provincial and territorial stream of a new Build Communities Strong Fund. The budget states *“Funding will support housing-enabling infrastructure (e.g., roads, water/wastewater), health-related infrastructure (e.g., hospitals), and infrastructure at colleges and universities. To access funds, provinces and territories must agree to cost-match federal funding and to substantially reduce development charges and not levy other taxes that hinder the housing supply”*.

The portion of the cost of increasing water supply capacity (net of grant funding) that is attributable to future users of the water system would typically be recovered through DCCs. To do so it would be necessary to update the City's DCC Bylaw to include the costs of increasing water supply capacity and reliability. Given that the need to increase water supply capacity is only partially driven by community growth, the DCC benefit factor could be calculated based on the proportion of the population at the DCC planning horizon that will be added through new development. As shown in Table 5-1, Parksville's population is projected to increase from 14,718 to 21,566 between 2025 and 2050. The added

population of 6,848 represents 32% of the total projected population in 2050. On this basis, it is estimated that 32% of the capital cost of projects that increase the City's water supply capacity would be eligible to be recovered through DCCs.

The remainder of capital costs (likely in the order of 23-68% depending on availability of grant funding), and all O&M and future asset renewal costs associated with new infrastructure, must be recovered through utility revenues (taxes and user charges). A long-term financial plan would provide a basis for phasing in adjustments to tax and user charge rates without requiring large changes in a single year.

## **Demand Management**

Of the \$14 million recommended investment in renewal and upgrading municipal park landscaping and irrigation, funding may be shared between three general sources though all are internal to the City. As a general set of principles:

- The portion of project costs attributable to asset renewal (i.e., replacement of aged irrigation assets and landscaping features with new assets that provide a similar level of service) should be funded from the City's parks capital asset renewal program. This is expected to be the primary funding source for the program.
- Project costs that are incurred primarily to improve levels of service to park users (e.g., serving new or improved purposes such as the creation of new trails that improve an interconnected network) should also be funded from the Parks capital program.
- Project costs that are incurred solely for improving water efficiency, beyond renewing park assets and improving service levels to park users (e.g. added cost of upgrading irrigation from spray or rotor to drip, or increasing depth of topsoil to improve moisture retention) should be funded from water utility revenue under the demand management program. It is assumed that at most this will be one third of the total estimated cost of the municipal park asset renewal and upgrade program cost.

Most of the demand management programs will be funded from water utility operating revenues. Programs that reduce irrigation and outdoor water uses benefit only the water utility; however, programs that reduce indoor use also significantly benefit the sewer service. Consideration could be given to funding a portion of the demand program from sewer utility revenues particularly where there is a strategic benefit of leveraging demand management to avoid or defer sewer capacity upgrades. Roughly half of the projected savings from the recommended measures (90 ML/year) represent indoor water use that would also reduce sewer flows relative to the status quo.

Two of the recommended management measures, revising water rates and beginning to transition to smart (AMI) meters, also represent opportunities improve alignment between revenues and costs of service for both water and sewer services. Potential revenue strategies aligned with rate design and smart metering include:

- Utilizing a high top tier volumetric rate (typically representing high seasonal irrigation use) to contribute to reserve funds for capital projects to increase water supply capacity.
- Using high-resolution AMI meter data to establish accurate water budgets and billing structures for different classes of residential and commercial customer (e.g. tier thresholds for single-family residential and potentially multi-family residential; seasonal rates for hotels and resorts, and potentially time-of-day pricing).
- Reducing revenue loss to leak adjustments by identifying and notifying customers of leaks promptly.

## Summary

All operating costs and likely the majority of capital costs of the water supply and demand strategies identified in this study must be recovered through water utility operating revenues. Approximately 32% of the capital cost of projects to increase surface water or groundwater capacity is estimated to be recoverable through DCCs. Up to 2/3 of the cost of these projects net of DCCs could be recovered through federal/provincial or federal/UBCM grants if appropriate opportunities become available and applications are successful, both of which are reasonably likely.

Some demand management measures, particularly those involving renewing and upgrading park landscaping and irrigation assets, should be funded from the City's Parks capital budget. There is also a case for recovering a portion of the demand management program cost from sanitary sewer utility revenues.

## 10.4 Lifecycle Costs and Benefits

### Lifecycle Costs

Based on the capital and operating costs presented in Sections 10.1 and 10.2, this section presents simplified estimates of annualized lifecycle costs based on the assumption that capital costs are amortized on a straight line over the estimated average lifespans of assets acquired through capital expenditures (i.e. interest on reserves and debt are ignored, which is considered reasonable given the high uncertainties in the estimated costs, and that reserves may be accumulated for roughly a decade before major water supply projects are constructed).

The resulting estimated annualized lifecycle costs are shown in Table 10-3. Although a new surface water supply project is likely the most cost-effective strategy in the long run, demand management and increased groundwater supply are likely necessary as interim strategies to prevent or minimize further deterioration of supply reliability before a new supply source can be brought online.

**Table 10-3: Estimated Total Lifecycle Costs of Strategies**

| Supply or Demand Strategy Option | Average Asset Lifespan (years) | Estimated Annualized Lifecycle Cost (millions) |
|----------------------------------|--------------------------------|------------------------------------------------|
| Increased Surface Water Supply   | 80                             | \$0.55                                         |
| Increased Groundwater Supply     | 60                             | \$0.83                                         |
| Demand Management                | 40                             | \$1.13                                         |

## Utility Funded Lifecycle Costs

Table 10-4 shows the estimated lifecycle costs that would be recovered by water utility operating revenues (parcel tax and user fee revenues), net of capital funding from other sources as discussed in Section 10.3. In the table, external funding includes potential grants by third parties, contributions from developers through DCCs, and funding for renewal of City owned irrigation systems and landscape areas from Parks revenue (i.e. not water utility revenue). These represent the probable maximum available external funding of capital expenditures.

**Table 10-4: Estimated Utility Funded Lifecycle Costs**

| Supply or Demand Strategy Option | % External Funding | Estimated Annualized Lifecycle Cost (millions) |
|----------------------------------|--------------------|------------------------------------------------|
| Increased Surface Water Supply   | 55%                | \$0.25                                         |
| Increased Groundwater Supply     | 55%                | \$0.38                                         |
| Demand Management                | 29%                | \$0.72                                         |

This table shows that the annualized lifecycle cost impact of a surface water or groundwater source development project on the water utility revenue requirement may fall between \$250,000 and \$400,000, though these estimates are highly uncertain.

The utility funded demand management cost is based on the estimated demand management operating cost with 80% of the capital cost funded by the Parks service.

## Lifecycle Benefits

The strategies and individual project and program options each yield different outcomes for the City, summarized in Table 10-5. The benefits generally fall into four categories: Improvement in water supply reliability, reducing costs to the utility, improving environmental flows in the Englishman River, and reductions in the use of natural resources including water, energy, and manufactured goods, with associated reductions in greenhouse gas emissions.

This analysis of benefits is qualitative and comparative; quantitative analysis may be necessary to select specific project or program measures after further data collection and analysis in the next phase of the Study. The benefits of the strategies can be described as follows, as summarized in Table 10-5:

- At least three of the four surface water supply options will improve water supply reliability above 95%, and will enable the EFN to be consistently met. The Shelton Lake option is less certain than the others in both respects.
- If a new groundwater source such as Aquifer 221 or 1252 is determined to yield sufficient water quantity and quality, it may substantially improve water supply reliability but cannot yield more than a small improvement in EFN by reducing withdrawals from the ERWS source.
- The demand management program described in Section 8, in combination with potential optimization of the use of the existing Parksville wells, is estimated to enable the City to maintain the current reliability of the ERWS supply over the next ten years until a new surface water supply project is completed. These measures will also marginally improve the availability of surface water for EFN. The cost reduction associated with demand management results from deferral of the need for capital upgrades to ERWS treatment and pumping facilities, as discussed in the following two sections. Reducing water use also reduces operating costs and energy use for pumping and treatment of drinking water and wastewater, and GHG emissions associated with heating water for domestic use.

**Table 10-5: Lifecycle Benefit Comparison**

| Supply or Demand Strategy Option | Lifecycle Benefit  |                |                 |                      |
|----------------------------------|--------------------|----------------|-----------------|----------------------|
|                                  | Supply Reliability | Cost Reduction | EFN Improvement | Reduced Resource Use |
| Increased Surface Water Supply   |                    |                |                 |                      |
| South Englishman                 | High               |                | High            |                      |
| Shelton                          | Med                |                | Med             |                      |
| Healey                           | High               |                | High            |                      |
| Fishtail                         | High               |                | High            |                      |
| Increased Groundwater Supply     | Med                |                | Low             |                      |
| Demand Management                | Low                | Med            | Low             | Med                  |

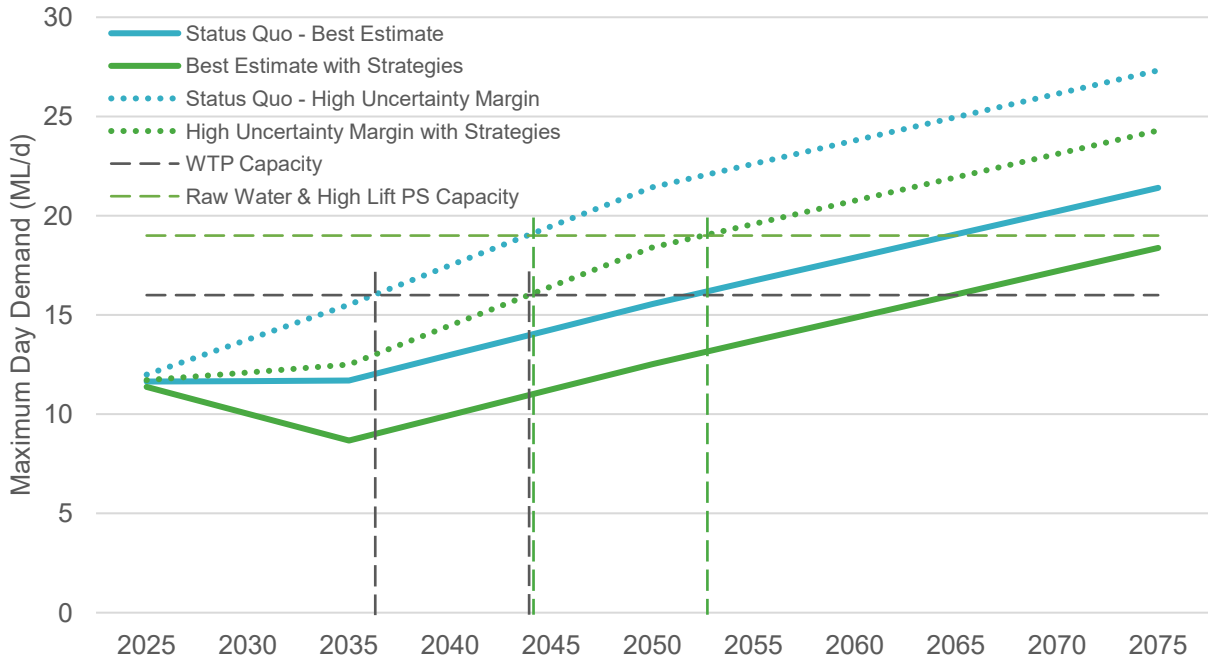
## 10.5 Timing of Supply Upgrades

This section presents a forecast of the timing and expected costs of water supply system capacity upgrades that will be required to meet future water demands in the ERWS system. Figure 10-1 shows a forecast of four scenarios for maximum day demands with the capacities of the Water Treatment Plant and the Raw Water and High Lift Pump Stations.

The estimated timing of upgrades is based on the upper uncertainty margin of water demand forecasts. Uncertainty margins on demand are as shown in the tables in Section 4. These margins are estimated qualitatively but are intended to cover both the variability in demands associated with weather and climate (more water is used for irrigation when summers are longer, hotter, and drier), and uncertainty in growth rates and changes in land use and average efficiencies of indoor and outdoor water uses. Uncertainty in demand has an amplified effect on the uncertainty in timing of projects.

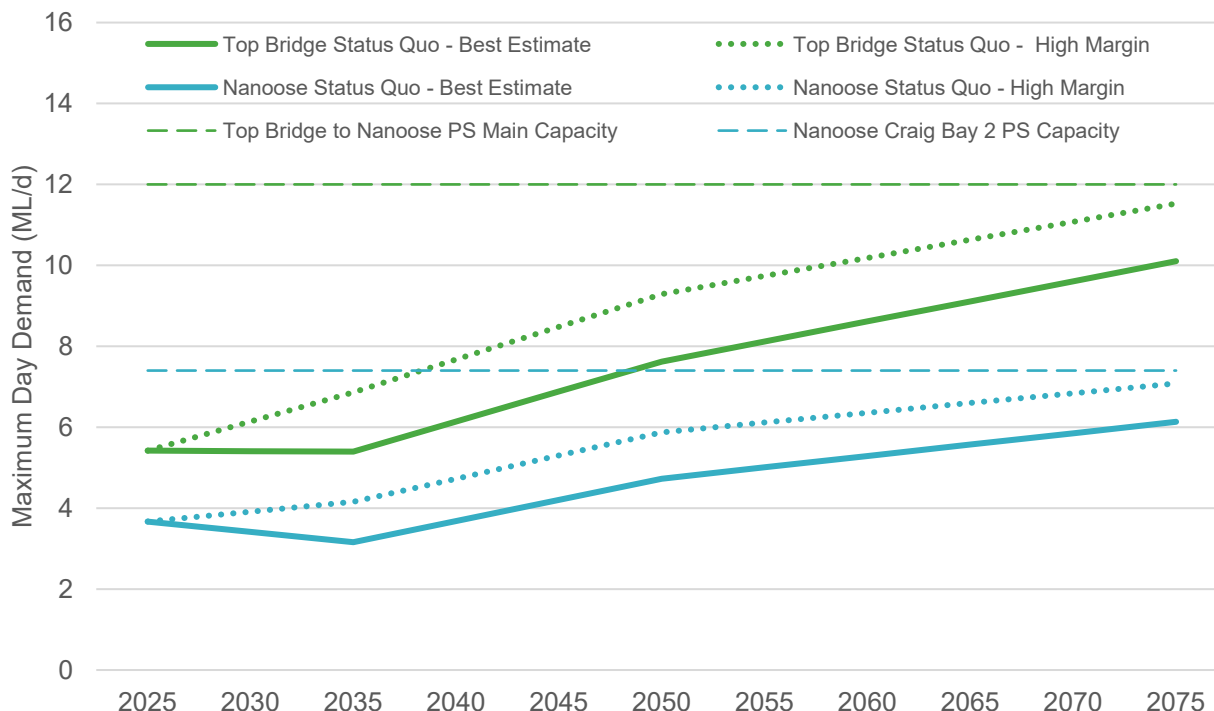
The forecast also shows the times that upgrade projects will be required using vertical dashed lines where the upper uncertainty margins for demand intersect the capacities. For each capacity there are two vertical lines, representing the timing of an upgrade based on the status quo forecast and the timing with demand management and groundwater optimization strategies implemented. The groundwater optimization strategy scenario is based on the assumption that the Parksville wells will supply 6.3 ML/d on maximum day (2.1 ML/d more than the status quo forecast), and that demand management will also reduce MDD by 2 ML/d from the status quo by 2035. As shown in the figure, no upgrade is required before 2035 with these strategies implemented, though the WTP would likely require upgrading by 2037 and the pump stations by 2043 under the status quo scenario. Implementing groundwater and demand management strategies is estimated to enable the WTP upgrade to be deferred to 2043, and the pump stations to 2053.





**Figure 10-1: ERWS Maximum Day Demand Forecast with Capacity Upgrade Timing**

Figure 10-2 shows a similar forecast for demands on the portion of the ERWS system that supplies the eastern part of Parksville and Nanoose Bay via the Top Bridge Reservoir. The blue lines represent MDD through the main that supplies both eastern Parksville and Nanoose Bay from the Top Bridge Reservoir, and the green lines represent the main that supplies only the Nanoose system. Under a status quo scenario no upgrades would be required to this system before 2075.



**Figure 10-2: ERWS East Branch Demand Forecast - Maximum Day with Groundwater Maximized**

Table 10-6 shows the forecasted timing of water treatment and pump station upgrade projects with and without the demand management and groundwater strategies, including order of magnitude cost estimates. The WTP and pump station cost estimates are based on 2014 estimates by CH2M HILL, adjusted for inflation. The financial benefit of deferring these upgrades is also estimated based on present value at a 4% discount rate.

Based on the best estimate upgrade costs, the estimated total financial benefit of applying the demand management and groundwater optimization strategies is \$1.0 million in 2025 dollars, based on the best estimates of upgrade costs. This estimated benefit is order of magnitude at best as it is based on cost estimates having uncertainties of at least  $\pm 50\%$ , projections of project timing that are dependent on highly uncertain long-term demand forecasts, and an assumed discount rate.

**Table 10-6: Timing and Estimated Costs of ERWS Treatment and Pump Station Upgrades**

| Asset                  | Nominal Existing Capacity (MLD) | Upgrade Year (status quo) | Upgrade Year (with strategies) | Project cost (millions) |               |               | PV of Cost Deferral (millions) |
|------------------------|---------------------------------|---------------------------|--------------------------------|-------------------------|---------------|---------------|--------------------------------|
|                        |                                 |                           |                                | Low                     | Best Estimate | High          |                                |
| Water Treatment Plant  | 16                              | 2037                      | 2043                           | \$2.6                   | \$5.3         | \$7.9         | \$0.7                          |
| High Lift Pump Station | 19                              | 2043                      | 2053                           | \$0.5                   | \$1.0         | \$1.5         | \$0.2                          |
| Raw Water Pump Station | 19                              | 2043                      | 2053                           | \$0.5                   | \$1.0         | \$1.5         | \$0.2                          |
| <b>TOTAL</b>           |                                 |                           |                                | <b>\$3.6</b>            | <b>\$7.3</b>  | <b>\$10.9</b> | <b>\$1.0</b>                   |

## 10.6 10-Year Financial Forecast

The forecast of order of magnitude costs shown in Figure 10-3 is based on the following scope of work and assumptions:

- Planning, design, and construction of a surface water supply project will commence in 2027 and will be completed by 2035, including the following:
  - Civil, geotechnical, and environmental investigation of candidate sites, detailed feasibility assessment, conceptual design, and site selection – \$0.6 million, 2027 - 2028.
  - Pre-design, permitting and engagement – \$0.7 million, 2029 - 2030.
  - Detailed design and procurement – \$0.7 million, 2031 - 2032.
  - Construction and commissioning – \$22 million, 2033 - 2035.
- The demand management measures described in Section 6 will be implemented over the next ten years, beginning in 2026, at an annual program cost of \$2.2 million including \$0.8 million annual program delivery cost and \$1.4 million annual investment in parks asset renewal.
- The Groundwater Execution Plan described in Section 7 will be implemented in 2026 and 2027 at a cost of \$0.5 million, including performance monitoring and optimization of the existing City wells and exploration of potential new groundwater sources. The cost of developing a new groundwater source is not included in the ten-year forecast based on the assumption that such a project would only proceed if either:
  - It is more cost-effective than developing a new surface water source and yields equivalent benefit in terms of water supply capacity and reliability for the City's projected needs, and would replace that project; or
  - It cost-effectively enables the surface water project to be delayed by several years.
- No electricity generation project is included in the ten-year forecast, on the basis that the projects evaluated for this study are not expected to yield sufficient benefit to justify their cost.
- All cost estimates are in 2025 constant dollars, with an uncertainty margin of at least  $\pm 50\%$ .

The overall ten-year program has a total cost of \$46.5 million and an annual average cost of \$4.65 million in 2025 dollars.



**Figure 10-3: Ten-Year Financial Forecast (2025 Dollars)**

## 10.7 Long Term Financial Forecast

Figure 10-4 shows a forecast from 2036 to 2075 in 2025 constant dollars, including timing of supply system upgrades, estimated operation and maintenance costs of new infrastructure developed based on this plan, and ongoing program delivery based on this plan. Long-range financial forecasts are inherently highly uncertain. The forecast is based on the following estimates and assumptions, with reference to previous sections of this report:

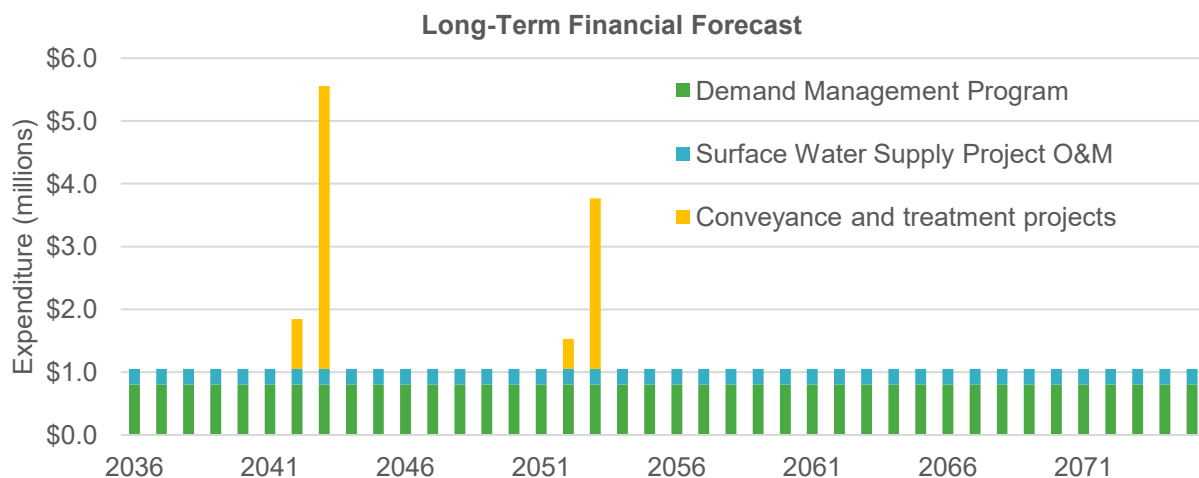
- Annual O&M cost of the completed surface water supply project is \$0.25 million.
- Upon completion of Parks asset renewal projects to reduce seasonal irrigation demand, the core demand management program continues at an annual cost of \$0.8 million.
- Conveyance and treatment capacity upgrade projects will be completed when needed based on groundwater and demand management measures successfully implemented within the next ten years, each including 15% of project cost in the first year for design and 85% in the second year for construction:

- ERWS water treatment capacity upgrade – \$5.5 million, 2042 - 2043.
- High lift pump station upgrade – \$1.6 million, 2052 - 2053.
- Raw water pump station upgrade – \$1.6 million, 2052 - 2053.

O&M costs of upgraded treatment and conveyance projects are not significantly higher than current costs.

- All cost estimates are in 2025 constant dollars, with an uncertainty margin of at least  $\pm 50\%$ .

The combined annual average cost of these measures is \$1.28 million in 2025 dollars.



**Figure 10-4: Long-Term Financial Forecast (2025 Dollars)**

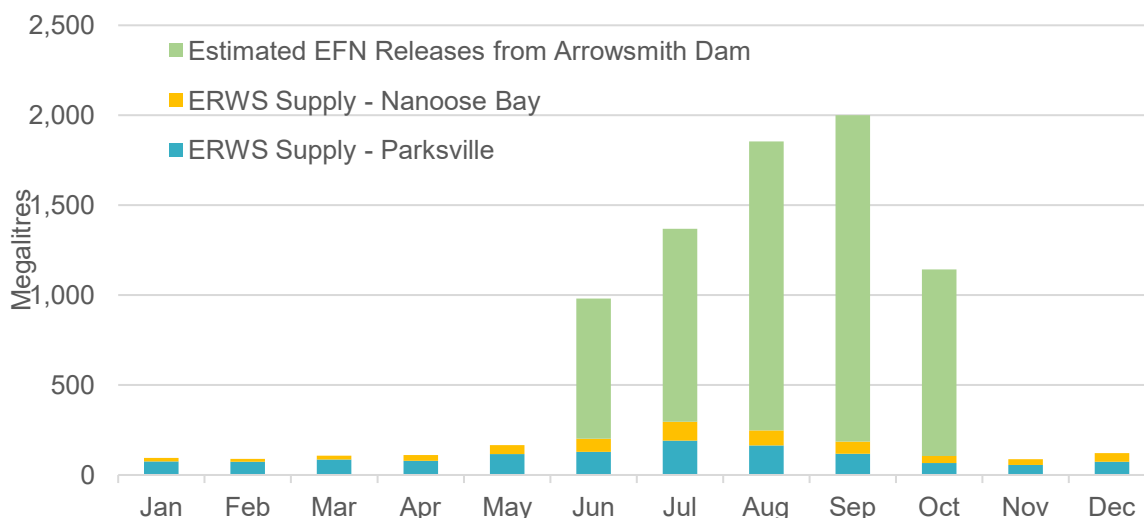


## 11. Summary and Recommended Actions

### 11.1 Key Findings

The following key findings are based on the review and analysis of available background documents and data, field review, and discussion with City and RDN staff:

1. Environmental flow need (EFN) dominates the reliability of the ERWS source (Figure 11-1). Based on analysis of current demands using 1981 - 2010 historical weather data, the reliability of the ERWS source is estimated to be 70%. Current reliability is thought to be somewhat lower as a result of climate change that has occurred since the baseline period as evidenced by watering restrictions have been escalated to Stage 3 or 4 in seven of the past ten years.



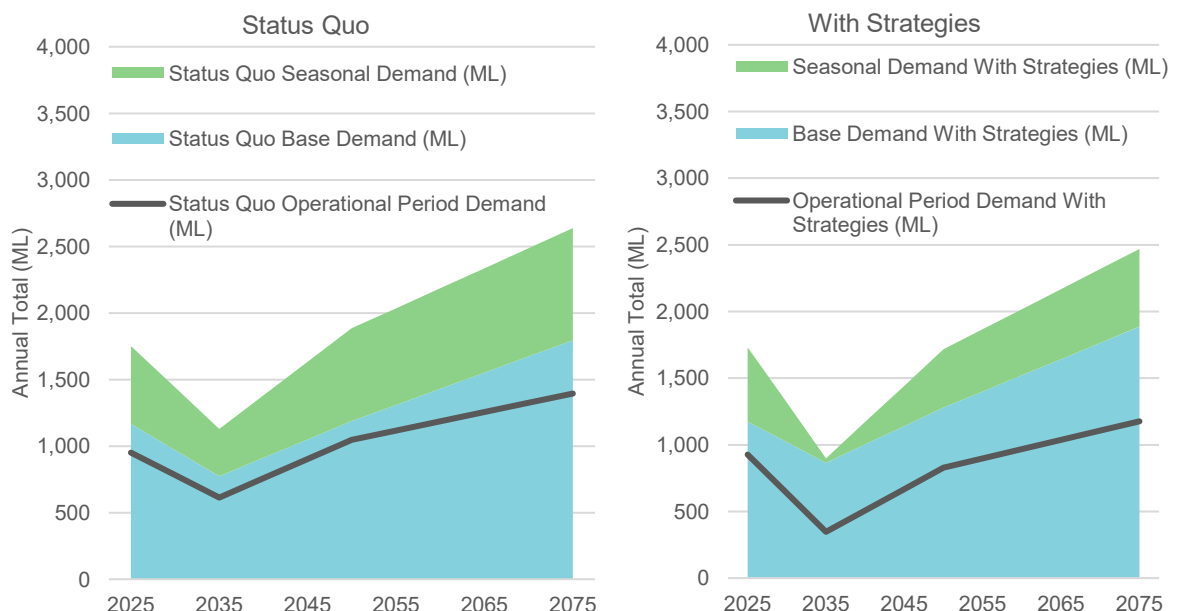
**Figure 11-1: Estimated 2024 ERWS Supply Flows and EFN Releases**

2. Reliability of the ERWS source cannot be significantly improved without a major surface water supply project, and is forecasted to deteriorate nominally to 60% by 2035 under a status quo scenario driven by climate change and demand growth. Given the low current reliability and the declining trend, a supply project will be required as soon as practicable; preferably within 10 years. Potential options assessed for this project are estimated to cost in broad range of \$7 to \$30 million, and most likely in the range of \$14-29 million, depending on the site and configuration selected.
3. Both the existing City and Nanoose Bay groundwater sources provide important capacity and flexibility for managing demands on the ERWS source and supply system; however, the source aquifers have limited capacity and are highly stressed:
  - a. Some of the City wells exhibited stress under higher use before the ERWS upgrades entered service in 2020; however, withdrawal rates have also varied widely day-to-day with combined totals for the Railway and Springwood wells ranging from 0-7 ML/d throughout the year. Optimization of the operation of the City's wells with the advice of a hydrogeologist may enable the groundwater source to reduce demands on the ERWS source during the operating period.

- b. The Nanoose groundwater source is currently operated at about 30% of its estimated sustainable capacity of 3.5 ML/d in favour of utilizing the ERWS source. It is planned to increase the use of this groundwater source to capacity before upgrading the ERWS water treatment plant.

Through optimization of both the Parksville and Nanoose groundwater sources it is estimated that groundwater can sustainably supply at least 7.3 ML/d on maximum day and 6.2 ML/d average during the operating period.

4. In combination with groundwater optimization, implementing a 10-year water demand management strategy can prevent a reduction of surface water supply reliability within the next ten years, reduce reliance on the ERWS for community water supply in drought cycles, and help to defer the need for increasing the capacities of treatment and pumping facilities by years or decades. It is estimated that in combination, demand management and groundwater optimization strategies will reduce demand on the ERWS source by 266 ML (1.94 ML/d) during the operating period relative to the status quo (Figure 11-4). These measures will serve an important purpose for water security until a new surface water source can be brought online. The deferral of water treatment and conveyance capacity upgrades that would likely result from implementing these strategies has a present value benefit in the order of \$1.0 million (2025 dollars).



**Figure 11-2: Impact of Strategies on ERWS Source Forecast**

5. There is potential for development of a new groundwater source; however, it is unlikely that groundwater can eliminate the need for development of a surface water source. Due to climate change, the reliability of the ERWS source for supplying EFN will require a capacity increase in the order of 0.2 m<sup>3</sup>/s (17.3 ML/d) during the operating period, which is nearly three times the combined sustainable capacity of the existing City and Nanoose Bay groundwater sources. An additional 5 ML/d annual average and 15 ML/d maximum day supply capacity increase is estimated to be needed to supply the combined 2075 demands for the City and Nanoose Bay. Potential groundwater strategies include:

- a. Aquifer 221 has potential to augment current sources and may be a viable strategy to augment ERWS source reliability before a new surface water source can be developed. The aquifer underlies part of the Parksville distribution system so the cost of interconnection may be minimal; however, treatment may be necessary.
  - b. Aquifer 1252 and unmapped South Englishman sand and gravel aquifer: Given the distances from the Parksville distribution system, developing and connecting a supply from either of these potential sources is likely to be similar in overall cost to developing a new surface water source, and is therefore unlikely to be cost-effective.
  - c. Though it was not evaluated in detail as part of this study, aquifer storage and recovery (ASR) is a potentially viable strategy that is currently being assessed by RDN. The outcome of the current RDN study may indicate potential for ASR as a component of a strategy for the City's future water supply.
6. Of the two electricity generation options evaluated under this study, a hydropower project at the Arrowsmith Dam was found not to be financially feasible under BC Hydro's current commercial terms, and a rooftop solar photovoltaic (PV) project at the Englishman River Pump Station was found to be marginally cost-effective with the incentive funding currently available. Neither option yields significant benefit for the ERWS or the City of Parksville water service.

## 11.2 Recommended Actions

The recommended actions based on this study are provided in Table 11-1. It is also recommended that City review the prior scope of work for Phase 2 as per RFP 2240-20-WPS and revise it to include findings from Phase 1 where appropriate.

**Table 11-1: Recommended Actions**

| Recommendation |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Estimated Cost (millions, 2025) | Timeframe   |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-------------|
| 1-5 Years      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                 |             |
| 1              | Review and update the AWS Operating Rule to further optimise the EFN releases from the Arrowsmith Dam Reservoir. This also includes continued engagement with regulators and First Nations relating to ongoing adaptive management of EFN and refine suitability of 1.0 m <sup>3</sup> /s EFN target during drought conditions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | \$0.025                         | 2026        |
| 2              | Complete conceptual design and site selection for a new surface water source: <ul style="list-style-type: none"> <li>Conduct engineering and environmental investigation of candidate sites.</li> <li>Complete detailed feasibility assessment.</li> <li>Confirmation of EFN targets for the South Englishman River to support future water source development.</li> <li>Carry out a structured decision-making process with First Nations, regulators, and other key stakeholders to refine the storage options analysis using results of the detailed feasibility/ screening assessment.</li> <li>Complete further detailed climate analysis to account for the limitations in inter-annual variability in the climate model data.</li> </ul>                                                                                      | \$0.6                           | 2026 - 2028 |
| 3              | Initiate a 10-year demand management plan and program. <ul style="list-style-type: none"> <li>Develop parks and irrigation renewal program plan</li> <li>Develop and implement staffing plan.</li> <li>Develop an AWWA M36 system water audit and water loss management plan.</li> <li>Conduct a water and sewer rate review.</li> <li>Develop an advanced metering infrastructure (AMI) implementation plan.</li> <li>Review watering restriction program.</li> <li>Continue to work with the RDN to enhance the DWWPP to help meet specific watershed protection needs in the Englishman River as they relate to community water supply and EFN.</li> </ul>                                                                                                                                                                        | \$2.2                           | 2026-2027   |
| 4              | Implement groundwater execution plan including: <ul style="list-style-type: none"> <li>Performance monitoring and optimization of existing wells.</li> <li>Groundwater modelling of Aquifers 216, 221 and 1252.</li> <li>Sample collection and water quality testing from existing wells.</li> <li>Development, permitting, and testing of a new well.</li> <li>Optimization of control logic for ERWS and groundwater flows into the distribution system to level peak flowrates and manage impacts on aquifers and EFN during the operating period.</li> <li>Review ASR initiatives recently undertaken by the RDN to determine if deemed successful and whether further assessment is warranted for a potential strategy to increase groundwater use during periods of low surface water flow on the Englishman River.</li> </ul> | \$0.5                           | 2026 - 2027 |
| 5              | Implement demand management and parks and irrigation asset renewal program.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | \$20                            | 2027 - 2036 |



| Recommendation |                                                                                           | Estimated Cost<br>(millions,<br>2025) | Timeframe         |
|----------------|-------------------------------------------------------------------------------------------|---------------------------------------|-------------------|
| 6              | Conduct pre-design, permitting and engagement for new surface water source once selected. | \$0.7                                 | 2029 - 2030       |
| 6-10 Years     |                                                                                           |                                       |                   |
| 7              | Conduct detailed design and procurement for new surface water source.                     | \$0.7                                 | 2031 - 2032       |
| 8              | Construct and commission new surface water source.                                        | \$22                                  | 2033 - 2035       |
| 9              | Ongoing implementation of core demand management program.                                 | \$0.8<br>(annual)                     | 2036 -<br>ongoing |
| 10             | Ongoing operation and maintenance of new surface water source.                            | \$0.25<br>(annual)                    | 2036 -<br>ongoing |
| 11             | Upgrade ERWS water treatment plant capacity.                                              | \$5.5                                 | 2036 - 2037       |
| 12             | Upgrade capacity of High Lift and Raw Water Pump Stations.                                | \$3.2                                 | 2044 - 2045       |





## 12. Report Submission

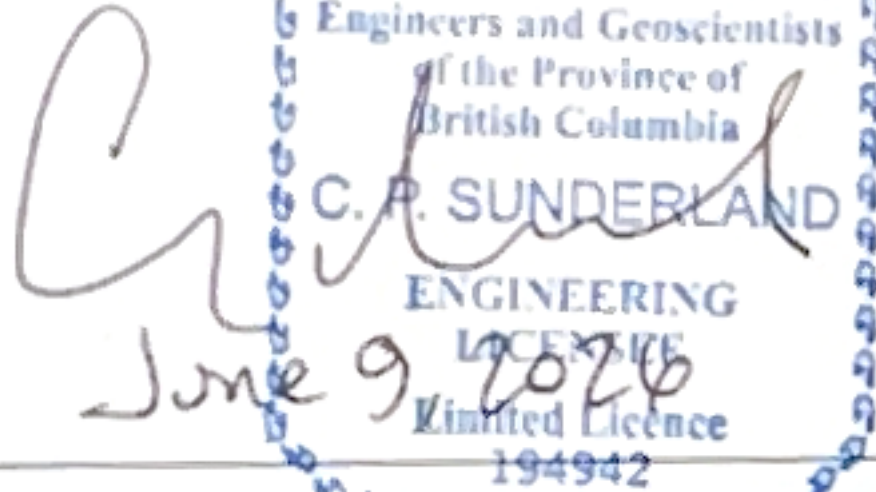
Prepared by:

KERR WOOD LEIDAL ASSOCIATES LTD.



EGBC Permit to Practice:  
1000696

Stephen Bridger, P.Eng. (BC)  
Project Manager



Colwyn Sunderland, A.Sc.T. (BC), P.L.Eng. (BC)  
Demand Management Engineer  
Permit to Practice # 1000696

Craig Sutherland, M.Sc., P.Eng. (BC), IRP  
Water Supply and Climate Change Engineer

Ron Monk, M.Eng., P.Eng. (BC, ON, YT)  
Power Engineer

Reviewed by:

Eric Morris, P.Eng. (BC, ON)  
Technical Reviewer



## Statement of Limitations

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## Revision History

| Revision # | Date         | Status | Revision | Author |
|------------|--------------|--------|----------|--------|
| 0          | June 5, 2026 | Final  |          | SAB    |
|            |              |        |          |        |

## Appendix A

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## Appendix A: References

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## Appendix B

# Task 1 – Water Supply Well Data Compilation and Overview of the Englishman River Aquifers

Waterline Resources Inc.  
March 9, 2026

**TASK 1 – WATER SUPPLY WELL DATA  
COMPILATION AND OVERVIEW OF THE  
ENGLISHMAN RIVER AQUIFERS FOR THE  
CITY OF PARKSVILLE, BRITISH COLUMBIA**

Submitted To:



300A – 4185 Still Creek Drive  
Burnaby BC, V5C 6G9

Submitted By:

Waterline Resources Inc.  
Nanaimo, British Columbia  
March 09, 2026  
3917-24-001



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## **1.0 INTRODUCTION**

### **1.1 Background**

The City of Parksville (Parksville) is undertaking a comprehensive water supply study to be completed in two phases. In Phase 1, a Water Use Planning and Management Study will be completed to assess future water supply and demand scenarios and options, and current and future risks to their water supply. The Phase 1 Study will inform a feasibility study in Phase 2, which should be reviewed congruently with ongoing investigations by other local municipalities (i.e., Qualicum Bay) and the Regional District of Nanaimo (RDN).

The Phase 1 Study is being managed by Kerr Wood Leidal Consulting Engineers (KWL). KWL retained Waterline Resources Inc. (Waterline) to provide technical hydrogeological support. As part of this scope, Waterline will provide the following reports, with relevant information to be incorporated into KWL's final Phase 1 Study:

- *Task 1 – Water Supply Well Data Compilation and Overview of the Englishman River Aquifers*
- *Task 2 – Hydrogeological Assessment of Parksville's Water Supply Well Operations and the Englishman River Aquifers*
- *Task 3 – Groundwater Supply Resilience Planning*

### **1.2 Objectives and Scope of Work**

The objective of Task 1 was to review and compile relevant technical groundwater data for analysis in Task 2. To help meet this objective, Waterline completed the following tasks:

- Reviewed the relevant regulatory requirements for groundwater licensing, development and quality in BC;
- Reviewed and compiled groundwater use, and chemistry data provided by Parksville for the current groundwater system; and
- Reviewed and compiled publicly available hydrogeological data and aquifer mapping for the Englishman River watershed, encompassing Parksville's municipal boundary (the Study Area).

## **2.0 REGULATORY CONSIDERATIONS**

### **2.1 Groundwater Licensing**

The BC *Water Sustainability Act* (WSA; BC Government, 2025a) and associated regulations came into effect on February 29, 2016. The WSA is intended to protect groundwater resources in BC and requires licensing of non-domestic groundwater use (e.g., water systems, irrigation, commercial or industrial use) in the Province.



Use of a groundwater source for supplying communities must be licensed under the WSA, including use of any volume of groundwater that exceeds previously authorized water use (i.e., existing use groundwater licence). As such, a new use licence application must be submitted and approved by the BC Ministry of Water, Land and Resource Stewardship (WLRS) before the groundwater can be extracted and/or beneficially used. Applications may be referred to provincial and federal government agencies, and Indigenous groups in the area may be consulted. Additionally, affected landowners, licensees and riparian landowners may be notified of the application and given a chance to respond.

The application for an existing use groundwater licence allows the applicant to continue beneficially using groundwater for the same purpose(s) and volume(s) used prior to the enactment of the WSA in 2016, until WLRS adjudicates the application (BC Government, 2025a). Upon receiving an approved licence, licensees must comply with provisions of the WSA and its regulations, the terms and conditions of the licence, and orders under the WSA.

The WSA requires land use authorization(s) to accompany a Water Use Licence, whether that be for municipal or private lands, provincial crown land, federal crown land (e.g., parks and protected areas) or Indigenous land. Specific consideration should be taken:

- If the water system infrastructure will cross or otherwise affect provincial crown land, a Permit over Crown Land may be required, and can be applied for as part of a Water Use Licence application under the WSA, Section 24 (BC Government, 2025a). If a Permit over Crown Land is not sufficient for the water use purpose(s), quantity, and/or proposed works, a Crown Land Tenure under the BC *Land Act* (BC Government, 2025b) may be required.
- If any work will occur within a public road allowance and/or cross a public road, a BC Ministry of Transportation and Transit (MOTT) authorization may be required.
- If the water system infrastructure will cross or otherwise affect federal crown land, authorization(s) under the *Canada National Parks Act* (MoJ, 2024) and its applicable regulations may be required.
- If the water system infrastructure will cross or otherwise affect Indigenous reserve land, a federal crown land use authorization from Crown-Indigenous Relations and Northern Affairs (CIRNAC) may be required. Consultation and terms of negotiation with the affected Indigenous council or individual(s) are required as part of this authorization process.

Submission of a WSA New Use Licence application could trigger an archaeology assessment by FrontCounter BC (FCBC) to determine whether the proposed activities are likely to impact a protected archaeological site within the project area. Depending on the level of archaeological potential determined, the applicant may be required to engage an accredited archaeologist to obtain *Heritage Conservation Act* (BC Government, 2025c) permit(s) and conduct archaeological assessment(s) before a WSA New Use Licence can be issued.

WSA licensing is not generally required for groundwater used for domestic purposes (i.e., the use of water for household purposes by the occupants of one or more private dwellings located on a single parcel of land), as per Section 22(8) of the WSA. Each private dwelling on a parcel is

authorized to use up to 2.0 cubic metres per day ( $\text{m}^3/\text{day}$ ) or the amount of groundwater the engineer is satisfied the person has been using for domestic purposes (BC Government, 2025a).

All groundwater users are encouraged to register their wells with the Ministry of Environment and Parks (ENV), so that a record of water use is created in the provincial Groundwater Wells and Aquifers (GWELLS; ENV, 2025) database. Well registration and documentation of groundwater use help to ensure that all users are considered in decision making and during times of water scarcity.

## 2.2 Groundwater Development

Groundwater development must ensure the water source is protected. Regulatory standards listed in the WSA *Groundwater Protection Regulation* (GWPR; BC Government, 2022) set out several offset distances and conformance requirements for development of new groundwater wells and operation of existing wells. Guidelines for testing and assessing groundwater, so that existing groundwater users and the receiving environment are protected, are summarized in the *Guidelines for Technical Assessment Requirements in Support of an Application for Groundwater Use in British Columbia* (Todd et al., 2020). Licensing individual water supply wells (WSWs) or well fields with capacities greater than 75 litres per second (L/s;  $6,480 \text{ m}^3/\text{day}$ ) require referral to the BC Environmental Assessment Office (EAO et al., 2019), resulting in greater scrutiny of the licence application.

Assessment of aquifer vulnerability is also important for groundwater development. The BC Aquifer Classification System (WLAP, 2002) categorizes aquifers according to the:

1. Level of aquifer development. Aquifer development is assessed based on the balance of water supply vs. water demand. If such assessment has not been completed, aquifer development can also be rated based on the number of registered groundwater wells; and
2. Level of aquifer vulnerability to surface contamination. Vulnerability is based on the hydrogeological properties of the aquifer and not the type of surface contamination present.

## 2.3 Groundwater Quality

### 2.3.1 Groundwater Systems

Supplying water to two or more residences is considered a water supply system as defined by the BC *Drinking Water Protection Act* (DWPA; BC Government, 2025d). The DWPA requires that a Construction Permit and a Permit to Operate be issued by the regional health authority (i.e., Island Health), in accordance with the DWPA *Drinking Water Protection Regulation* (DWPR; BC Government, 2025e) prior to operating any new water source that will be connected to an existing water system.

### 2.3.2 Groundwater Source Protection

Surface water contaminants such as pathogenic bacteria and viruses can be of concern to a community water supply, particularly when groundwater is found to be in direct hydraulic communication with the ground surface. As such, a groundwater source assessment should be completed in accordance with the BC Ministry of Health (MoH) *Guidance Document for Determining Groundwater at Risk of Containing Pathogens* (GARP; MoH, 2017), as part of operational approval of a groundwater system.

The Ministry of Health, Leisure, and Sport (MHLS) *Comprehensive Drinking Water Source-to-Tap Assessment Guideline* (CS2TA; MHLS, 2010) also serves as a tool to develop a comprehensive understanding of the measures that can be taken to ensure safety and security of a groundwater source. The CS2TA is generally used to inform a wellhead protection plan, which is often conditional upon receiving source water approval or a water system operating permit from the regional health authority.

For coastal BC, the potential for saltwater intrusion into an aquifer must also be considered and assessed. Under Section 58 of the WSA (BC Government, 2025a), it is prohibited to operate a well in a manner that causes intrusion of saline water into the aquifer. According to the *Best Practice for Prevention of Saltwater Intrusion* published by the former BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD, 2016), wells completed in aquifers adjacent to the coast containing groundwater with chloride concentration greater than 150 milligram per litre (mg/L), electrical conductivity greater than 1,000 microsiemens per centimetre ( $\mu\text{S}/\text{cm}$ ), or a total dissolved solids (TDS) concentration greater than 700 mg/L, are deemed to be affected by saltwater intrusion. These thresholds have been established as operational objectives, and a groundwater well should only be pumped if it can produce a water quality that does not exceed these threshold values (FLNRORD, 2016).

Mitigative measures to protect groundwater resources from impacts related to saltwater intrusion include completing a new groundwater well in a location that is greater than 50 metres (m) from the coastline and limiting drawdown below sea level during operation of the WSW (FLNRORD, 2016).

## 3.0 METHODOLOGY

### 3.1 Document Review and Conceptual Site Model Development

To assess hydrogeological conditions across the Study Area, publicly available data were reviewed using Waterline's proprietary Enviro Web Services (EWS) geodatabase system. Data inputs relevant to the Study Area were also obtained from Parksville. A list of the public and private digital data sources used in this assessment is provided in Table 1.

**Table 1: Public and Private Digital Data Sources for the Study Area**

| Data Source                                                   | Reference                                                      |
|---------------------------------------------------------------|----------------------------------------------------------------|
| <b>City of Parksville Data</b>                                |                                                                |
| WSW Groundwater Chemistry Data                                | Parksville, 2010-2024                                          |
| WSW Operations Data (Use and Water Level)                     | Parksville, 2012-2024                                          |
| WSA Existing Use Groundwater Licence Applications             | Parksville, 2016-2017                                          |
| Land Use / Zoning                                             | Parksville, 2024                                               |
| Water System Infrastructure                                   | Parksville, 2024                                               |
| <b>Public Data</b>                                            |                                                                |
| Cadastral Data (Land Parcels, Indigenous lands)               | ParcelMap BC Parcel Fabric, 2022                               |
| Municipal Boundary                                            | Tantalus – Municipalities, October 2016                        |
| Watershed Data                                                | FLNRORD Freshwater Atlas, July 2022                            |
| Streams and Waterbodies                                       | FLNRORD Freshwater Atlas, September 2017                       |
| Aquifer Mapping, Water Wells and Provincial Observation Wells | BC Groundwater Wells and Aquifers database (GWELLS), June 2025 |
| Surficial and Bedrock Geology                                 | Geological Survey of Canada; Russell and Benoit, 2016          |

**Notes:** ENV denotes Ministry of Environment and Parks; FLNRORD denotes Ministry of Forests, Lands, Natural Resource Operations and Rural Development; WSA denotes *Water Sustainability Act*; WSW denotes water supply well.

The digital data sources were combined with hydrogeological data from local and regional studies prepared by consultants and provided by Parksville. A list of the consultant reports that were reviewed is provided in Table 2.

**Table 2: Available Groundwater Related Reports for the Study Area**

| No. | Title                                                                                                        | Location             | Author, Date    |
|-----|--------------------------------------------------------------------------------------------------------------|----------------------|-----------------|
| 1   | Water Budget Project: RDN Phase One (Vancouver Island)                                                       | RDN                  | Waterline, 2013 |
| 2   | State of Our Aquifers, Regional District of Nanaimo, Aquifer 216                                             | RDN                  | GWS, 2017       |
| 3   | State of Our Aquifers, Regional District of Nanaimo, Aquifer 219                                             | RDN                  | GWS, 2017       |
| 4   | State of Our Aquifers, Regional District of Nanaimo, Aquifer 220                                             | RDN                  | GWS, 2017       |
| 5   | Water Quality and Quantity Risk Assessment for RDN Electoral Area F                                          | RDN Electoral Area F | GWS, 2020       |
| 6   | Refined Water Budget (Phase 3) for Nanoose (Electoral Area E)                                                | Nanoose              | Golder, 2020    |
| 7   | Assessment of Groundwater at Risk of Containing Pathogens (GARP), Railway Station Well Field, Parksville, BC | Parksville           | WSP, 2023       |
| 8   | Refined Water Budget (Phase 3) for French Creek                                                              | French Creek         | WSP, 2023       |
| 9   | Regional Groundwater Level Analysis Pre-Summer 2024                                                          | RDN                  | RDN, 2024       |

**Notes:** Golder denotes Golder Associates Inc.; GWS denotes GW Solutions Inc.; RDN denotes Regional District of Nanaimo; Waterline denotes Waterline Resources Inc.; WSP denotes WSP Canada Inc.

## 3.2 Performance Monitoring Program

Parksville's WSW performance monitoring program consists of the following tasks:

- Collecting groundwater levels and groundwater use data for active wells using Parksville's Supervisory Control and Data Acquisition (SCADA) system.

- Performing visual inspection of the WSW wellheads, measuring groundwater levels for calibration of pressure transducers and completing maintenance (well rehabilitation) as required.
- Sampling of raw groundwater for analysis of general chemistry and major ions, total metals, and microbiological parameters by an accredited laboratory.

### 3.3 Performance Monitoring Data Compilation and Review

Waterline compiled the historical groundwater level data, groundwater use data and groundwater chemistry results from the active WSWs and generated groundwater level hydrographs, water use charts and summary data tables.

For assessing sustainable operation of Parksville's WSWs, historical groundwater level data was reviewed to ensure the drawdown at each well did not exceed 70% of the available head in the well, calculated between the static groundwater elevation and the top of screen elevation. This threshold level is a best practice guideline stipulated by ENV for *Evaluating Long-term Well Capacity for a Certificate of Public Convenience and Necessity* (ENV, 1999). By maintaining drawdown to less than the 70% threshold level during prolonged pumping, the potential for localized dewatering of the aquifer is minimized, also providing a buffer for seasonal fluctuations in groundwater levels.

Parksville's groundwater analytical data was used to assess potential increasing trends in indicator parameter concentrations. As defined by the best practices for operations of water wells, Calcium (Ca), Magnesium (Mg), Iron (Fe), Manganese (Mn), Chloride (Cl), Electrical Conductivity (EC), Turbidity, TDS, Total Coliforms and Heterotrophic Plate Count (HPC) can be used to indicate deteriorating well conditions or impacts to aquifer conditions from anthropogenic sources or saltwater intrusion (Hanna et al., 2016).

## 4.0 CITY OF PARKSVILLE GROUNDWATER SYSTEM

### 4.1.1 Water Supply Well Network

Parksville currently sources groundwater from 16 active WSWs to supplement their surface water supply; all WSWs are registered in GWELLS. The active WSWs all divert water from Aquifer 216 (ENV, 2025) and are located within two well fields; the Railway Station Well Field and the Springwood Well Field (Figure 1). Both well fields are located within Parksville's municipal boundary north of Highway 19 and are greater than 1 kilometre (km) from the coastline. Construction details for the WSWs, obtained from provincial well records, reports and record drawings are summarized in Table 3 and photographs of each WSW location are included in Appendix A.



**Table 3: Construction Details for the City of Parksville Water Supply Wells**

| WSW Name                   | WTN    | WIN    | Well Completion Date | UTM Coordinates (Zone 10) |          | Top of Screen Assembly (mbgl) | Base of Screen (mbgl) | Screen Length (m) | Photos |
|----------------------------|--------|--------|----------------------|---------------------------|----------|-------------------------------|-----------------------|-------------------|--------|
|                            |        |        |                      | Easting                   | Northing |                               |                       |                   |        |
| Railway Station Well Field |        |        |                      |                           |          |                               |                       |                   |        |
| RSW 1                      | 107055 | 13575  | 1990-08-22           | 404180                    | 5462495  | 23.8                          | 30.5                  | 6.7               | A1     |
| RSW 2                      | 107040 | 13758  | 1994-02-16           | 404095                    | 5462509  | 25.9                          | 32.3                  | 6.4               | A2     |
| RSW 3                      | 107046 | 13759  | 1994-03-11           | 403992                    | 5462510  | 20.4                          | 25.3                  | 4.9               | A3     |
| RSW 4                      | 107092 | 13760  | 1995-04-19           | 404144                    | 5462557  | 17.6                          | 22.5                  | 4.9               | A4     |
| RSW 5                      | 107094 | 13761  | 1996-03-20           | 404106                    | 5462430  | 28.7                          | 35.9                  | 7.2               | A5     |
| RSW 6                      | 107096 | 13762  | 1996-04-22           | 404199                    | 5462424  | 29.1                          | 36.6                  | 7.5               | A6     |
| RSW 7                      | 107099 | 13763  | 1997-03-01           | 404002                    | 5462438  | 25.2                          | 32.1                  | 6.9               | A7     |
| RSW 8                      | 96288  | 28169  | 2008-09-26           | 403226                    | 5462823  | 20.7                          | 28.0                  | 7.3               | A8     |
| Springwood Well Field      |        |        |                      |                           |          |                               |                       |                   |        |
| SW 1                       | 39215  | 13765  | 1978-02-01           | 403026                    | 5462935  | 22.3                          | 30.2                  | 7.9               | A9-10  |
| SW 3                       | 107121 | 13767  | 1983-07-01           | 402977                    | 5463029  | 18.7                          | 25.3                  | 6.6               | A11-12 |
| SW 5                       | 37482  | 13769  | 1977-05-17           | 402820                    | 5463021  | 20.5                          | 30.2                  | 9.7               | A13-14 |
| SW 6                       | 107119 | 13770  | 1988-06-01           | 402766                    | 5463056  | 21.3                          | 30.8                  | 9.5               | A15    |
| SW 7                       | 107111 | 13771  | 1990-04-01           | 402623                    | 5463166  | 30.8                          | 40.2                  | 9.4               | A16    |
| SW 8                       | 107112 | 13772  | 1990-04-01           | 402526                    | 5463254  | 28.8                          | 38.4                  | 9.7               | A17-18 |
| SW 9 <sup>a</sup>          | 48951  | 107110 | 1997-04-25           | 402709                    | 5463262  | 29.2                          | 38.9                  | 9.8               | -      |
| SW 10                      | 95022  | 26062  | 2008-07-16           | 403011                    | 5462957  | 18.2                          | 25.6                  | 7.4               | A19    |
| SW 11                      | 95023  | 26069  | 2008-05-17           | 402901                    | 5462984  | 19.9                          | 27.3                  | 7.4               | A20    |

**Notes:** mbgl denotes metres below ground level; mbtoc denotes metres below top of casing; RSW denotes Railway Station Well; SW denotes Springwood Well; UTM denotes Universal Transverse Mercator; WIN denotes Well Identification Number; WTN means Well Tag Number; <sup>a</sup> Indicates that the well is inactive; - indicates no data available.

It should be noted that Parksville has one inactive well, Springwood Well (SW) 9, located within the Springwood Well Field (Table 3) and completed in Aquifer 216. This well is flowing artesian and is scheduled to be decommissioned due to well integrity issues. Two WSWs, SW 2 and SW 4, were decommissioned in 2014 and 2015, respectively. The well construction details for the decommissioned WSWs were not included in Table 3.

Parksville's SCADA system controls operation of the WSWs. The WSWs are not pumped continuously and are cycled on and off throughout the day based on system demand and reservoir levels. Reservoir levels are used to initiate a well pump to start and stop, and a predetermined pumping cycle signals which well should go into service. By consequence, this allows the groundwater level at each well to partially recover towards static levels before the next pumping sequence is initiated. Groundwater level data including static groundwater levels and available head for each WSW is included in Table 4.

**Table 4: Groundwater Level Data for City of Parksville Active Water Supply Wells**

| WSW Name                          | Ground Elevation (masl) <sup>a</sup> | Top of Casing Elevation (masl) | Top of Screen Assembly Elevation (masl) | Static Groundwater Elevation (masl) <sup>b</sup> | Transducer Elevation (masl) | Available Head (m) | 70% of the Available Head Elevation (masl) <sup>c</sup> |
|-----------------------------------|--------------------------------------|--------------------------------|-----------------------------------------|--------------------------------------------------|-----------------------------|--------------------|---------------------------------------------------------|
| <b>Railway Station Well Field</b> |                                      |                                |                                         |                                                  |                             |                    |                                                         |
| RSW 1                             | 58.35                                | 58.63                          | 34.55                                   | 46.58                                            | 38.58                       | 12.03              | 38.16                                                   |
| RSW 2                             | 58.61                                | 58.91                          | 32.73                                   | 47.04                                            | 33.74                       | 14.31              | 37.02                                                   |
| RSW 3                             | 58.50                                | 58.91                          | 38.14                                   | 47.22                                            | 38.32                       | 9.08               | 40.86                                                   |
| RSW 4                             | 53.20                                | 53.50                          | 35.60                                   | 46.65                                            | 36.85                       | 11.05              | 38.92                                                   |
| RSW 5                             | 63.38                                | 63.75                          | 34.67                                   | 46.67                                            | 36.57                       | 12.00              | 38.27                                                   |
| RSW 6                             | 62.63                                | 63.00                          | 33.53                                   | 46.62                                            | 37.12                       | 13.09              | 37.46                                                   |
| RSW 7                             | 63.21                                | 64.38                          | 38.03                                   | 47.51                                            | 39.11                       | 9.48               | 40.87                                                   |
| RSW 8                             | 56.66                                | 56.93                          | 35.93                                   | 49.56                                            | 36.40                       | 13.63              | 40.02                                                   |
| <b>Springwood Well Field</b>      |                                      |                                |                                         |                                                  |                             |                    |                                                         |
| SW 1                              | 56.10                                | 56.42                          | 33.85                                   | 49.65                                            | 36.25                       | 15.80              | 38.59                                                   |
| SW 3 <sup>d</sup>                 | 47.70                                | 48.11                          | 29.05                                   | 48.19                                            | 27.02                       | 19.14              | 34.79                                                   |
| SW 5 <sup>d</sup>                 | 50.86                                | 51.37                          | 30.34                                   | 51.33                                            | 29.33                       | 20.99              | 36.64                                                   |
| SW 6                              | 53.27                                | 53.75                          | 32.01                                   | 51.92                                            | 34.52                       | 19.91              | 37.98                                                   |
| SW 7 <sup>d</sup>                 | 52.85                                | 53.10                          | 22.05                                   | 53.33                                            | 25.63                       | 31.28              | 31.43                                                   |
| SW 8 <sup>d</sup>                 | 52.05                                | 52.28                          | 23.30                                   | 51.99                                            | 27.69                       | 28.69              | 31.91                                                   |
| SW 10                             | 51.24                                | 51.46                          | 22.09                                   | 49.25                                            | 32.55                       | 27.16              | 30.24                                                   |
| SW 11                             | 51.63                                | 51.90                          | 33.43                                   | 49.97                                            | 31.57                       | 16.54              | 38.39                                                   |

**Notes:** m denotes metres; masl denotes metres above sea level; RSW denotes Railway Station Well; SW denotes Springwood Well; WSW denotes water supply well; <sup>a</sup> indicates the ground elevation was taken from the engineered drawing of the well or Lidar data; <sup>b</sup> indicates the static groundwater elevation was measured between December 13-20, 2024; <sup>c</sup> indicates available head is calculated between the static groundwater elevation and the top of screen elevation; <sup>d</sup> Indicates well is flowing artesian.

The flow rate of each WSW is manually controlled at the wellhead with a gate valve; flow rates are typically adjusted twice a year, once during the dry season and once during the wet season. The raw groundwater is treated before being sent to the water distribution system.

#### 4.1.2 Groundwater Licence Applications

As Parksville was beneficially using groundwater prior to the enactment of the WSA in 2016, Parksville was eligible to apply for existing use groundwater licences. Parksville submitted existing use groundwater licence applications in 2016/2017 to FCBC for the 16 active WSWs (Table 5).

The total licence application diversion rate is 3,298 m<sup>3</sup>/day, or an annual diversion volume of 1.2 x 10<sup>6</sup> cubic metres (m<sup>3</sup>), as summarized in Table 5. The individual WSW diversion rates applied for are based on historical water use; the Railway Station Wells' diversion rates are based on

Parksville's 2014 annual diversion volumes and the Springwood Wells' diversion rates are based on Parksville's 2016 annual diversion volumes.

As existing groundwater users are authorized to continue making beneficial use of groundwater through their existing use applications under the authority of Section 140 of the WSA (BC Government, 2025a) but new water use applicants are not, WLRS is prioritizing the review and approval of new use licence applications over existing use applications. As such, the timeline for Parksville receiving conditional approval for their existing groundwater use is currently undetermined.

**Table 5: Groundwater Licence Application Volumes for City of Parksville Active Water Supply Wells**

| Well Field                                           | WSW Name | WSA Existing Use Groundwater Licence Application Information |                   |                      |
|------------------------------------------------------|----------|--------------------------------------------------------------|-------------------|----------------------|
|                                                      |          | Tracking Number                                              | Diversion Volume  |                      |
|                                                      |          |                                                              | m³/day            | m³/year              |
| Railway Station                                      | RSW 1    | 100186482                                                    | 214               | 77,947               |
|                                                      | RSW 2    | 100187401                                                    | 202               | 73,668               |
|                                                      | RSW 3    |                                                              | 80                | 29,257               |
|                                                      | RSW 4    |                                                              | 147               | 53,714               |
|                                                      | RSW 5    | 100187622                                                    | 320               | 116,881              |
|                                                      | RSW 6    |                                                              | 294               | 107,262              |
|                                                      | RSW 7    |                                                              | 146               | 53,252               |
|                                                      | RSW 8    | 100187751                                                    | 230               | 83,839               |
| Cumulative Volume for the Railway Station Well Field |          |                                                              | 1632 <sup>a</sup> | 595,820 <sup>a</sup> |
| Springwood                                           | SW 1     | 100197948                                                    | 98                | 35,755               |
|                                                      | SW 3     | 100202134                                                    | 164               | 59,873               |
|                                                      | SW 5     | 100206306                                                    | 270               | 98,465               |
|                                                      | SW 6     | 100206309                                                    | 134               | 48,747               |
|                                                      | SW 7     | 100197731                                                    | 132               | 48,029               |
|                                                      | SW 8     |                                                              | 340               | 124,182              |
|                                                      | SW 10    | 100188899                                                    | 189               | 69,163               |
|                                                      | SW 11    |                                                              | 339               | 123,788              |
| Cumulative Volume for Springwood Well Field          |          |                                                              | 1665 <sup>b</sup> | 608,002 <sup>b</sup> |
| Total Groundwater Volume                             |          |                                                              | 3,298             | 1,203,822            |

**Notes:** m<sup>3</sup>/day denotes cubic metres per day; m<sup>3</sup>/year denotes cubic metres per year; RSW denotes Railway Station Well; SW denotes Springwood Well; WSA denotes *Water Sustainability Act*; WSW denotes water supply well; <sup>a</sup> Indicates applied diversion volumes are based on Parksville's 2014 annual diversion volumes; <sup>b</sup> Indicates applied diversion volumes are based on Parksville's 2016 annual diversion volumes.

#### 4.1.3 Performance Monitoring Data

Parksville SCADA data is available since 2012. Groundwater use data has been collected daily for the period of 2012 to 2024. Annual diversions for active WSWs over the last 10 years (2015 to 2024) are summarized in Table 6. Hourly minimum and maximum groundwater levels are available for each active WSW since 2022, while prior to 2022, only daily minimum and maximum values were recorded.

**Table 6: Annual Groundwater Use Data for City of Parksville Active Water Supply Wells**

| WSW Name                      | Recorded Annual Diversion (m <sup>3</sup> /year) |                  |                  |                  |                  |                |                |                |                |                |
|-------------------------------|--------------------------------------------------|------------------|------------------|------------------|------------------|----------------|----------------|----------------|----------------|----------------|
|                               | 2015                                             | 2016             | 2017             | 2018             | 2019             | 2020           | 2021           | 2022           | 2023           | 2024           |
| RSW 1                         | 52,539                                           | 60,059           | 69,315           | 55,615           | 74,731           | 58,590         | 40,574         | 45,324         | 48,259         | 29,887         |
| RSW 2                         | 49,652                                           | 87,979           | 87,361           | 118,357          | 102,586          | 76,518         | 74,130         | 75,817         | 58,945         | 48,171         |
| RSW 3                         | 17,871                                           | 22,272           | 25,030           | 33,346           | 44,450           | 31,213         | 32,913         | 31,216         | 24,627         | 30,479         |
| RSW 4                         | 40,110                                           | 36,821           | 47,267           | 33,793           | 53,028           | 46,170         | 29,233         | 28,370         | 35,053         | 47,430         |
| RSW 5                         | 90,901                                           | 68,335           | 87,591           | 65,513           | 91,563           | 74,618         | 46,808         | 49,076         | 71,111         | 90,523         |
| RSW 6                         | 94,979                                           | 79,935           | 87,057           | 36,254           | 49,113           | 20,018         | 54,936         | 78,664         | 58,900         | 87,703         |
| RSW 7                         | 44,251                                           | 51,632           | 57,312           | 20,094           | 83,623           | 33,094         | 21,705         | 52,304         | 51,269         | 66,222         |
| RSW 8                         | 58,591                                           | 64,394           | 75,406           | 57,976           | 60,793           | 0              | 0              | 0              | 0              | 34,384         |
| <i>Total RSW Diversion</i>    | <b>448,895</b>                                   | <b>471,427</b>   | <b>536,338</b>   | <b>420,948</b>   | <b>559,886</b>   | <b>340,221</b> | <b>300,300</b> | <b>360,771</b> | <b>348,164</b> | <b>434,799</b> |
| SW 1                          | 36,878                                           | 35,755           | 35,182           | 35,058           | 29,138           | 23,582         | 0              | 3,792          | 19,877         | 25,833         |
| SW 3                          | 39,711                                           | 59,873           | 43,777           | 65,386           | 56,712           | 44,896         | 34,783         | 33,052         | 37,042         | 44,671         |
| SW 5                          | 89,106                                           | 98,465           | 104,123          | 56,853           | 83,055           | 68,343         | 45,577         | 0              | 34,073         | 65,270         |
| SW 6                          | 38,847                                           | 48,747           | 77,236           | 89,001           | 89,987           | 57,272         | 11,393         | 2,618          | 56,201         | 71,029         |
| SW 7                          | 55,842                                           | 48,029           | 159,161          | 261,428          | 195,314          | 60,870         | 129,410        | 188,125        | 89,673         | 107,934        |
| SW 8                          | 100,348                                          | 124,182          | 127,248          | 128,021          | 95,804           | 52,105         | 96,114         | 38,992         | 80,537         | 106,372        |
| SW 10                         | 66,806                                           | 69,163           | 72,835           | 97,090           | 83,236           | 66,617         | 53,597         | 55,043         | 43,934         | 56,476         |
| SW 11                         | 116,401                                          | 123,788          | 127,188          | 109,867          | 86,382           | 71,344         | 64,512         | 78,779         | 49,734         | 14,935         |
| <i>Total SW Diversion</i>     | <b>543,939</b>                                   | <b>608,003</b>   | <b>746,749</b>   | <b>842,704</b>   | <b>719,628</b>   | <b>445,027</b> | <b>435,388</b> | <b>400,403</b> | <b>411,071</b> | <b>492,520</b> |
| <b>Total Annual Diversion</b> | <b>992,834</b>                                   | <b>1,079,430</b> | <b>1,283,087</b> | <b>1,263,652</b> | <b>1,279,514</b> | <b>785,248</b> | <b>735,688</b> | <b>761,174</b> | <b>759,235</b> | <b>927,319</b> |

**Notes:** m<sup>3</sup>/year denotes cubic metres per year; RSW denotes Railway Station Well; SW denotes Springwood Well; WSW denotes water supply well.

Parksville staff have been collecting raw groundwater quality samples from active WSWs since 2010. A summary of years with available chemistry data between 2010 and 2024 is provided in Table 7. No water quality samples were collected in 2012 or 2015.

**Table 7: Available Groundwater Chemistry Data for City of Parksville Active Water Supply Wells**

| WSW Name                          | 2010 | 2011 | 2013 | 2014 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|-----------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| <b>Railway Station Well Field</b> |      |      |      |      |      |      |      |      |      |      |      |      |      |
| RSW 1                             | -    | -    | X    | -    | -    | X    | -    | -    | -    | X    | -    | X    | X    |
| RSW 2                             | X    | -    | -    | -    | -    | -    | X    | -    | -    | -    | -    | X    | -    |
| RSW 3                             | -    | X    | X    | -    | X    | -    | -    | -    | X    | -    | -    | -    | X    |
| RSW 4                             | -    | -    | -    | X    | -    | -    | -    | -    | -    | -    | X    | -    | -    |
| RSW 5                             | -    | X    | -    | -    | X    | -    | X    | -    | -    | -    | X    | -    | -    |
| RSW 6                             | X    | -    | -    | -    | -    | -    | -    | X    | -    | -    | -    | X    | -    |
| RSW 7                             | -    | -    | -    | X    | -    | -    | -    | -    | X    | -    | -    | -    | X    |
| RSW 8                             | -    | -    | -    | -    | -    | X    | -    | -    | -    | -    | -    | -    | X    |
| <b>Springwood Well Field</b>      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| SW 1                              | -    | -    | X    | -    | -    | X    | -    | -    | -    | -    | -    | X    | -    |
| SW 3                              | X    | -    | X    | -    | -    | -    | -    | -    | X    | -    | -    | -    | X    |
| SW 5                              | -    | X    | -    | -    | X    | -    | X    | -    | -    | -    | X    | -    | X    |
| SW 6                              | -    | X    | -    | -    | X    | -    | -    | -    | X    | -    | -    | -    | X    |
| SW 7                              | X    | -    | -    | -    | -    | -    | -    | X    | -    | -    | -    | X    | -    |
| SW 8                              | -    | -    | -    | X    | -    | X    | -    | -    | -    | X    | -    | -    | X    |
| SW 10                             | -    | -    | -    | -    | -    | -    | X    | -    | -    | -    | X    | -    | -    |
| SW 11                             | -    | -    | -    | X    | -    | -    | -    | X    | -    | -    | X    | -    | -    |

**Notes:** RSW denotes Railway Station Well; SW denotes Springwood Well; WSW denotes water supply well; X indicates data available; - indicates no data available.

It should be noted that Parksville's water quality data was also assessed by WSP Canada Inc. (WSP) as part of a GARP Stage 1 hazard screening and assessment for the Railway Station Well Field (WSP, 2023). Turbidity and bacteriological parameters such as *Escherichia coli* (*E. coli*) and total coliforms were reviewed to assign a groundwater risk rating.

## 5.0 STUDY AREA HYDROGEOLOGY

### 5.1 Regional Scale Mapping

The surficial and bedrock geology on the east coast of Vancouver Island has been extensively mapped. The local surficial deposits consist of post-glacial marine and fluvial sediments overlying successive intervals of unconsolidated, glacial material (Russell and Benoit, 2016; Figure 2). The surficial sediments are underlain by Upper Cretaceous sedimentary bedrock of the Nanaimo Group (Russell and Benoit, 2016). The regionally mapped bedrock and surficial stratigraphy (youngest to oldest) includes:



- **Capilano-Salish Sediments** consisting of post-glacial silt, sand and gravel channel/floodplain deposits (Salish) overlying stratified glacio-fluvial outwash and deltaic sands and gravels, followed by glaciomarine sediments of stoney till-like clay (Capilano);
- **Vashon Till** comprised of massive to stratified sandy diamictons with poorly sorted pebbles to boulders, cemented in a fine clay to sand-size matrix, originating as ice-proximal morainal to surface tills;
- **Quadra Sand** comprised of pro-glacial, homogeneous, stratified and cross-stratified sand with minor gravel and silt. Lower sections contain organic-rich lenses;
- **Dashwood-Cowichan Sediments** consisting of estuarine and fluvial sandy silt and gravel overlying marine clayey silt and sand (Cowichan Head) followed by bedded sand, silt and clay with minor gravel (Dashwood Drift); and
- **Nanaimo Group** consisting of boulder, cobble and pebble conglomerate, coarse to fine sandstone, siltstone, shale and coal.

Provincially mapped aquifers, including Aquifer 216 (ENV, 2025), that intersect with the Study Area are displayed on Figure 3. Aquifer descriptions are included in Table 8.

**Table 8: Description of Mapped Aquifers in the Study Area**

| Aquifer No.                             | Aquifer Location                            | Aquifer Type  | Aquifer Material   | Vulnerability | Productivity |
|-----------------------------------------|---------------------------------------------|---------------|--------------------|---------------|--------------|
| <b>Unconsolidated Sediment Aquifers</b> |                                             |               |                    |               |              |
| 209                                     | Errington; Morison Creek area               | Confined      | Quadra Sediments   | Low           | Moderate     |
| 216                                     | Parksville                                  | Confined      | Quadra Sediments   | Moderate      | Moderate     |
| 219                                     | Nanoose Creek                               | Confined      | Quadra Sediments   | Low           | Moderate     |
| 221                                     | Parksville                                  | Unconfined    | Salish Sediments   | High          | High         |
| 1252                                    | Between Englishman River and Morrison Creek | Unconfined    | Capilano Sediments | High          | Moderate     |
| <b>Fractured Bedrock Aquifers</b>       |                                             |               |                    |               |              |
| 212                                     | Parksville                                  | Confined      | Nanaimo Group      | Low           | Low          |
| 214                                     | Madrona Point / Parksville                  | Semi-Confined | Nanaimo Group      | Moderate      | Low          |
| 220                                     | Errington                                   | Semi-Confined | Nanaimo Group      | Moderate      | Low          |

**Notes:** Aquifer information summarized from GWELLS (ENV, 2025).

There are at least four types of aquifers in the Study Area, including:

1. Shallow alluvial aquifers associated with recent deposition in river/creek valleys. These aquifers are typically unconfined and hydraulically connected to the surface. An aquifer with this type of setting is mapped Aquifer 221;
2. Shallow glacio-fluvial aquifers associated with late-stage glaciation and deposition of Capilano marine sediments. These deposits are layered and may form shallow unconfined or confined aquifers away from the creek/river valleys. An aquifer with this type of setting is mapped Aquifer 1252;

3. Glacio-fluvial or pre-glacial aquifers related to the deposition of the Quadra sediments. The Quadra Sand unit is a major regional aquifer within the Nanaimo lowlands and is confined from surface by a dense till unit referred to as the Vashon till. Major creeks and rivers have eroded through the Vashon till, exposing the Quadra Sand unit at ground surface. Aquifers with this type of setting are mapped Aquifers 209, 216 and 219; and
4. Fractured bedrock of the Nanaimo group. Aquifers with this type of setting are mapped Aquifers 212, 214, and 220.

Hydrogeological cross-section traces for the Springwood Well Field and Railway Station Well Field are included on Figure 4 and individual cross-sections are shown on Figure 5 to Figure 8. Figure 5 and Figure 7 show the stratigraphy in a south to north orientation and Figure 6 and Figure 8 show the stratigraphy in a west to east orientation. The cross-sections include the regionally mapped bedrock and surficial stratigraphy from select Parksville WSWs and adjacent registered wells from GWELLS (ENV, 2025). Measured static groundwater levels are posted for the Parksville WSWs, helping to convey the piezometric head elevation for Aquifer 216, which is flowing artesian near the Springwood Well Field (Figure 5 and Figure 6).

## 5.2 Regional Scale Groundwater Use

GWELLS categorizes groundwater use types per well for the purposes of tracking and regulating groundwater diversion in BC. Table 9 summarizes the number of provincially registered wells correlated to each aquifer identified in the Study Area, along with a breakdown of use types, number of approved WSA licences, and the total volume of groundwater licensed.

**Table 9: Groundwater Use Types and Licensing in the Study Area Aquifers**

| Aquifer No.                      | Correlated Registered Wells | Wells with Groundwater Use Type |             |                                    |                    | Approved WSA Licenses | Total Licensed Groundwater Volume (m³/year) <sup>c</sup> |
|----------------------------------|-----------------------------|---------------------------------|-------------|------------------------------------|--------------------|-----------------------|----------------------------------------------------------|
|                                  |                             | Domestic                        | Water Works | Commercial-Industrial <sup>a</sup> | Other <sup>b</sup> |                       |                                                          |
| Unconsolidated Sediment Aquifers |                             |                                 |             |                                    |                    |                       |                                                          |
| 209                              | 59                          | 46                              | 1           | 5                                  | 7                  | 2                     | 85,202                                                   |
| 216                              | 225                         | 123                             | 35          | 21                                 | 46                 | 7                     | 107,665                                                  |
| 219                              | 32                          | 10                              | 10          | 6                                  | 6                  | 2                     | 12,200                                                   |
| 221                              | 29                          | 18                              | 6           | 0                                  | 5                  | 0                     | 0                                                        |
| 1252                             | 40                          | 20                              | 0           | 0                                  | 20                 | 0                     | 0                                                        |
| Fractured Bedrock Aquifers       |                             |                                 |             |                                    |                    |                       |                                                          |
| 212                              | 32                          | 9                               | 0           | 7                                  | 16                 | 0                     | 0                                                        |
| 214                              | 42                          | 14                              | 1           | 1                                  | 26                 | 0                     | 0                                                        |
| 220                              | 328                         | 213                             | 7           | 11                                 | 97                 | 1                     | 9,125                                                    |

**Notes:** m<sup>3</sup>/year denotes cubic metres per year; WSA denotes *Water Sustainability Act*; <sup>a</sup> indicates that use type includes golf course and irrigation uses. <sup>b</sup> indicates that use type includes observation wells, dry wells, and wells with unknown use type; <sup>c</sup> indicates that volumes are for approved licences only and do not include licence applications under review. Well information summarized from GWELLS (ENV, 2025).

Wells classified as ‘domestic’ use make up most wells in the Study Area, with Aquifer 209 having the highest percentage of domestic wells at 78%. As domestic wells do not require WSA licensing, this water use is not actively tracked and is not considered as part of the licensed groundwater volume per aquifer. To understand the potential impact on an aquifer’s total groundwater availability, it is assumed that each domestic water well could be diverting up to 2 m<sup>3</sup>/day, as per Section 22(8) of the WSA (BC Government, 2025a).

Parksville’s 16 active WSWs share Aquifer 216 with another 209 wells (total of 225 wells), of which 55% are classified as ‘domestic’ use. ‘Other’ water use types make up the second highest percentage of wells in Aquifer 216, at 20%. ‘Other’ use types include observation wells (typically non-pumping wells), dry wells, and wells with ‘unknown use’ type. Wells classified as ‘unknown use’ were typically constructed prior to the WSA’s well registration requirements and are assumed to be for domestic purposes. Parksville’s WSWs, plus wells registered to several businesses located in Parksville and the surrounding area, make up the 16% of wells classified for ‘Water Works’ use. The remaining 9% of wells are classified for ‘Commercial and Industrial’ purposes, which include golf course and irrigation uses.

At present, licensed groundwater volumes per aquifer are low, correlating with very few approved WSA licences per aquifer. It is assumed that the current licensed volume amounts shown in Table 9 do not reflect the actual groundwater usage volumes, as existing non-domestic groundwater users are most likely also diverting and beneficially using groundwater while they await licence approval from WLRS. An increase in the number of approved licences, and thus licensed groundwater volumes, are to be expected once WLRS issues more new and existing use licences. Note that the total licensed well volume for Aquifer 216 does not include the  $1.2 \times 10^6$  m<sup>3</sup>/year of groundwater that Parksville has applied to license (summarized in Table 5).

### 5.3 Regional Scale Groundwater Monitoring

To improve the understanding of groundwater conditions for potential groundwater shortage response and to build awareness of general groundwater conditions (i.e., water levels and water chemistry), the mapped aquifers within the Study Area are being monitored. The RDN has instrumented and is actively monitoring Volunteer Observation Well (VOW) locations as part of the Volunteer Observation Well Network (VOWN). These data locations are in addition to the observation well (OW) locations managed by ENV as part of the Provincial Groundwater Observation Well Network (PGOWN).

Within the Study Area, there are 17 active VOW and OW locations, as displayed in Figure 3. A summary of the associated OW locations and corresponding aquifer is included in Table 10.

**Table 10: Observation Wells Associated with Mapped Aquifers in the Study Area**

| Aquifer No.                      | Aquifer Location                            | Associated Observation Wells                                     |                     |
|----------------------------------|---------------------------------------------|------------------------------------------------------------------|---------------------|
|                                  |                                             | VOWN                                                             | PGOWN               |
| Unconsolidated Sediment Aquifers |                                             |                                                                  |                     |
| 209                              | Errington; Morison Creek area               | -                                                                | -                   |
| 216                              | Parksville                                  | Fourneau (VOW 01), Hodges (VOW 14)                               | OW304, OW314, OW398 |
| 219                              | Nanoose Creek                               | Sanders (VOW 25)                                                 | OW393, OW395, OW396 |
| 221                              | Parksville                                  | -                                                                | -                   |
| 1252                             | Between Englishman River and Morrison Creek | -                                                                | -                   |
| Fractured Bedrock Aquifers       |                                             |                                                                  |                     |
| 212                              | Parksville                                  | Lowrys (VOW 15)                                                  | -                   |
| 214                              | Madrona Point / Parksville                  | B2 (VOW 30), B3 (VOW 31), B4 (VOW 32), B7, (VOW 33), B9 (VOW 34) | -                   |
| 220                              | Errington                                   | Middlegate (VOW 18)                                              | OW287               |

**Notes:** OW denotes observation well; PGOWN denotes Provincial Groundwater Observation Well Network; VOW denotes volunteer observation well; VOWN denotes Volunteer Observation Well Network; - indicates no data available.

## 6.0 SUMMARY

To support Phase 1 of Parksville’s comprehensive water supply study, Waterline completed this Task 1 report. Task 1 included review of relevant regulatory requirements for groundwater licensing, development and quality in BC, publicly available hydrogeological information for the Study Area, as well as review and compilation of Parksville’s operation data from their groundwater system.

Key takeaways include:

Parksville currently sources groundwater from 16 active WSWs in two well fields, completed in mapped Aquifer 216;

Parksville’s historical (past 10 years) groundwater use has ranged from 735,688 m<sup>3</sup>/year (2021) to 1,283,087 m<sup>3</sup>/year (2017);

- Parksville operates their well fields using a SCADA system, alternating active WSWs to manage aquifer drawdown local to the WSWs; and
- Water levels in the WSWs are collected hourly, and Parksville conducts annual raw water groundwater sampling at select WSWs.

Regionally, within the Englishman River watershed:

- There are five mapped aquifers in unconsolidated sediment and three mapped fractured bedrock aquifers;
- Water levels in these aquifers are monitored through a combination of the PGOWN and VOWN; and
- Groundwater use volume is inferred from a well’s groundwater use type recorded in GWELLS, as domestic use of groundwater does not need to be licensed and reported, and the process of licensing existing non-domestic users is ongoing.

## 7.0 CERTIFICATION

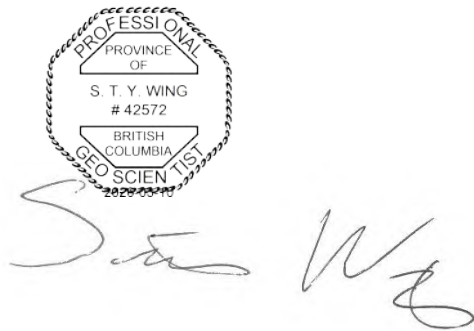
This document was prepared under the direction of a professional geoscientist registered in the Province of British Columbia.

Waterline Resources Inc. trusts that the information provided in this document is sufficient for your requirements. Should you have any questions or concerns, please do not hesitate to contact the undersigned.

Respectfully submitted,

**Waterline Resources Inc.**  
**EGBC Permit No. 1000669**

**Reviewed By:**



Simon Wing, B.Sc., P.Geo.  
Senior Hydrogeologist



Andrew Hinnell, Ph.D., P. Geo  
Principal Hydrogeologist



Steph Righi, B.NRP, RBTech  
Regulatory Specialist



## 8.0 REFERENCES

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## **9.0 LIMITATIONS AND USE**

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## Figures

**Figure 1: Location Map**

**Figure 2: Surficial Geology Map**

**Figure 3: Aquifers Map**

**Figure 4: Cross-Section Traces**

**Figure 5: Hydrogeological Cross-Section Springwood Well Field (A-A')**

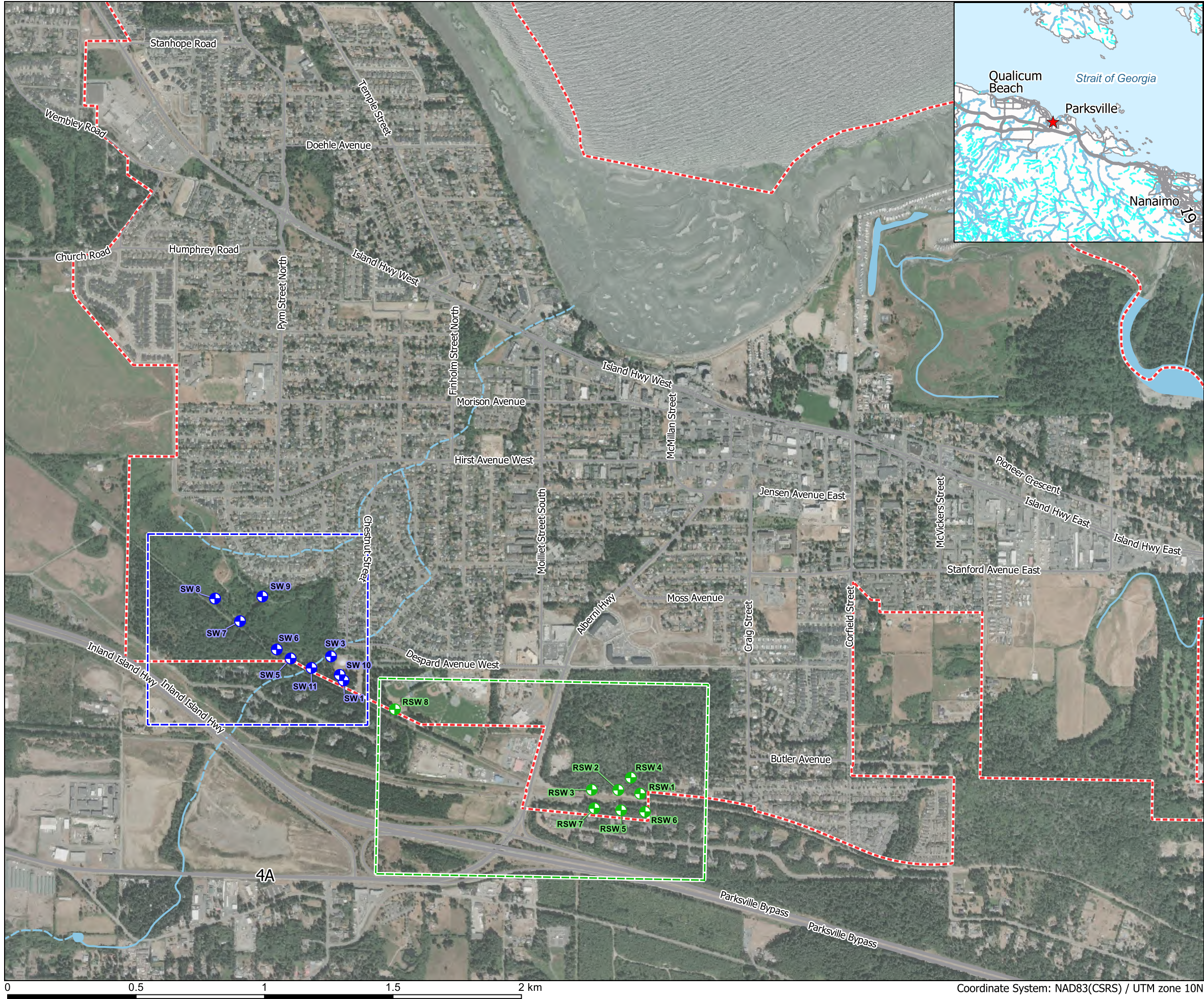
**Figure 6: Hydrogeological Cross-Section Springwood Well Field (B-B')**

**Figure 7: Hydrogeological Cross-Section Railway Station Well Field (C-C')**

**Figure 8: Hydrogeological Cross-Section Railway Station Well Field (D-D')**



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- Springwood Water Supply Well
- Railway Station Water Supply Well
- River/Stream - Definite
- River/Stream - Indefinite
- Road - Expressway / Highway
- Road - Arterial / Collector
- Springwood Well Field
- Railway Station Well Field
- Parkville Municipal Boundary

References:  
Fresh Water Atlas (2017), National Road Network (2016),  
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Englishman River Aquifers City of Parkville, British Columbia  
Submitted to Kerr Wood Leidal Consulting Engineers

### LOCATION MAP



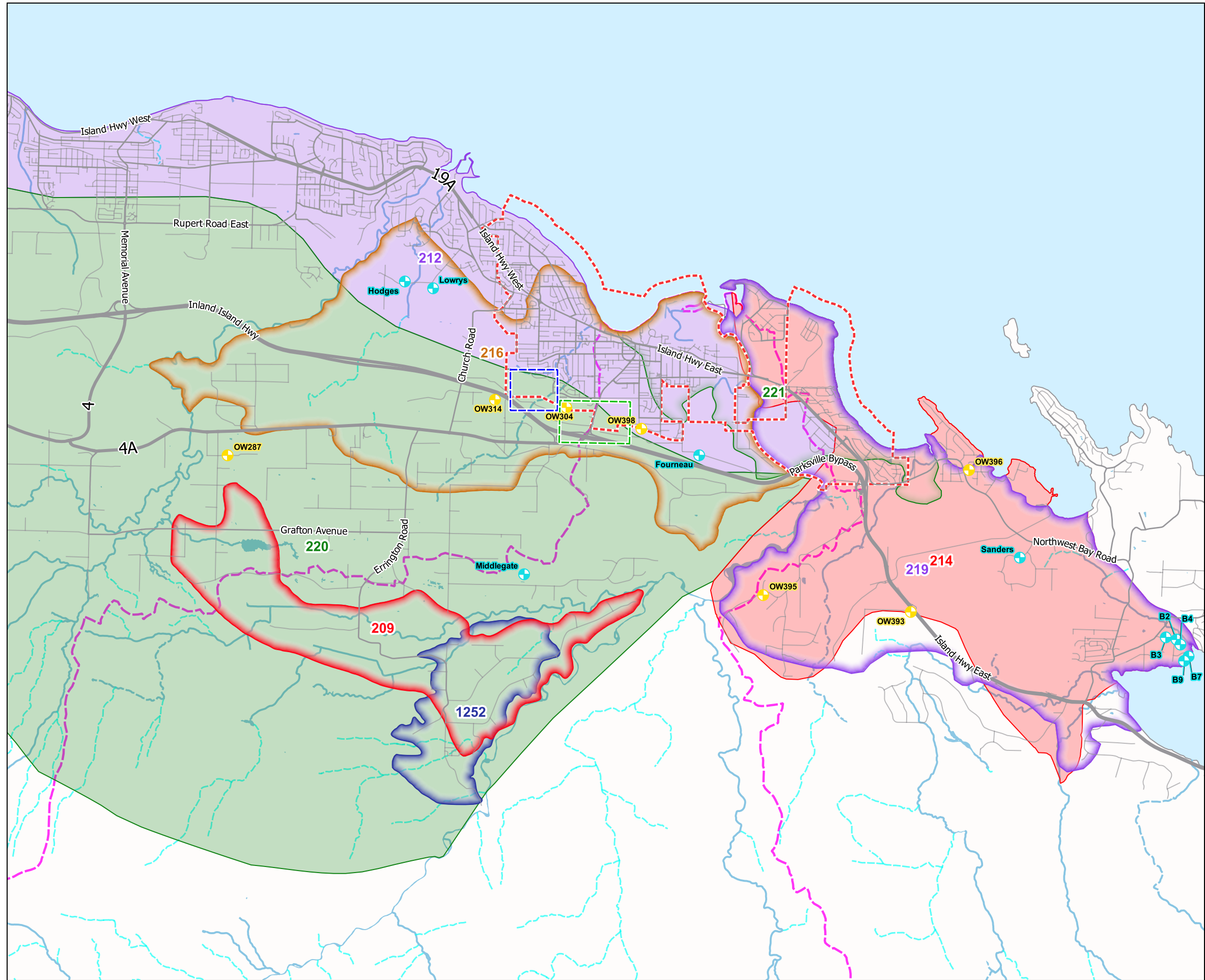
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| Compiled By: mwine                    |
| Date Issued: 2025-Sep-15              |
| Date Revised: --                      |

FIGURE 1





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- Provincial Observation Well
- RDN Volunteer Observation Well
- River/Stream - Definite
- River/Stream - Indefinite
- River/Stream - Intermittent
- Road - Expressway / Highway
- Road - Arterial / Collector
- Road
- Springwood Well Field
- Railway Station Well Field
- Englishman River Watershed
- Parkville Municipal Boundary
- Aquifer 209: Surficial Confined
- Aquifer 216: Surficial Confined
- Aquifer 219: Surficial Confined
- Aquifer 221: Surficial Unconfined
- Aquifer 1252: Surficial Unconfined
- Aquifer 214: Bedrock Aquifer
- Aquifer 220: Bedrock Aquifer
- Aquifer 212: Bedrock Aquifer

References:  
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### AQUIFERS MAP

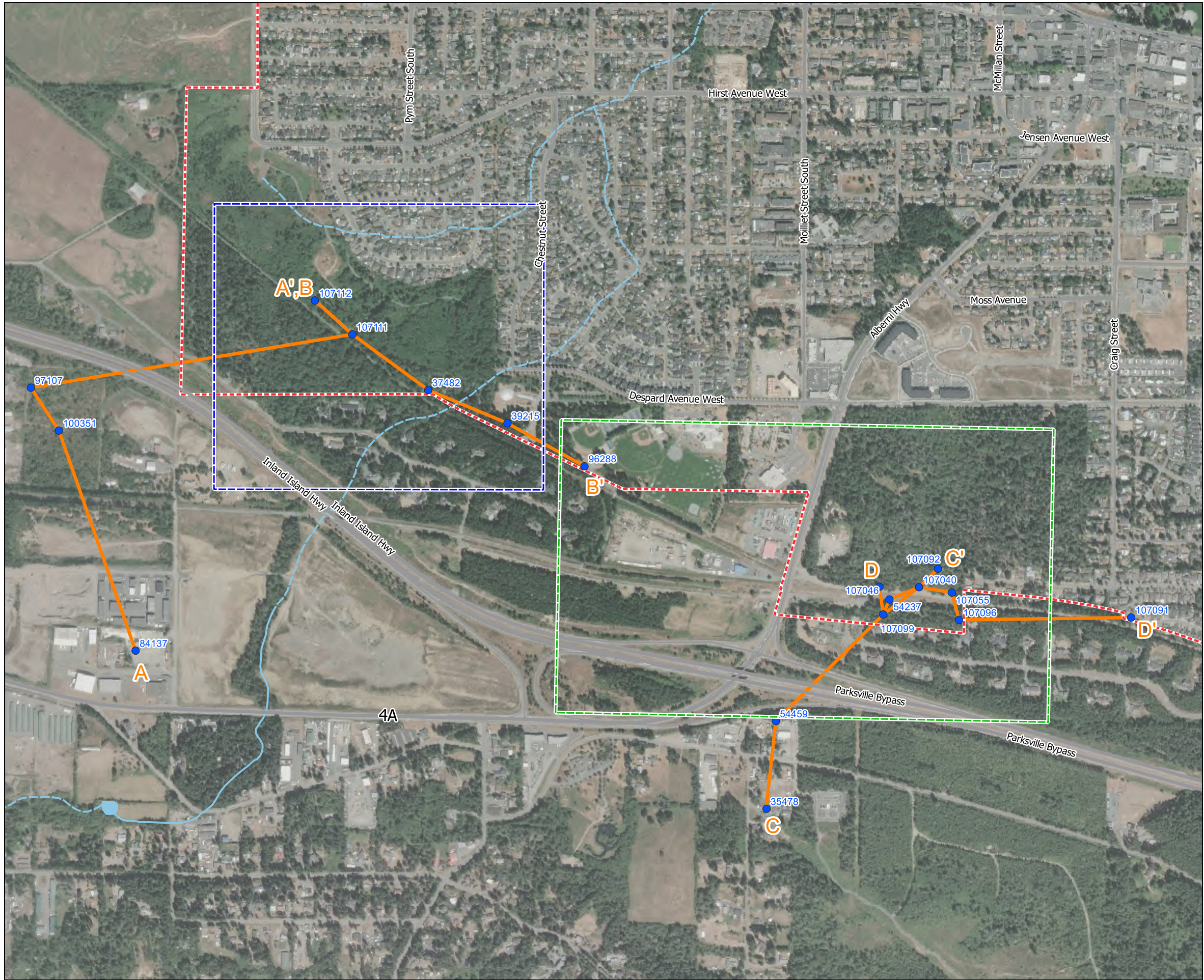
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|                                                                                       | Project Number: 3917-24-001           |
|                                                                                       | Compiled By: mwine                    |
|                                                                                       | Date Issued: 2025-Sep-15              |
| Date Revised: --                                                                      |                                       |

FIGURE 3

Coordinate System: NAD83(CSRS) / UTM zone 10N



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- Registered Well
- Cross-Section Trace
- River/Stream - Definite
- River/Stream - Indefinite
- Road - Expressway / Highway
- Road - Arterial / Collector
- Springwood Well Field
- Railway Station Well Field
- Parkville Municipal Boundary



References:  
Fresh Water Atlas (2017), National Road Network (2016),  
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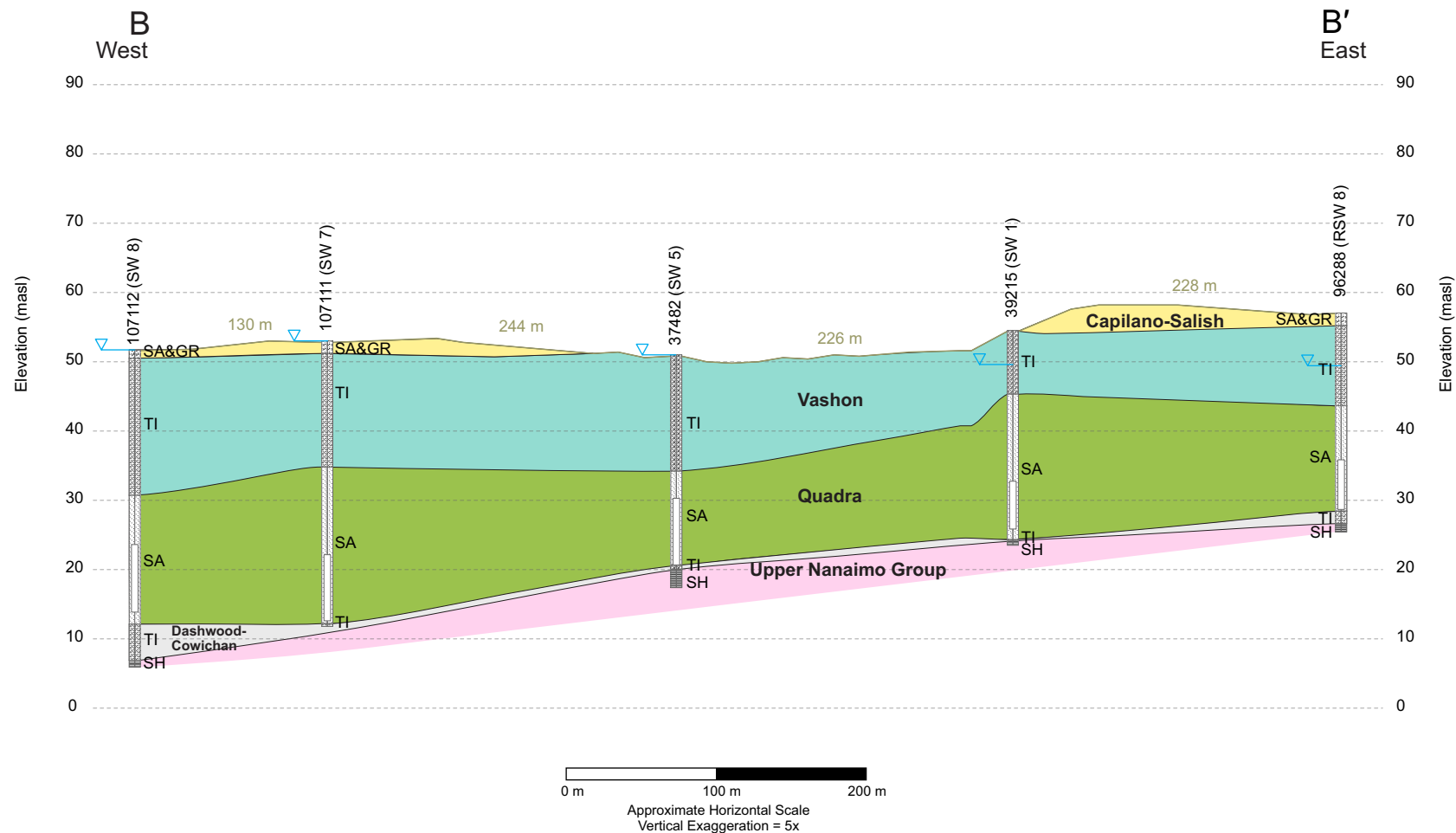
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|--|---------------------------------------|-----------------|
|  | Prepared By: Waterline Resources Inc. | <b>FIGURE 4</b> |
|  | Project Number: 3917-24-001           |                 |
|  | Compiled By: mwine                    |                 |
|  | Date Issued: 2025-Sep-15              |                 |
|  | Date Revised: --                      |                 |

Coordinate System: NAD83(CSRs) / UTM zone 10N







Groundwater Level  
(December 13-20, 2024)

Screen Interval

Interpreted Ground Surface

130 m Distance Between Wells

#### Logged Lithology

Sand & Gravel (SA&GR)

Sand (SA)

Till (TI)

Shale (SH)

#### Surficial Geology

Capilano-Salish

Vashon

Quadra

Dashwood-Cowichan

Upper Nanaimo Group

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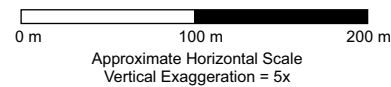
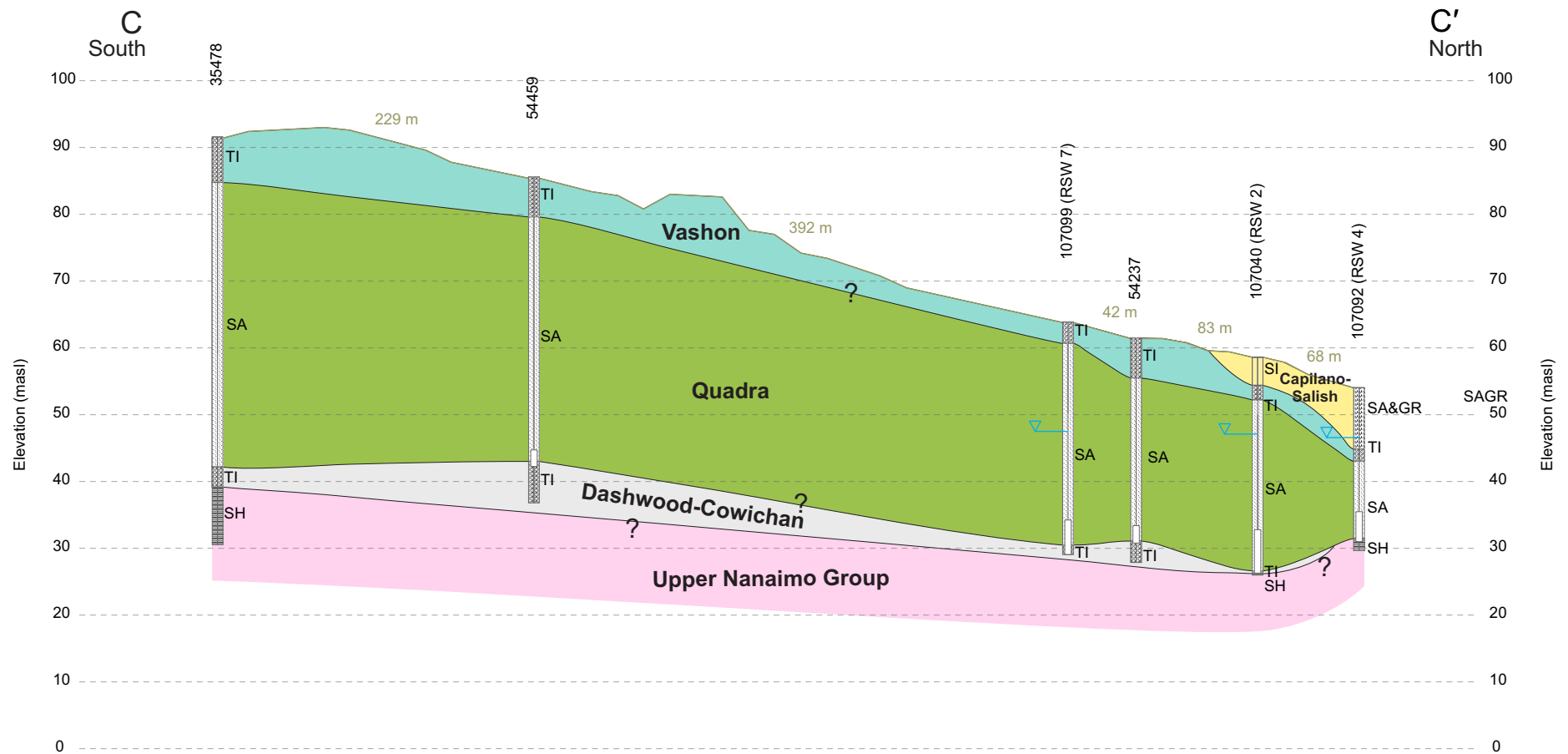
### HYDROGEOLOGICAL CROSS-SECTION SPRINGWOOD WELL FIELD (B-B')

**Waterline**

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COMPILED BY: mwine  
DATE ISSUED: July 2025  
REVISED: --

**FIGURE 6**





- |                                                                                                                                                        |                                                                                                                                 |                                                                                                                                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>▽ Groundwater Level<br/>(December 13-20, 2024)</p> <p>□ Screen Interval</p> <p>— Interpreted Ground Surface</p> <p>229 m Distance Between Wells</p> | <p><b>Logged Lithology</b></p> <p>□ Sand &amp; Gravel (SA&amp;GR)</p> <p>□ Sand (SA)</p> <p>□ Till (TI)</p> <p>□ Shale (SH)</p> | <p><b>Surficial Geology</b></p> <p>□ Capliano-Salish</p> <p>□ Vashon</p> <p>□ Quadra</p> <p>□ Dashwood-Cowichan</p> <p>□ Upper Nanaimo Group</p> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|

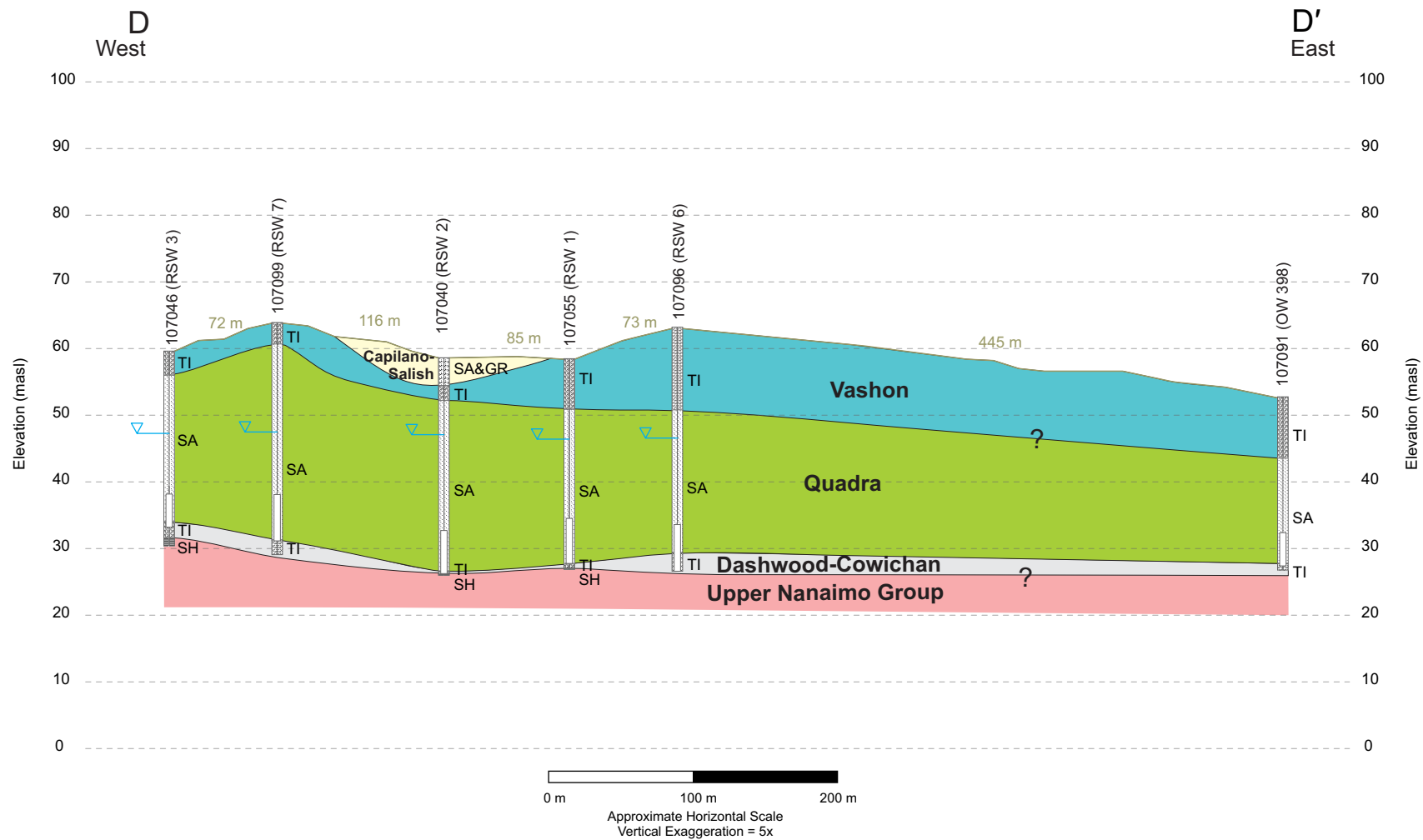
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## HYDROGEOLOGICAL CROSS-SECTION RAILWAY STATION WELL FIELD (C-C')



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COMPILED BY: mwine  
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REVISED: --

**FIGURE 7**



#### Logged Lithology

- Sand & Gravel (SA&GR)
- Sand (SA)
- Till (TI)
- Shale (SH)

#### Surficial Geology

- Capilano-Salish
- Vashon
- Quadra
- Dashwood-Cowichan
- Upper Nanaimo Group

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### HYDROGEOLOGICAL CROSS-SECTION RAILWAY STATION WELL FIELD (D-D')

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COMPILED BY: mwine  
DATE ISSUED: July 2025  
REVISED: --

**FIGURE 8**

## **Appendix A**

### **Photograph Log**



**Photograph A1:** RSW 1 – Looking inside the well house. No issues noted.





**Photograph A2:** RSW 2 – Looking inside the well house. No issues noted.





**Photograph A3:** RSW 3 – Looking inside the well house. No issues noted.





**Photograph A4:** RSW 4 – Looking inside the well house. No issues noted.





**Photograph A5 (LEFT):** RSW 5 – Looking inside the well house. No issues noted. **Photograph A6 (RIGHT):** RSW 6 – Looking inside the well house. No issues noted.





**Photograph A7:** RSW 7 – Looking inside the well house. Leaky wellhead fitting noted causing some corrosion of the casing lid.





**Photograph A8 (LEFT):** RSW 8 – Looking down at the wellhead. No issues noted. **Photograph A9 (MIDDLE):** SW 1 – Looking down and south at the wellhead. **Photograph A10 (RIGHT):** SW 1 – Looking down and north at the wellhead. The electrical cable for the pump, that is passing through the well house floor (concrete) inside a PVC conduit, is not secured (unsealed).





**Photograph A11 (LEFT):** SW 3 – Looking inside the well house, no issues noted. The well is flowing artesian during periods of non-pumping.  
**Photograph A12 (RIGHT):** SW 3 – Close-up view of the wellhead. The flowing water is being directed to a floor drain.





**Photograph A13 (LEFT):** SW 5 – Looking inside the well house. The well is flowing artesian during periods of non-pumping. **Photograph A14 (MIDDLE):** SW 5 – Close-up view of the wellhead. The pressure fitting for the electrical cable to the pump is leaking, allowing for uncontrolled flow and standing water to accumulate in the well house. As a result the wellhead components are corroding, leading to iron staining (oxidation) and bioaccumulation. **Photograph A15 (RIGHT):** SW 6 – Looking inside the well house. No issues noted.





**Photograph A16:** SW 7 – Looking inside the well house. No issues noted. The well can exhibit intermittent flowing artesian conditions during periods of non-pumping.





**Photograph A17 (LEFT):** SW 8 – Looking inside the well house. No issues noted. **Photograph A18 (RIGHT):** SW 8 – Close-up view of the wellhead. The well can exhibit intermittent flowing artesian conditions during periods of non-pumping and therefore, a 1" PVC pipe is installed to direct flow towards a floor drain.





**Photograph A19 (LEFT):** SW 10 – Looking down at the wellhead. No issues noted. **Photograph A20 (RIGHT):** SW 11 – Looking down at the wellhead. No issues noted.

## Appendix C

# Task 2 – Hydrogeological Assessment of Parksville's Water Supply Well Operations and the Englishman River Aquifers

Waterline Resources Inc.  
March 9, 2026

**TASK 2 – HYDROGEOLOGICAL ASSESSMENT OF  
PARKSVILLE'S WATER SUPPLY WELL  
OPERATIONS AND THE ENGLISHMAN RIVER  
AQUIFERS FOR THE CITY OF PARKSVILLE,  
BRITISH COLUMBIA**

Submitted To:



300A – 4185 Still Creek Drive  
Burnaby BC, V5C 6G9



Submitted By:

Waterline Resources Inc.  
Nanaimo, British Columbia  
March 09, 2026  
3917-24-001

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## **1.0 INTRODUCTION**

### **1.1 Background**

As part of the City of Parksville’s (Parksville) Phase 1 Water Use Planning and Management Study (Phase 1 Study), managed by Kerr Wood Leidal Consulting Engineers (KWL), Waterline Resources Inc. (Waterline) was retained to provide technical hydrogeological support, producing the following reports, with relevant information to be incorporated into KWL’s final Phase 1 Study:

- *Task 1 – Water Supply Well Data Compilation and Overview of the Englishman River Aquifers*
- *Task 2 – Hydrogeological Assessment of Parksville’s Water Supply Well Operations and the Englishman River Aquifers*
- *Task 3 – Groundwater Supply Resilience Planning*

Following Task 1 (data compilation report; Waterline, 2025), Waterline was tasked with analysing the compiled data, including groundwater use, groundwater level and water chemistry data for Parksville’s water supply wells (WSWs). Additionally, Waterline was tasked to review aquifer productivity and water use for aquifers in the Englishman River watershed, including Aquifer 216, Parksville’s groundwater source.

Assessment results presented herein are used to complete Task 3 (groundwater supply resiliency planning) for Parksville’s Phase 1 Study.

### **1.2 Objectives and Scope of Work**

The objective of Task 2 was to evaluate the current groundwater supply sustainability of Parksville’s WSWs and the Englishman River watershed groundwater sources, to help develop community water supply strategies. The scope of work completed for Task 2 included:

- Assessing the sustainability and reliability of Parksville’s active WSWs;
- Confirming timing and quantity of groundwater withdrawals from Parksville’s WSWs; and
- Assessing the groundwater supply potential of aquifers in the Englishman River watershed.

## **2.0 ASSESSMENT RESULTS OF THE PARKSVILLE WATER SUPPLY WELL SYSTEM**

### **2.1 Groundwater Level Data Assessment**

The groundwater level data for Parksville’s 16 active WSWs (Figure 1) was compiled from Parksville’s Supervisory Control and Data Acquisition (SCADA) system. The data outputted from the SCADA system included both minimum (pumping) and maximum (non-pumping) groundwater level conditions, either on an hourly or daily frequency. Short-term and long-term trend charts (i.e., hydrographs) were compiled for each WSW, to assess sustainable operations of Parksville’s Railway Station and Springwood Well Fields, helping inform current and future water supply

potential. Groundwater levels were compared against each WSW's top of screen elevation and calculated 70% of available head elevation, to assess overuse.

### 2.1.1 Short-Term Groundwater Level Trends

Hourly pumping groundwater levels (minimum water levels) and daily use rates for each WSW were assessed for the short-term monitoring period (2022-2024). Groundwater level trends from the short-term groundwater use assessment are summarized in Table 1; groundwater level hydrographs and use charts for each WSW are included in Appendix A (Figures A1-A16).

**Table 1: Parksville Water Supply Wells - Short-term Pumping Groundwater Level Trends**

| WSW Name                          | Trends                                                                                                                                                                                                                                      | Figure No. |
|-----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>Railway Station Well Field</b> |                                                                                                                                                                                                                                             |            |
| RSW 1                             | Pumping level fluctuated by 9.1 m (38.9-48.0 masl). WSW was offline between Feb-May 2024.                                                                                                                                                   | A1         |
| RSW 2                             | Pumping level fluctuated by 13.3 m (34.2-47.5 masl). WSW was offline between Aug-Dec 2024.                                                                                                                                                  | A2         |
| RSW 3                             | Pumping level fluctuated by 9.3 m (38.5-47.8 masl).                                                                                                                                                                                         | A3         |
| RSW 4                             | Pumping level fluctuated by 8.6 m (38.7-47.3 masl). WSW was offline between May-Jul 2022.                                                                                                                                                   | A4         |
| RSW 5                             | Pumping level fluctuated by 9.5 m (37.8-47.3 masl). WSW was offline between May-Jul 2022.                                                                                                                                                   | A5         |
| RSW 6                             | Pumping level fluctuated by 10.7 m (37.8-48.5 masl).                                                                                                                                                                                        | A6         |
| RSW 7                             | Pumping level fluctuated by 8.1 m (39.9-48.0 masl).                                                                                                                                                                                         | A7         |
| RSW 8                             | Pumping level fluctuated by 12.8 m (37.1-49.9 masl).                                                                                                                                                                                        | A8         |
| <b>Springwood Well Field</b>      |                                                                                                                                                                                                                                             |            |
| SW 1                              | Pumping level fluctuated by 13.3 m (36.9-50.2 masl). WSW was offline at beginning of the monitoring period, coming back online at the end of Oct 2022.                                                                                      | A9         |
| SW 3                              | Pumping level fluctuated by 20.2 m (27.8-48.0 masl). WSW is flowing artesian; water level above ground level (47.7 masl). WSW was offline between Oct-Nov 2022.                                                                             | A10        |
| SW 5                              | Pumping level fluctuated by 19.1 m (33.6-52.7 masl). WSW is flowing artesian; water level above ground level (50.9 masl) during lower use periods. WSW was offline at beginning of the monitoring period but started pumping in Feb 2023.   | A11        |
| SW 6                              | Pumping level fluctuated by 18.6 m (34.8-53.4 masl). WSW is flowing artesian; water level above ground level (53.3 masl) during non-pumping periods. WSW was offline at beginning of the monitoring period but started pumping in Jan 2023. | A12        |
| SW 7                              | Pumping level fluctuated by 20.8 m (32.5-53.3 masl). WSW is flowing artesian; water level above ground level (52.9 masl) during lower use periods.                                                                                          | A13        |
| SW 8                              | Pumping level fluctuated by 24.9 m (28.0-52.9 masl). WSW is flowing artesian; water level above ground level (52.1 masl) during lower use periods. WSW was offline at beginning of monitoring period but started pumping in Oct 2022.       | A14        |
| SW 10                             | Limited level data available (May-Oct 2022 and Nov 2024-Jan 2025). Pumping water level fluctuated by 15.2 m (34.6-49.8 masl).                                                                                                               | A15        |
| SW 11                             | Pumping level fluctuated by 18.3 m (32.0-50.3 masl). WSW was offline between Apr-Nov 2024 and again in Dec 2024.                                                                                                                            | A16        |

**Notes:** masl denotes metres above sea level; RSW denotes Railway Station Well; SW denotes Springwood Well; WSW denotes water supply well.

Notable observations from the short-term trends are discussed below:

- When offline, water levels at non-pumped WSWs returned to static levels but still exhibited pumping-like fluctuations, suggesting hydraulic connection between WSWs within each well field.
- Of the Railway Station WSWs, only Railway Station Well (RSW) 2, RSW 3, RSW 7 and RSW 8 routinely exceeded the 70% available head threshold limit:
  - RSW 2 and RSW 8 were in exceedance throughout the monitoring period, while RSW 3 and RSW 7 were only in exceedance during periods of increased pumping (i.e., dry summer months).
  - Exceedance of the 70% threshold is not recommended for extended periods of time but is expected during peak demand periods.
- Springwood WSWs routinely exceeded the 70% available head threshold limit during pumping, except for Springwood Well (SW) 1, SW 7 and SW 10 (limited short-term data available for SW 10):
  - SW 3 and SW 11 were in exceedance of this threshold throughout the monitoring period, while SW 5, SW 6, and SW 8 were only in exceedance during periods of increased pumping (i.e., dry summer months).
  - Like the Railway Station Well Field, operation of WSWs with water levels below the 70% of available head threshold limit is not abnormal for short durations during peak demand. However, well operations at SW 3 and SW 11 were problematic, as pumping water levels exceeded the top of screen elevations on multiple occasions for sustained periods of time.

Groundwater level data for provincial observation well (OW) 398 and OW 304 (ENV, 2025) and total precipitation data for the Qualicum River Fish Hatchery climate station (Climate ID 1026565) obtained from Environment and Climate Change Canada (ECCC, 2025) were plotted with the WSW groundwater levels for each well field (Figure A17 and A18). Both OW 398 (Figure A17) and OW 304 (Figure A18) exhibit decreasing groundwater level trends through the drier months (June to September) and increasing groundwater level trends during the wetter months (October to May). Seasonally groundwater levels in Aquifer 216 return to the same maximum elevation and an overall decreasing trend is not apparent, indicating sustainable groundwater withdrawal near both the Railway Station and Springwood Well Fields.

### 2.1.2 Long-Term Trends and Exceedances

Daily non-pumping groundwater levels (maximum water levels) for each WSW were assessed for the long-term monitoring period (2012-2024). Water level trends from the long-term groundwater use assessment are summarized in Table 2; groundwater level hydrographs and use charts for each WSW are included in Appendix B (Figures B1-B16). The individual WSW hydrographs also include the date at which Parksville switched from their old SCADA system to their new SCADA system in 2021, so that old and new system data could be compared.



**Table 2: Parksville Water Supply Wells - Long-term Non-Pumping Groundwater Level Trends**

| WSW Name                          | Trends                                                                                                                                                                                                 | Figure No. |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>Railway Station Well Field</b> |                                                                                                                                                                                                        |            |
| RSW 1                             | Groundwater level fluctuated by 4.1 m (44.2-48.3 masl) during the monitoring period; however, there was an overall stable trend.                                                                       | B1         |
| RSW 2                             | Groundwater level fluctuated by 9.5 m (38.0-47.5 masl) during the monitoring period; however, there was an overall increasing trend since 2014.                                                        | B2         |
| RSW 3                             | Groundwater level fluctuated by 7.0 m (41.3-48.3 masl) during the monitoring period; however, there was an overall increasing trend since 2014.                                                        | B3         |
| RSW 4                             | Groundwater level fluctuated by 5.2 m (42.1-47.3 masl) during the monitoring period; however, there was an overall increasing trend.                                                                   | B4         |
| RSW 5                             | Groundwater level fluctuated by 10.9 m (39.0-49.9 masl) during the monitoring period. Levels trended downward until summer of 2015, then increased.                                                    | B5         |
| RSW 6                             | Groundwater levels fluctuated by 4.3 m (45.7-50.0 masl) during the monitoring period; however, there was an overall stable trend.                                                                      | B6         |
| RSW 7                             | Available data shows groundwater levels fluctuated by 10.5 m (39.4-49.9 masl) during the monitoring period. Levels trended upwards, peaking in 2021, then declining and stabilizing between 2022-2024. | B7         |
| RSW 8                             | Groundwater level fluctuated by 10.3 m (39.8-50.1 masl) during the monitoring period. Levels trended upwards, peaking in 2021 then declining and stabilizing in 2024.                                  | B8         |
| <b>Springwood Well Field</b>      |                                                                                                                                                                                                        |            |
| SW 1                              | Groundwater level fluctuated by 14.0 m (37.5-51.5 masl) during the monitoring period. Levels trended downward until summer of 2015, then increased and have been stable since 2022.                    | B9         |
| SW 3                              | Groundwater level fluctuated by 19.4 m (28.6-48.0 masl) during the monitoring period; however, there was an overall increasing trend.                                                                  | B10        |
| SW 5                              | Groundwater level fluctuated by 18.5 m (33.4-51.9 masl) during the monitoring period; however, there was an overall stable trend.                                                                      | B11        |
| SW 6                              | Groundwater level fluctuated by 17.8 m (35.6-53.4 masl) during the monitoring period; however, there was an overall stable trend.                                                                      | B12        |
| SW 7                              | Groundwater level fluctuated by 16.7 m (36.6-53.3 masl) during the monitoring period; however, there was an overall stable trend.                                                                      | B13        |
| SW 8                              | Groundwater level fluctuated by 25.4 m (27.5-52.9 masl) during the monitoring period; however, there was an overall stable trend.                                                                      | B14        |
| SW 10                             | Groundwater level fluctuated by 14.6 m (35.4-50.0 masl) during the monitoring period; however, there was an overall stable trend.                                                                      | B15        |
| SW 11                             | Groundwater level fluctuated up to 15.8 m (34.7-50.5 masl) during the monitoring period; however, there was an overall stable trend.                                                                   | B16        |

**Notes:** masl denotes metres above sea level; RSW denotes Railway Station Well; SW denotes Springwood Well; WSW denotes water supply well.

Notable observations from the long-term trends are discussed below:

- Seasonal recharge/use patterns are similar at all WSWs, with the highest annual groundwater levels in the wetter months and the lowest annual groundwater levels in the drier months.
- None of the WSWs exhibited decreasing groundwater level trends over the monitoring period. Decreasing trends were only observed during high water use years and only for short durations. Generally, the WSWs exhibited increasing or stable groundwater level trends for the monitoring period.

- There was erroneous data reported before the transition from the old to new SCADA system in 2021, resulting in data gaps at eight of the 16 WSWs, including RSW 2, RSW 6, RSW 7, RSW 8, SW 1, SW 6, SW 10 and SW 11.

## 2.2 Groundwater Use Assessment

The long-term water use data (2012-2024) was compiled for both the Railway Station and Springwood Well Fields, included as Figures C1 and C2 of Appendix C, respectively. Table 3 compares the estimated well yields from well construction, the *Water Sustainability Act* (WSA) licence application diversion volumes, and the operation data for the well fields and individual WSWs. The operational data includes calculated daily average use for each of the last three years (2022, 2023 and 2024), as well as the last five-year (2020-2024) and 10-year period (2015-2024).

**Table 3: Parksville Water Supply Wells - Groundwater Availability and Average Use**

| Well Field         | WSW Name | Well Yield from Construction Report | WSA Existing Use Groundwater Licence Application Diversion Volume | Average Use |       |       |                     |                      |
|--------------------|----------|-------------------------------------|-------------------------------------------------------------------|-------------|-------|-------|---------------------|----------------------|
|                    |          |                                     |                                                                   | 2022        | 2023  | 2024  | 5-Year <sup>a</sup> | 10-Year <sup>a</sup> |
|                    |          |                                     |                                                                   |             |       |       |                     |                      |
|                    |          | m <sup>3</sup> /day                 |                                                                   |             |       |       |                     |                      |
| Railway Station    | RSW 1    | 720                                 | 214                                                               | 124         | 132   | 82    | 119                 | 142                  |
|                    | RSW 2    | 736                                 | 202                                                               | 208         | 161   | 132   | 180                 | 206                  |
|                    | RSW 3    | 463                                 | 80                                                                | 86          | 67    | 84    | 82                  | 78                   |
|                    | RSW 4    | 392                                 | 147                                                               | 78          | 96    | 130   | 100                 | 107                  |
|                    | RSW 5    | 741                                 | 320                                                               | 134         | 195   | 248   | 176                 | 196                  |
|                    | RSW 6    | 839                                 | 294                                                               | 216         | 161   | 240   | 147                 | 162                  |
|                    | RSW 7    | 709                                 | 146                                                               | 143         | 140   | 181   | 115                 | 121                  |
|                    | RSW 8    | 654                                 | 230                                                               | 0           | 0     | 94    | <u>94</u>           | <u>156</u>           |
| Cumulative Volume: |          | 5,255                               | 1,632 <sup>b</sup>                                                | 988         | 954   | 1,191 | 1,013               | 1,168                |
| Springwood         | SW 1     | 703                                 | 98                                                                | 10          | 54    | 71    | <u>40</u>           | <u>64</u>            |
|                    | SW 3     | 431                                 | 164                                                               | 91          | 101   | 122   | 106                 | 123                  |
|                    | SW 5     | 807                                 | 270                                                               | 0           | 93    | 179   | <u>141</u>          | <u>185</u>           |
|                    | SW 6     | 785                                 | 134                                                               | 7           | 154   | 195   | 64                  | 107                  |
|                    | SW 7     | 720                                 | 132                                                               | 515         | 246   | 296   | 294                 | 307                  |
|                    | SW 8     | 720                                 | 340                                                               | 107         | 221   | 291   | 192                 | 245                  |
|                    | SW 10    | 681                                 | 189                                                               | 151         | 120   | 155   | 150                 | 178                  |
|                    | SW 11    | 709                                 | 339                                                               | 216         | 136   | 41    | 133                 | 202                  |
| Cumulative Volume: |          | 5,555                               | 1,666 <sup>c</sup>                                                | 1,097       | 1,126 | 1,349 | 1,119               | 1,411                |
| Total Volume:      |          | 10,809                              | 3,298                                                             | 2,085       | 2,080 | 2,541 | 2,132               | 2,579                |

**Notes:** m<sup>3</sup>/day denotes cubic metres per day; RSW denotes Railway Station Well; SW denotes Springwood Well; WSA denotes *Water Sustainability Act*; WSW denotes water supply well; <sup>a</sup> The five-year and 10-year average daily use volumes are the geometric mean of the annual use volumes for the last five years (2020-2024) and the last 10 years (2015-2024), respectively; <sup>b</sup> Applied diversion volumes are based on Parksville's 2014 annual diversion volumes from the Railway Station Well Field; <sup>c</sup> Applied diversion volumes are based on Parksville's 2016 annual diversion volumes from the Springwood Well Field; Underlined values indicate that fewer than five or 10 years of data were used to calculate the average use.

Notable observations from the average use trends and groundwater availability data are discussed below:

- The total groundwater volume diverted daily from the Railway Station and Springwood Well Fields was almost identical for 2022 (2,085 m<sup>3</sup>/day) and 2023 (2,080 m<sup>3</sup>/day), which reflects the average daily use for the past five-year period (2,132 m<sup>3</sup>/day).
- Daily average groundwater use increased by 22% in 2024 (2,541 m<sup>3</sup>/day), which closely aligns with the 10-year average daily use (2,579 m<sup>3</sup>/day). It is assumed that the increased water use could be due to Parksville’s increased water demand.
- The cumulative WSA application diversion volumes for the Railway Station Well Field (1,632 m<sup>3</sup>/day) and the Springwood Well Field (1,666 m<sup>3</sup>/day) combined is 22% greater than the 10-year average groundwater usage.
- The total well yield volume (10,809 m<sup>3</sup>/day) calculated during well construction from analytical solutions, only represent short-term pumping and does not consider well interference. For individual well yield assessments, only nearby WSWs were monitored to assess potential impacts; a cumulative drawdown assessment of the well fields was not performed.

Parksville’s water use was also reviewed seasonally, to confirm peak groundwater use. Table 4 compares annual diversion volumes for the WSWs, and cumulatively for the well fields, with summer (June to September; four-month period) diversion volumes for each of the last two years (2023 and 2024).

**Table 4: Parksville Water Supply Wells - Annual and Summer Diversion Volumes**

| Well Field                | WSW Name | 2023                    |                                                |                                                    | 2024                    |                                                |                                                    |
|---------------------------|----------|-------------------------|------------------------------------------------|----------------------------------------------------|-------------------------|------------------------------------------------|----------------------------------------------------|
|                           |          | Annual Diversion Volume | Summer Diversion Volume (Jun-Sep) <sup>a</sup> | Summer Diversion as Percentage of Annual Diversion | Annual Diversion Volume | Summer Diversion Volume (Jun-Sep) <sup>a</sup> | Summer Diversion as Percentage of Annual Diversion |
|                           |          | m <sup>3</sup>          |                                                | %                                                  | m <sup>3</sup>          |                                                | %                                                  |
| Railway Station           | RSW 1    | 48,259                  | 19,082                                         | 40                                                 | 29,887                  | 19,966                                         | 67                                                 |
|                           | RSW 2    | 58,945                  | 24,236                                         | 41                                                 | 48,171                  | 21,521                                         | 45                                                 |
|                           | RSW 3    | 24,627                  | 9,922                                          | 40                                                 | 30,479                  | 13,056                                         | 43                                                 |
|                           | RSW 4    | 35,053                  | 14,572                                         | 42                                                 | 47,430                  | 20,655                                         | 44                                                 |
|                           | RSW 5    | 71,111                  | 28,998                                         | 41                                                 | 90,523                  | 40,348                                         | 45                                                 |
|                           | RSW 6    | 58,900                  | 24,378                                         | 41                                                 | 87,703                  | 38,516                                         | 44                                                 |
|                           | RSW 7    | 51,269                  | 21,234                                         | 41                                                 | 66,222                  | 30,451                                         | 46                                                 |
|                           | RSW 8    | 0                       | 0                                              | 0                                                  | 34,384                  | 19,342                                         | 56                                                 |
| <i>Cumulative Volume:</i> |          | 348,164                 | 142,422                                        | 41                                                 | 434,799                 | 203,855                                        | 47                                                 |
| Springwood                | SW 1     | 19,877                  | 8,148                                          | 41                                                 | 25,833                  | 11,645                                         | 45                                                 |
|                           | SW 3     | 37,042                  | 15,121                                         | 41                                                 | 44,671                  | 20,268                                         | 45                                                 |
|                           | SW 5     | 34,073                  | 17,385                                         | 51                                                 | 65,270                  | 29,949                                         | 46                                                 |
|                           | SW 6     | 56,201                  | 25,582                                         | 46                                                 | 71,029                  | 32,000                                         | 45                                                 |
|                           | SW 7     | 89,673                  | 36,208                                         | 40                                                 | 107,934                 | 48,925                                         | 45                                                 |
|                           | SW 8     | 80,537                  | 33,421                                         | 41                                                 | 106,372                 | 51,249                                         | 48                                                 |
|                           | SW 10    | 43,934                  | 18,448                                         | 42                                                 | 56,476                  | 25,695                                         | 45                                                 |
|                           | SW 11    | 49,734                  | 20,198                                         | 41                                                 | 14,935                  | 34                                             | 0.2                                                |
| <i>Cumulative Volume:</i> |          | 411,071                 | 174,511                                        | 42                                                 | 492,520                 | 219,765                                        | 45                                                 |
| <b>Total Volume:</b>      |          | 759,235                 | 316,933                                        | 42                                                 | 927,319                 | 423,620                                        | 46                                                 |

**Notes:** m<sup>3</sup> denotes cubic metres; RSW denotes Railway Station Well; SW denotes Springwood Well; WSW denotes water supply well; % denotes percent; <sup>a</sup> Summer diversion (peak use period) is from June 1 to September 30.

Annual water use increased during the dry summer period (June to September) and decreased during the wetter fall/winter period (October to May). In the last two years (2023 and 2024), summer diversion (four months or 33% of the year) accounted for 42-46% of the total annual groundwater diversion from the well fields. Although this accounts for an increase in seasonal groundwater use (9-13%), groundwater diversion is relatively consistent year-round.

## 2.3 Groundwater Quality Assessment

Raw groundwater quality samples were collected from active WSWs between 2010 and 2024. Parameters sampled include:

- Physical tests (colour, alkalinity, conductivity, hardness, pH, turbidity, and total dissolved solids (TDS);
- Major ions (chloride, fluoride, sulphate, nitrate, and nitrite);
- Total metals;
- Total cyanide; and
- Bacteriological parameters (*Escherichia coli* [*E. coli*] and total coliforms).

The laboratory analytical results from 2010 to 2024 were provided to Waterline by Parksville, for assessment and discussion herein. Waterline used its in-house Enviro Web Services (EWS) data management system to compile the data. A summary of Parksville’s raw groundwater quality results is presented in Tables D1 to D3 of Appendix D. Key parameters are also graphed per well field and presented in Figures E1 to E6 of Appendix E.

All groundwater quality results presented are compared to the Guidelines for Canadian Drinking Water Quality (GCDWQ; Health Canada, 2025). The GCDWQ set standards based on aesthetic objectives (AO) and on maximum acceptable concentrations (MAC). Conductivity, TDS and chloride results are also compared to operational objectives as set out by the *Best Practices for Prevention of Saltwater Intrusion* (FLNRORD, 2016).

### 2.3.1 Railway Station Well Field

Key findings from the water quality results assessment for the Railway Station Well Field include:

- Railway Station Well Field groundwater is considered “moderately hard” to “very hard”, with hardness concentrations ranging between 115 – 221 milligrams per litre (mg/L; Table D1 and Figure E1).
- TDS concentrations ranged between 152 – 268 mg/L (Table D1 and Figure E2), indicating the water is from a fresh source. TDS concentrations reported for the Railway Station Well Field were below the operational objective of 700 mg/L, for indication of potential saltwater intrusion, while chloride concentrations were also below the operational objective of 150 mg/L (Table D1 and Figure E2).



- Groundwater colour from all WSWs was below the GCDWQ AO limit of 15 True Color Units (TCU; Table D1).
- Turbidity results ranged from <0.1 to 0.4 Nephelometric Turbidity Units (NTU; Table D1), under the AO raw water limit of 1.0 NTU (Health Canada, 2025).
- Three WSWs (RSW 2, RSW 3, and RSW 6) had exceedances of the AO limit for total iron (0.1 mg/L), with the most recent exceedance occurring in 2019 at RSW 6 (Table D2 and Figure E3). The MAC for total lead (0.005 mg/L) was exceeded at RSW 8 on October 16, 2017, with a result of 0.0317 mg/L.
- All Railway Station WSWs, except for RSW 4 and RSW 5, have exceeded the total manganese AO (0.02 mg/L) at least once, and the total manganese GCDWQ MAC (0.12 mg/L) has been exceeded once each at RSW 1 and RSW 3 (Table D2 and Figure E3). Total manganese exceedances in 2024 occurred at RSW 1 (0.14 mg/L), RSW 3 (0.035 mg/L), and RSW 8 (0.027 mg/L).
- Sampling for microbiological parameters has been done at least once for each of the eight WSWs in the Railway Station Well Field since 2010. Total coliforms and *E. coli* were both non-detect in all samples (Table D3).

### 2.3.2 Springwood Well Field

Key findings from the water quality results assessment for the Springwood Well Field include:

- Springwood Well Field groundwater is considered “moderately hard” to “very hard”, with hardness concentrations ranging between 96 – 220 mg/L (Table D1 and Figure E4).
- TDS concentrations ranged between 137 – 273 mg/L (Table D1 and Figure E5), indicating the water is from a fresh source. TDS concentrations reported for the Springwood WSWs were below the operational objective of 700 mg/L, for indication of potential saltwater intrusion, while chloride concentrations were also below the operational objective of 150 mg/L (Table D1 and Figure E5).
- Groundwater colour from all WSWs was below the AO limit of 15 TCU (Table D1).
- Turbidity results ranged from <0.1 to 2.15 NTU, with three WSWs (SW 5, SW 6, and SW 8) exceeding the AO raw water limit of 1.0 NTU (Table D1; Health Canada, 2025).
- Four WSWs (SW 3, SW 5, SW 6, and SW 8) had exceedances of the AO limit for total iron (0.1 mg/L), with the most recent exceedances occurring in 2024 at SW 5 and SW 8 (Table D2 and Figure E6).
- Four WSWs (SW 3, SW 5, SW 6, and SW 11) had exceedances of the AO limit for total manganese (0.02 mg/L), with the most recent exceedances occurring in 2024 at SW 3 and SW 5 (Table D2 and Figure E6). Results from all samples collected from SW 3 and SW 11, and all but one sample collected from SW 5, exceeded the AO limit.
- Sampling for microbiological parameters has been done at least once for each of the eight WSWs in the Springwood Well Field since 2010. Total coliforms and *E. coli* were both non-detect in all samples (Table D3).

### **3.0 ASSESSMENT RESULTS OF THE ENGLISHMAN RIVER WATERSHED AQUIFERS**

#### **3.1 The Study Area**

Two groundwater modelling studies (Figure 2) have been completed by the Regional District of Nanaimo (RDN), centered on the Nanoose Creek/Bonell Creek and French Creek watersheds, including:

- The Refined Water Budget for Nanoose (referred to as the Nanoose model; Golder, 2020); and
- The Refined Water Budget for French Creek (referred to as the French Creek model; WSP, 2023).

The Nanoose model includes lower reaches of the Englishman River watershed south of the Englishman River; the Englishman River forms part of the northwest boundary of the model. The French Creek model includes the reaches of the Englishman River watershed north of the Englishman River; the Englishman River forms the southeast boundary of the model. The French Creek model includes Aquifer 216 and the Parksville WSWs.

The sections below focus on information provided for the French Creek model but draw on information from the Nanoose model, as appropriate.

#### **3.2 Data Inputs, Modelling Techniques, and Groundwater Model Calibration**

##### **3.2.1 Data Inputs**

In developing the numerical models, conceptual hydrogeological models were refined using updated information on geology, hydrostratigraphy, groundwater conditions, topography, surface water flow, and land and water use (WSP, 2023).

Data inputs for the French Creek numerical model are listed in Table 5, which are adopted from WSP (2023). The Nanoose model data inputs come from the same or similar sources as documented in Table 1 of Golder (2020).

Table 5: Data Sources Summary for the French Creek Watershed Groundwater Numerical Model

| Information                                                  | Source                                                                                                                                                                                                                                                                                                                                                                                                                                             | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Regional Topography                                          | Topographic surface used in the Groundwater Solutions Inc. (GWS) Leapfrog Model (GWS, 2020). It is understood that this surface was derived from LiDAR topographic data with 2 m resolution provided by the RDN (GWS, 2020). Bathymetry Contours from Coastal BC Bathymetry in the B.C. Data Catalogue (2022).                                                                                                                                     | The topography in the model area ranges from sea level along the coastal areas to over 1,000 masl in the southern portion of the French Creek watershed.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Orthophoto imagery (georeferenced)                           | Base map obtained in high resolution from Google Earth. Imagery from March 2021.                                                                                                                                                                                                                                                                                                                                                                   | No comment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Geology and Hydrostratigraphy                                | Waterline Phase 1 Water Budget (2013), GWELLS (ENV, 2025a), BC ENV Aquifer Delineation (Government of BC, 2023), Draft French Creek Area Hydraulic Connectivity and Aquifer Mapping Study (GWS, 2020), Deep Bay Area Groundwater Study Atlas (Benoit et al., 2016) and Mt. Arrowsmith Final Aquifers Modelling Project (EBA, 2005).                                                                                                                | GWS (2020) developed an updated three-dimensional (3D) hydrostratigraphic model of the French Creek area using Leapfrog® software (the GWS Leapfrog Model). The GWS Leapfrog Model presents refined geometries for aquifers in the region and updated bedrock topography and groundwater elevations for both bedrock and overburden aquifers. The Leapfrog Model shows the French River incised through the Quadra sands that compose Aquifer 216 and 217.                                                                                                                                                                                                                                     |
| Hydrogeological Properties of Stratigraphic Units            | Waterline Phase 1 Water Budget (2013), Carmichael Compendium of Re-evaluated Pumping Test in the RDN (2013), Deep Bay Area Groundwater Study Atlas (Benoit et al., 2016), Draft French Creek Area Hydraulic Connectivity and Aquifer Mapping Study (GWS, 2020) and Surfside Well Field – Well Protection Plan (Thurber Engineering, 2016).                                                                                                         | Summary of hydrogeological properties for aquifers within the model area are summarized in Table 9 in WSP (2023). These data are used to guide values used in the model calibration. Quadra sand (Aquifers 216 and 217) has a hydraulic conductivity between 2 x 10 <sup>-6</sup> m/s and 4 x 10 <sup>-3</sup> m/s and storativity between 3 x 10 <sup>-7</sup> and 2 x 10 <sup>-2</sup> .                                                                                                                                                                                                                                                                                                     |
| Groundwater Levels                                           | GWELLS (ENV, 2025a), Draft French Creek Area Hydraulic Connectivity and Aquifer Mapping Study (GWS, 2020), PGOWN (ENV, 2025b) and RDN Volunteer Monitoring Wells (RDN, 2021).                                                                                                                                                                                                                                                                      | WSP assembled and reviewed long-term water level monitoring data for five RDN volunteer observation wells and eleven PGOWN wells that are maintained by ENV.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Production Well Data from Water Providers and Municipalities | RDN 2018-2021 production well data and well reports (RDN, 2022a), City of Parksville 2021 production well data (RDN, 2021), EPCOR 2021 production well data (RDN, 2022a), water licensing application data (BC FOR, 2022) and Qualicum Beach production well data (RDN, 2022a).                                                                                                                                                                    | Estimates of groundwater use by municipal water supply systems were derived from municipal pumping records that were provided by the RDN and other water providers. Potential groundwater use outside of the municipal water service areas was estimated based on land use information.                                                                                                                                                                                                                                                                                                                                                                                                        |
| Surface Water Discharge                                      | Three hydrometric stations along French Creek within the Project Area: French Creek at Coombs, French Creek above Pumphouse and French Creek DS of Barclay Cres (from Aquarius Web Portal, 2022 and RDN, 2022), Watershed Performance Targets for Rainwater Management – French Creek Water Region (NHC, 2021), flume data from FOR/DFO (included in NHC study) and French Creek Flow Monitoring Summary Report 2006-2010 (Shawn Stenhouse, 2011). | Four hydrometric stations were identified within the model area; all located along French Creek. Only one of the four hydrometric stations in the Project Area is currently active. Data excluded the Englishman River as it is predominantly in the adjacent Water Region. Streamflow in French Creek peaks during the winter months is significantly reduced (often less than 0.1 m³/s) during the dry, summer months (June to August).                                                                                                                                                                                                                                                      |
| Surface Water Licences                                       | Downloaded from the provincial database on April 27, 2022 (WLRS, 2022).                                                                                                                                                                                                                                                                                                                                                                            | Includes licences on the Englishman River (and Morison and Swayne Creeks), French Creek, Little Qualicum River, and additional smaller creeks. Total licenced surface water diversion in the model area is 78,246,000 m³/year.                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Climate                                                      | ENV Canada Weather stations in the area (Government of Canada, 2022), Watershed Performance Targets for Rainwater Management – French Creek Water Region (NHC, 2021), Forecast Climate Change for Nanaimo from Pacific Climate Impact Consortium (PCIC, 2022).                                                                                                                                                                                     | The climate of the French Creek area is characterized by cool, wet winters and mild, dry summers. Of the six climate stations identified, the climate station operated by Parksville Operations was considered accurate based on monitoring equipment and was considered more representative of climate conditions at lower elevations for the model area. There are no climate stations at higher elevations within the model area.                                                                                                                                                                                                                                                           |
| Groundwater Recharge                                         | Recharge rates were estimated by Waterline (2013) as part of the Phase 1 Water Budget Study. Rates were determined based on climate data, landcover, soil characteristics and using a water balance model developed by USGS (McCabe and Markstrom, 2007), Orthophoto comparison of change in landcover from 2011 to 2020 (RDN, 2022a) and Morningstar Golf Club Irrigation Data (RDN, 2022a).                                                      | Precipitation during the wet season is the primary source of groundwater recharge to the aquifer system (overburden and bedrock) in the model area. Recharge was not changed from Phase 1 Water Budget Study.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Land Use and Zoning Information                              | Land use and zoning map provided by RDN (2021), Land Use Inventory Database provided by RDN (2021), Agricultural Land Use Inventory Database provided by RDN (BC Ministry of Agriculture, 2012) and Build-out map provided by RDN (2022a).                                                                                                                                                                                                         | Most of the land use in the upper elevations of the model area is privately managed forest lands. Some commercial and light industrial development areas located in Coombs. The central sections of the model area are a mixture of rural development with agriculture and low density residential. The coastal portion of the model area is more developed, as it includes both the Town of Qualicum Beach and the northwestern portion of the City of Parksville. These areas consist of high-density residential development and commercial properties. Landcover change between 2011 and 2020 are less than 2% of the extent of the aquifers underlying areas where change was documented. |
| Water Use in Non-Serviced Area                               | Agricultural Water Demand Study (BC Ministry of Agriculture, 2013), RDN 2019-2021 Metered Water Use (RDN, 2021), EPCOR 2019-2021 Utility Quarterly Consumption Report (RDN, 2022a), Town of Qualicum Beach 2021 Metered Water Use (RDN, 2022a) and Morningstar Golf Club Irrigation Data (RDN, 2022a).                                                                                                                                             | No comment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Groundwater-Surface Water Interactions                       | Mapped by GWS (2020) using GIS.                                                                                                                                                                                                                                                                                                                                                                                                                    | Englishman River – likely connected to aquifer 212 and 220 (within the model area). Morison Creek – likely connected to aquifer 220. Swayne Creek – likely connected to aquifers 220 and 1252. French Creek – likely connected to aquifers 216, 220, 1248 and 1250.                                                                                                                                                                                                                                                                                                                                                                                                                            |

**Notes:** ENV denotes Ministry of Environment and Parks; ENV Canada denotes Environment Canada; GWELLS denotes BC Groundwater Wells and Aquifers database; GWS denotes Groundwater Solutions Inc.; LiDar denotes light detection and ranging; m denotes metres; m/s denotes metres per second; m³/s denotes cubic metres per second; m³/year denotes cubic metres per year; masl denotes metres above sea level; PGOWN denotes Provincial Groundwater Observation Well Network; RDN denotes Regional District of Nanaimo; WLRS denotes Ministry of Water, Land and Resource Stewardship; WSP denotes WSP Canada Inc; % denotes percent.



### **3.2.2 Modelling Techniques**

#### **3.2.2.1 Numerical Model Software Selection**

The numerical models (French Creek and Nanoose) were both developed in FEFLOW; which is a 3D finite element code developed by DHI-WASY Institute in Germany. It was the preferred model based on its capability for simulating 3D groundwater flow in complex geological settings under a variety of boundary conditions and hydrogeological stresses (Golder, 2020; WSP, 2023).

#### **3.2.2.2 Numerical Model Domain**

The Nanoose numerical model domain encompasses the entirety of Electoral Area E, Aquifer 219 boundaries, and the main and sub-watersheds overlapping Electoral Area E. It is bounded by the Englishman River to the west, the ocean to the north and watershed boundaries to the east and south.

The French Creek numerical model domain includes all of Water Region 3, and the main and sub-watersheds surrounding French Creek. The model domain is bounded by the Little Qualicum River to the west, the Englishman River to the northeast, major watershed boundaries to the southeast and south, and the ocean to the north.

The model domains for the French Creek and Nanoose models both abut portions of the Englishman River. The full Englishman River watershed is not represented in these models (Figure 2).

#### **3.2.2.3 Numerical Model Boundary Conditions**

In the French Creek numerical model, specified head boundaries were applied to the portion of the Salish Sea that is represented in the model and set to mean sea level (i.e., zero metres above sea level [masl]). Specified heads were also used to represent the creeks in the low sub-basins (elevations below 150 masl) where watercourses were a permanent water body and the hydraulic connection with groundwater is strong (WSP, 2023). Hydraulic connections were inferred along French Creek, Morison Creek, Swayne Creek, Whisky Creek, the Little Qualicum River and the portion of the Englishman River included as the northwest edge of the model. Water level elevations were assigned based on elevation data of the river profile throughout the domain (WSP, 2023).

Head-dependent boundaries that only permit outflow of groundwater were applied along rivers and creeks in the upper watershed (elevations greater than 150 masl) and to watercourses that are inferred to have no hydraulic connection with groundwater (WSP, 2023).

A similar approach was used in the Nanoose numerical model for the Salish Sea and Englishman River. Specified heads were used to represent the portion of the Englishman River that was included in the model along the northwest boundary of the model domain. The Englishman River was a permanent water body and its hydraulic connection with groundwater was strong. The water



level elevations assigned to these boundaries were based on elevation data of the river profile throughout the domain.

The use of specified head boundaries assumes highly connected groundwater-surface water systems with an infinite supply of water to recharge or discharge the groundwater system. This can result in over-prediction of groundwater levels in aquifers connected to these boundaries, especially for future scenarios where surface water supply may change considerably (e.g. climate change or drought). An alternative approach would be to simulate the rivers and creeks using a fluid-transfer boundary condition where both a specified head and a conductance term are used to define the rate at which fluid transfers from groundwater to surface water systems and vice versa. For scenarios where there is a large increase in groundwater diversion, the inclusion of the conductance term limits the rate at which surface water could recharge the aquifer and thus may provide an improved projection of aquifer response under stress.

### **3.2.3 Numerical Model Calibration**

The French Creek numerical model was calibrated against a regional data set gathered from ENV's Groundwater Wells and Aquifers database (GWELLS; ENV, 2025a). The data available in this database are typically water levels measured at the time of drilling, and thus the data cover a broad temporal period. The combined data set is interpreted as representing the long-term average groundwater conditions (WSP, 2023). Calibration to this dataset was achieved using relatively small changes in hydraulic parameters from the initial estimates derived from the conceptual model. The model was subsequently calibrated using average seasonal conditions to a select set of wells (Provincial Groundwater Observation Well Network [PGOWN] and RDN volunteer observation wells) where a timeseries of data were available (WSP, 2023).

Overall, the model is biased to underestimate water levels in key aquifers (e.g., aquifer 216) under both steady state and transient simulations. For the transient simulation, the seasonal water level fluctuations are also underestimated (WSP, 2023). WSP identifies that this results in a conservative model given the proposed use of the model (i.e., water budget and stress analysis).

Calibration of the Nanoose numerical model followed the same process as was completed for the French Creek numerical model. The calibration results show a slight positive bias in the model, indicating the predicted hydraulic heads are slightly higher than the observed hydraulic head. The base flow estimates from the model reasonably replicate average data for three gauging stations located within the model domain (Figure 3 in Golder, 2020).

## **3.3 Climate Change Impacts on Groundwater Supply Reliability**

As part of their analyses to understand current and future aquifer stress, WSP simulated the impact of climate change on long-term groundwater conditions. The climate change predictions adopted from WSP (2023) are summarized in Table 6. KWL's climate predictions used for Parksville's future water supply assessment are also included in Table 6 for comparison.

**Table 6: Summary of Climate Change Predictions**

| Climate Variable                                             | Season | Median | Range (10 <sup>th</sup> to 90 <sup>th</sup> percentile) |
|--------------------------------------------------------------|--------|--------|---------------------------------------------------------|
| <b>WSP - Nanaimo Region (2050s) <sup>a</sup></b>             |        |        |                                                         |
| Temperature                                                  | Annual | +2.7°C | +1.9 °C to + 3.9°C                                      |
| Precipitation                                                | Summer | -13%   | -41% to + 3%                                            |
|                                                              | Winter | +3.4%  | -0.22% to + 9.3%                                        |
| Precipitation as Snow                                        | Summer | -80%   | -93% to -56%                                            |
|                                                              | Winter | -85%   | -91% to -76%                                            |
| <b>KWL – Englishman River Watershed (2050s) <sup>b</sup></b> |        |        |                                                         |
| Precipitation                                                | Summer | -1.1%  | -                                                       |
|                                                              | Winter | +6.9%  | -                                                       |

**Notes:** °C denotes degrees Celsius; % denotes percent; <sup>a</sup> indicates WSP’s summer season is from May to September (5-months); <sup>b</sup> indicates KWL’s summer season from June to September (4-months).

Annual climate is expected to generally be warmer and wetter with summers being longer, hotter and drier. Winters are expected to have more intense precipitation events. It should be noted that percent changes from a low baseline value can result in deceptively large percent change values. A small baseline can occur when the season and/or region together naturally make for zero or near-zero values. For example, snowfall in summer in low-lying southern areas.

In comparison with KWL’s climate change predictions, WSP is forecasting a greater decline in summer precipitation and a smaller increase in winter precipitation, for an overall more conservative (e.g., drier) estimate of potential recharge from infiltration.

### 3.4 Current Aquifer Stress Ratings

During the summer dry season, unconsolidated aquifers across the Englishman River watershed (i.e., Aquifers 216 and 209) have very high stress ratings (e.g., low groundwater availability; WSP, 2023). This is predominantly due to high water withdrawal for water supply by municipalities and private users. There are some exceptions, such as Aquifer 1252, Aquifer 221 and Aquifer 219, which have lower stress levels due to lower water usage (WSP, 2023; Golder, 2020).

Bedrock aquifers in the Englishman River watershed (i.e., Aquifers 220, 214 and 212) are considered to have lower stress levels (WSP, 2023; Golder, 2020). However, there are localized areas of declining water levels, which would indicate groundwater availability is changing due to less recharge or increased usage (WSP, 2023). As bedrock aquifers are highly variable in nature, having complex flow paths and sources of recharge, assigning one risk rating can be inherently difficult or misleading.

### 3.5 Groundwater Use Scenarios

To simulate the impact of climate change on the groundwater system, the climate change projections were translated to model inputs as follows:

- The dry season groundwater recharge rates across the model area were conservatively decreased by the median predicted reduction in precipitation (i.e., 13%) to simulate drier conditions in the summer;
- The length of the dry season was increased to a period of six months from a period of four months that is currently observed;
- Groundwater recharge during winter months, associated with increased precipitation, was not increased as the increase in precipitation is projected to occur as more intense storm events that would result in greater overland and surface water flow rather than increased recharge; recharge rates are controlled by soil/aquifer properties and are generally rate limiting compared to overland flow; and
- Increase in water use (50%) assigned to agricultural or rural land uses, as water use would be projected to increase to maintain shallow soil moisture conditions in a drier climate.

The model results from WSP (2023) and Golder (2020) for the potential climate change scenario for aquifers in the Englishman River watershed show:

- Groundwater levels in Aquifers 219, 216 and 209 (confined unconsolidated aquifers) are expected to decrease by 2 metres (m), more than 10 m and approximately 4 m, respectively. These projections are a result of both a decrease in recharge and an increase in agricultural/rural water demand in the drier summer months. The construction of the scenario does not separate the impact of climate change (i.e., reduced recharge) from the impact of an anthropogenic response to climate change (i.e., increase water demand). For Aquifer 219 specifically, decreases in groundwater levels in combination with groundwater gradient changes could result in increased risk from saltwater intrusion.
- Changes in groundwater levels at Aquifer 221 and Aquifer 1252 (unconfined unconsolidated aquifers) will be less than 4 m (WSP, 2023). However, as groundwater is expected to be hydraulically connected to surface water, it is expected that changes to baseflow will impact water availability, specifically Aquifer 221, which is hydraulically connected to the Englishman River (Golder, 2020).
- For the portions of Aquifers 220, 214 and 212 (fracture bedrock aquifers) within the Englishman River watershed, reduced recharge from overlying unconsolidated aquifers or direct infiltration of precipitation in the summers will result in groundwater levels declining by 2 to 3 m near the coastline (i.e., downgradient locations; Golder, 2020) and by 5 to 10 m at higher elevations in the watershed (i.e., upgradient locations; WSP, 2023).

The WSP numerical modelling (WSP, 2023) also simulated a scenario where agricultural land was converted to new development (referred to as the Future Built-Out scenario). In that scenario, the irrigation water demand is removed. In the Future Built-Out scenario, converting these agricultural areas to new residential developments results in a 10 m increase in water levels and combining the two scenarios (i.e., climate change and future build out) maintains this 10 m increase in water levels. Despite this rebound in water levels, aquifer stress levels at the end of the dry season are projected to remain very high (WSP, 2023).

### 3.6 Numerical Model Discussion and Data Gaps

Data gaps from Waterline’s review of the Nanoose and French Creek models include:

- As noted above, the selection of the specific head boundary condition (conservative) may impact the sensitivity of the model(s) for future scenarios (e.g., climate change).
- The aquifer of primary interest (e.g., aquifer 216) is contained within the French Creek numerical model. Based on the cross-sections shown by WSP (2023), French Creek has incised through the Quadra Sand unit and therefore Aquifer 216 would be expected to contribute to base flow in the creek. However, the numerical model does not simulate periodic water level changes in French Creek due to freshet or large precipitation events, and therefore, does not include the potential for periodic recharge of Aquifer 216 under high flow conditions.
- Groundwater flow within the Englishman River catchment is not simulated within one single model; rather, different portions of the catchment are represented in both the Nanoose and French Creek models. WSP (2023) indicated that changes in stage levels in the Englishman River from climate change were not considered at the time of investigation. Furthermore, only portions of Aquifer 1252 (located on the northwest side of the Englishman River) and Aquifer 221 (straddling the Englishman River near the outflow) are represented within either the French Creek or Nanoose modelled area, respectively.
- There are no mapped aquifers within the South Englishman River sub-watershed. This sub-watershed is not represented in either of the numerical models. Based on the mapping of Aquifers 209, 220, and 1252 in similar terrain on the northwest side of the Englishman River, additional aquifers could be expected in this area and are assumed to have not been mapped due to lack of available well information.

### 4.0 SUMMARY

To support Phase 1 of Parksville’s comprehensive water supply study, Waterline completed this Task 2 report, including reviewing operational data from Parksville’s 16 WSWs and the Englishman River watershed aquifer characteristics.

Key takeaways include:

- Groundwater levels in Aquifer 216 return to the same maximum elevation and a decreasing trend is not apparent, indicating sustainable groundwater withdrawal by Parksville.
- The WSA application diversion volume is 22% greater than the 2024 groundwater usage.
- Groundwater diversion is relatively consistent year-round with only a small increase in use during the dry summer period.
- The water quality from Railway Station and Springwood WSW is fresh, with no signs of impact from saltwater intrusion.
- The numerical modelling reports presented by Golder (2020) and WSP (2023) appear to be suitable for their defined purposes providing accurate stress rating for the aquifers in the Englishman River watershed.



## 5.0 CERTIFICATION

This document was prepared under the direction of a professional geoscientist registered in the Province of British Columbia.

Waterline Resources Inc. trusts that the information provided in this document is sufficient for your requirements. Should you have any questions or concerns, please do not hesitate to contact the undersigned.

Respectfully submitted,

**Waterline Resources Inc.**  
**EGBC Permit No. 1000669**

**Reviewed By:**



Simon Wing, B.Sc., P. Geo.  
Senior Hydrogeologist

A handwritten signature in blue ink, likely belonging to Andrew Hinnell.

Andrew Hinnell, Ph.D., P. Geo  
Principal Hydrogeologist

A handwritten signature in black ink, likely belonging to Steph Righi.

Steph Righi, B.NRP, RBTech  
Regulatory Specialist

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## **7.0 LIMITATIONS AND USE**

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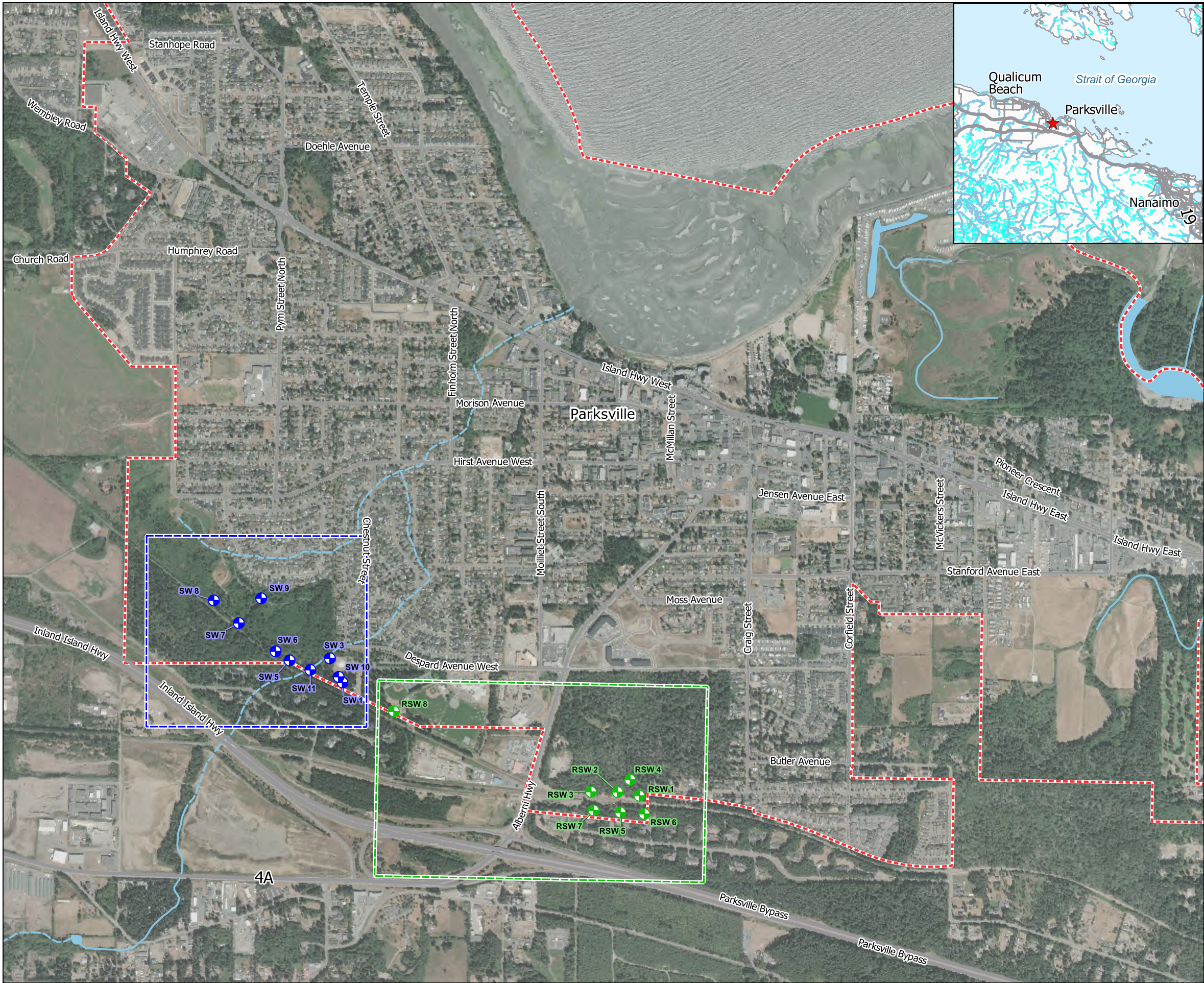
## Figures

**Figure 1: Location Map**

**Figure 2: Numerical Groundwater Modelling Domains**



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- Springwood Water Supply Well
- Railway Station Water Supply Well
- River/Stream - Definite
- River/Stream - Indefinite
- Road - Expressway / Highway
- Road - Arterial / Collector
- Springwood Well Field
- Railway Station Well Field
- Parkville Municipal Boundary

References:  
Fresh Water Atlas (2017), National Road Network (2016),  
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the Open Government Licence - Canada, ESRI World Imagery (WMS)

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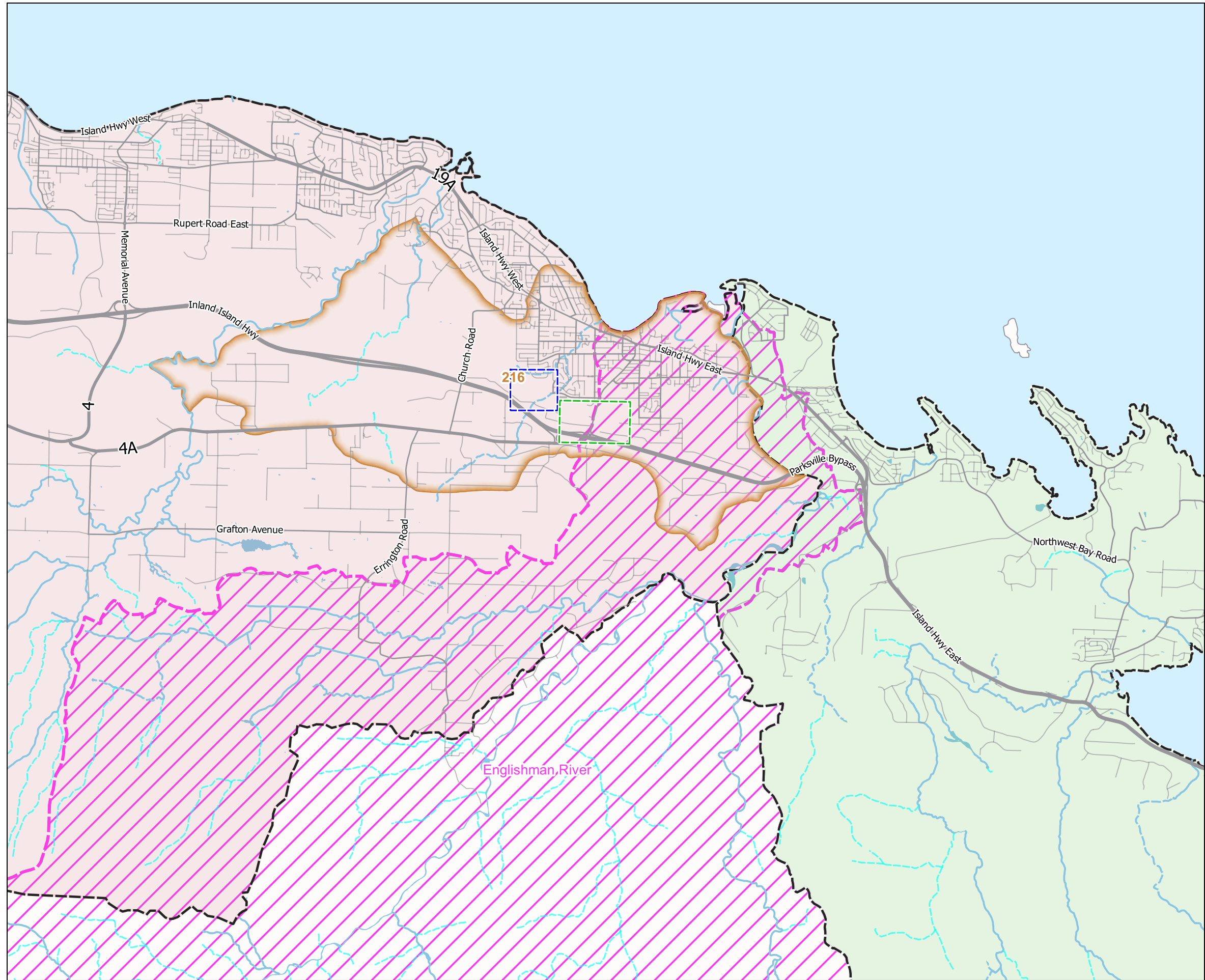
|                     |                                       |
|---------------------|---------------------------------------|
| <b>LOCATION MAP</b> |                                       |
|                     | Prepared By: Waterline Resources Inc. |
|                     | Project Number: 3917-24-001           |
|                     | Compiled By: mwine                    |
|                     | Date Issued: 2025-Aug-22              |
| Date Revised: --    |                                       |

**FIGURE 1**

Coordinate System: NAD83(CSRS) / UTM zone 10N



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- River/Stream - Definite
- River/Stream - Indefinite
- River/Stream - Intermittent
- Road - Expressway / Highway
- Road - Arterial / Collector
- Road
- Springwood Well Field
- Railway Station Well Field
- Englishman River Watershed
- Aquifer 216: Surficial Confined
- French Creek Model Domain
- Nanoose Model Domain



References:

Golder (2020), Fresh Water Atlas (2017), National Road Network (2016), Contains information licensed under the Open Government Licence - British Columbia and the Open Government Licence - Canada

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**NUMERICAL GROUNDWATER MODELING DOMAINS**

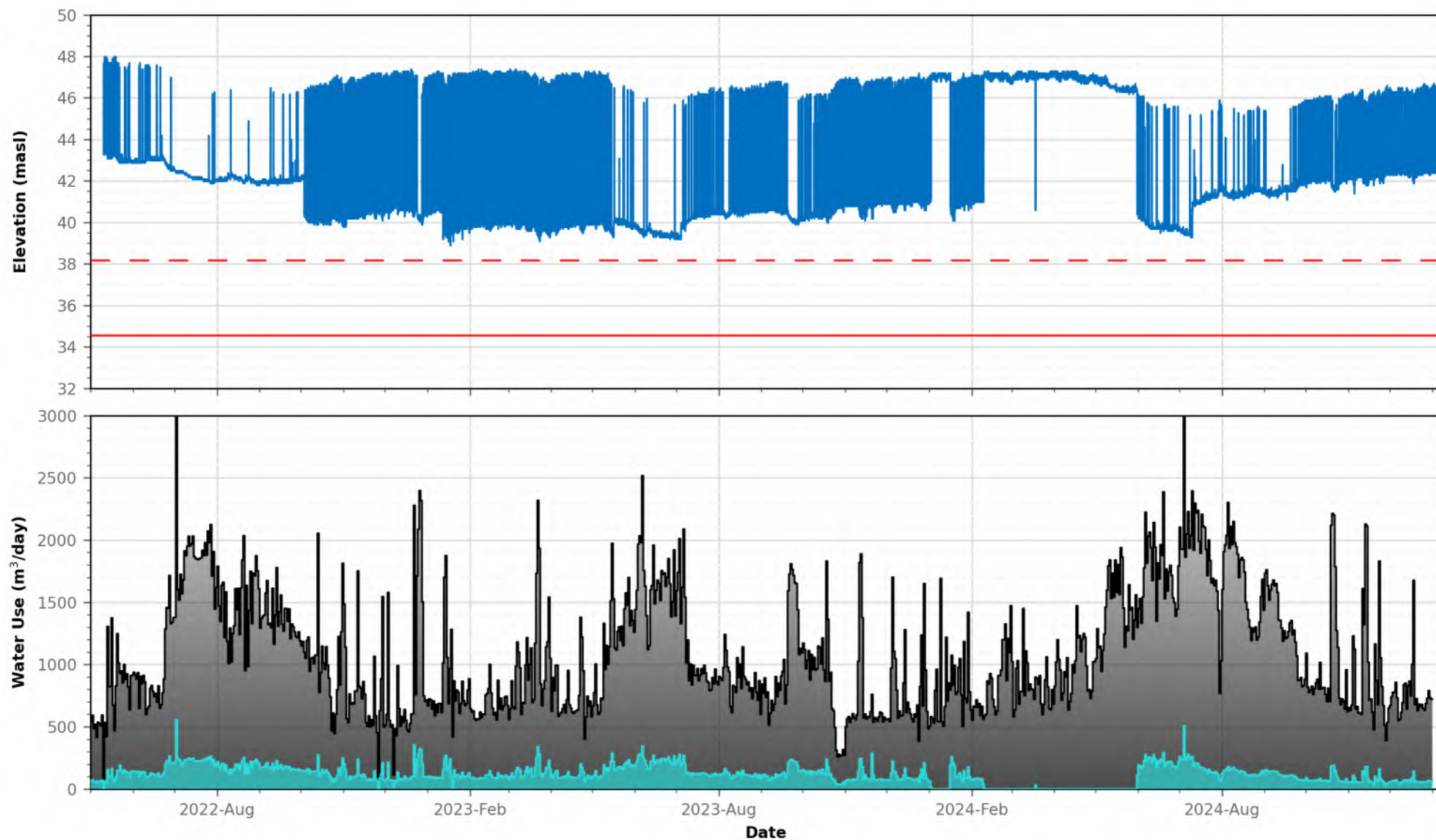
|  |                                       |                 |
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|  | Prepared By: Waterline Resources Inc. | <b>FIGURE 2</b> |
|  | Project Number: 3917-24-001           |                 |
|  | Compiled By: mwine                    |                 |
|  | Date Issued: 2025-Aug-22              |                 |
|  | Date Revised: --                      |                 |

Coordinate System: NAD83(CSRS) / UTM zone 10N

## **Appendix A**

### **Short-Term Groundwater Level Hydrographs and Groundwater Use Charts**





— Railway Station Well 1 - Pumping Water Level  
 - - - 70% of Available Head Elevation  
 — Top of Screen Elevation  
 — Railway Station Well Field - Cumulative Use  
 — Railway Station Well 1 - Groundwater Use

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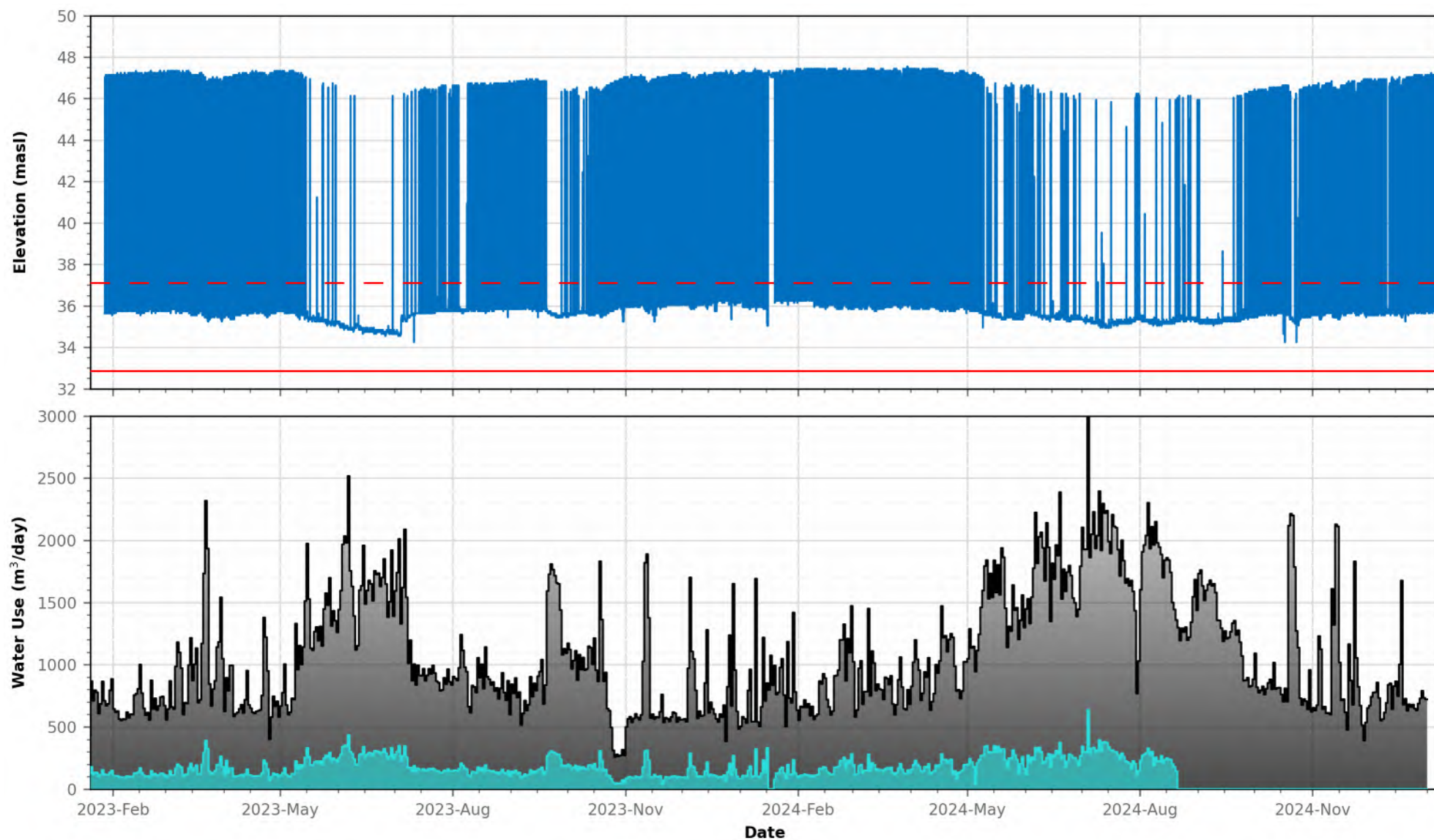
### Short-Term Groundwater Level & Use - Railway Station Well 1



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 COMPILED BY: Hydrachem  
 DATE ISSUED: 2025-Mar-27  
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**FIGURE A1**





— Railway Station Well 2 - Pumping Water Level  
 - - - 70% of Available Head Elevation  
 — Top of Screen Elevation  
 — Railway Station Well Field - Cumulative Use  
 — Railway Station Well 2 - Groundwater Use

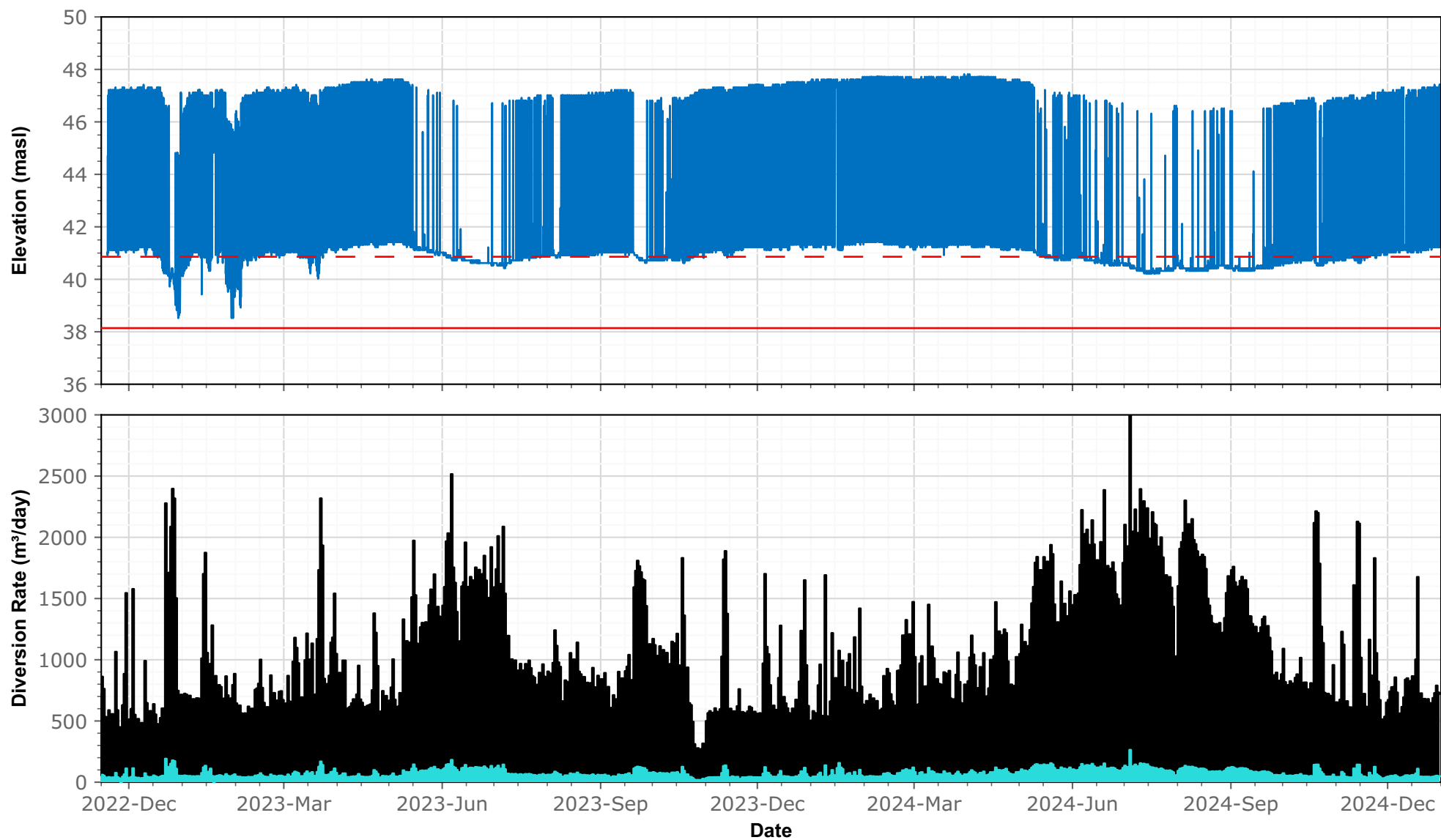
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### Short-Term Groundwater Level & Use - Railway Station Well 2



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 COMPILED BY: Hydrachem  
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FIGURE A2



- Railway Station Well 3 - Pumping Water Level
- - - 70% of Available Head Elevation
- Top of Screen Elevation
- Railway Station Well Field - Cumulative Use
- Railway Station Well 3 - Groundwater Use

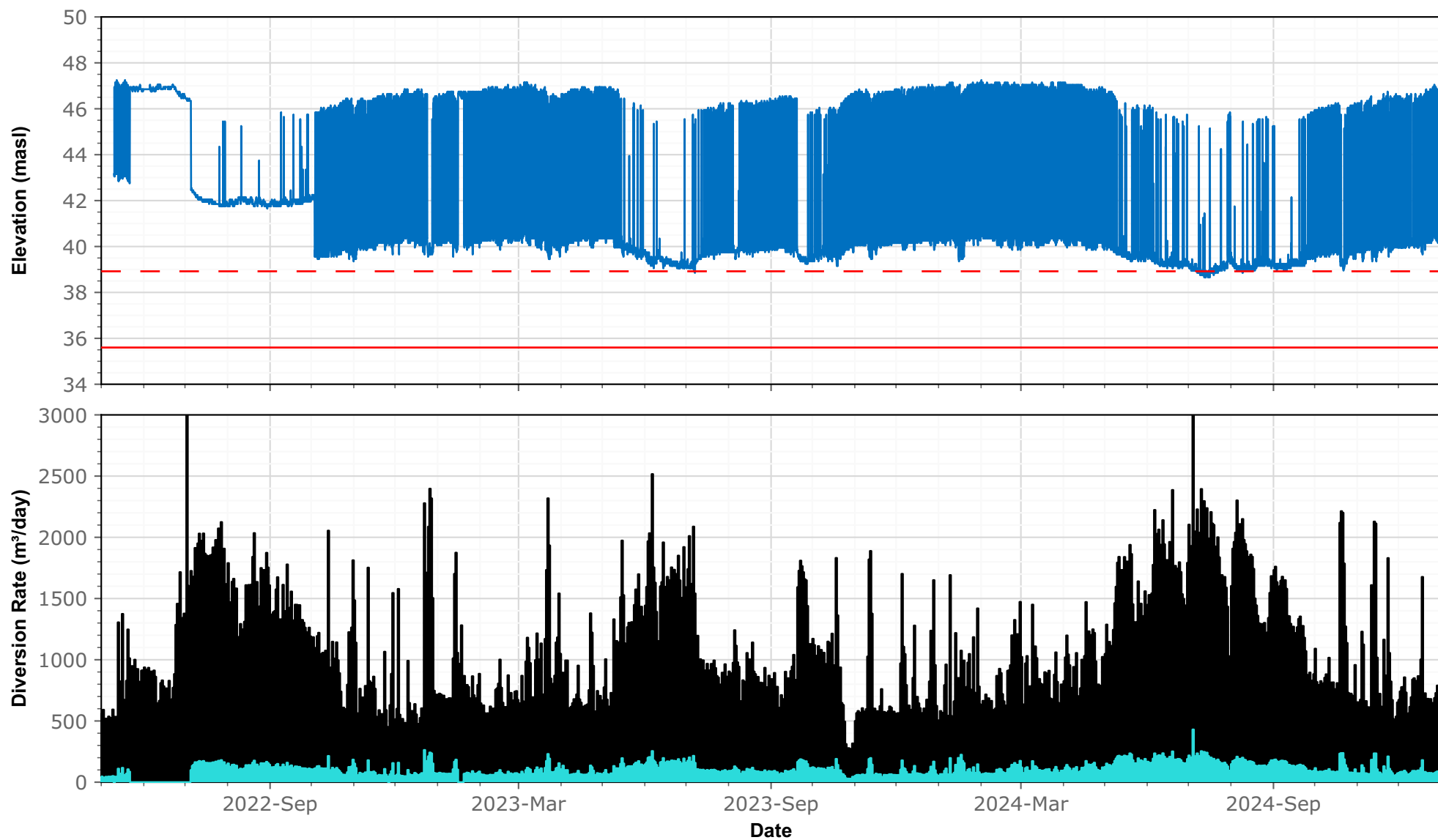
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### Short-Term Groundwater Level & Use - Railway Station Well 3



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 COMPILED BY: Hydrachem  
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FIGURE A3



- Railway Station Well 4 - Pumping Water Level
- - - 70% of Available Head Elevation
- Top of Screen Elevation
- Railway Station Well Field - Cumulative Use
- Railway Station Well 4 - Groundwater Use

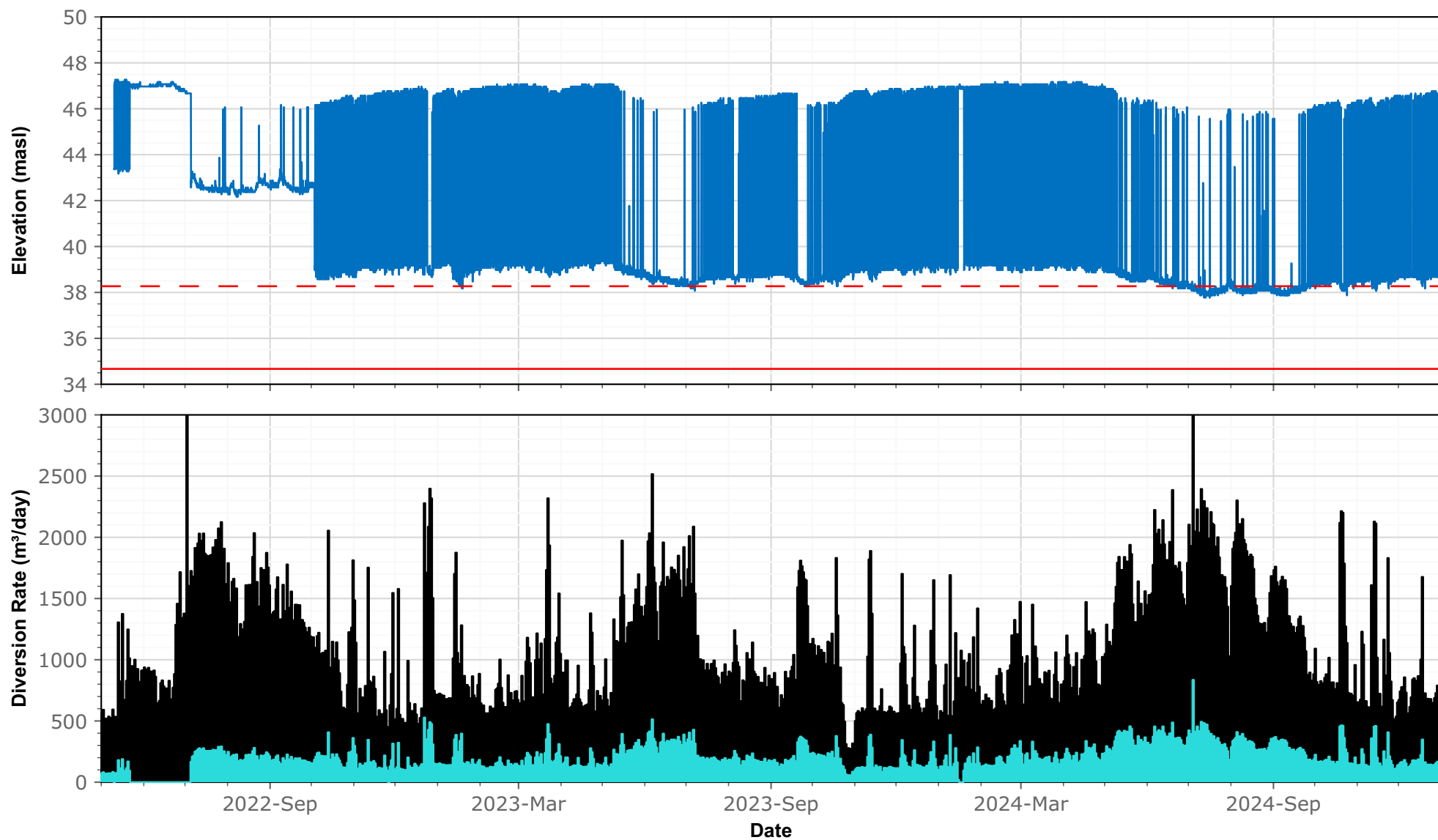
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### Short-Term Groundwater Level & Use - Railway Station Well 4



|                                       |
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FIGURE A4



- Railway Station Well 5 - Pumping Water Level
- - - 70% of Available Head Elevation
- Top of Screen Elevation
- Railway Station Well Field - Cumulative Use
- Railway Station Well 5 - Groundwater Use

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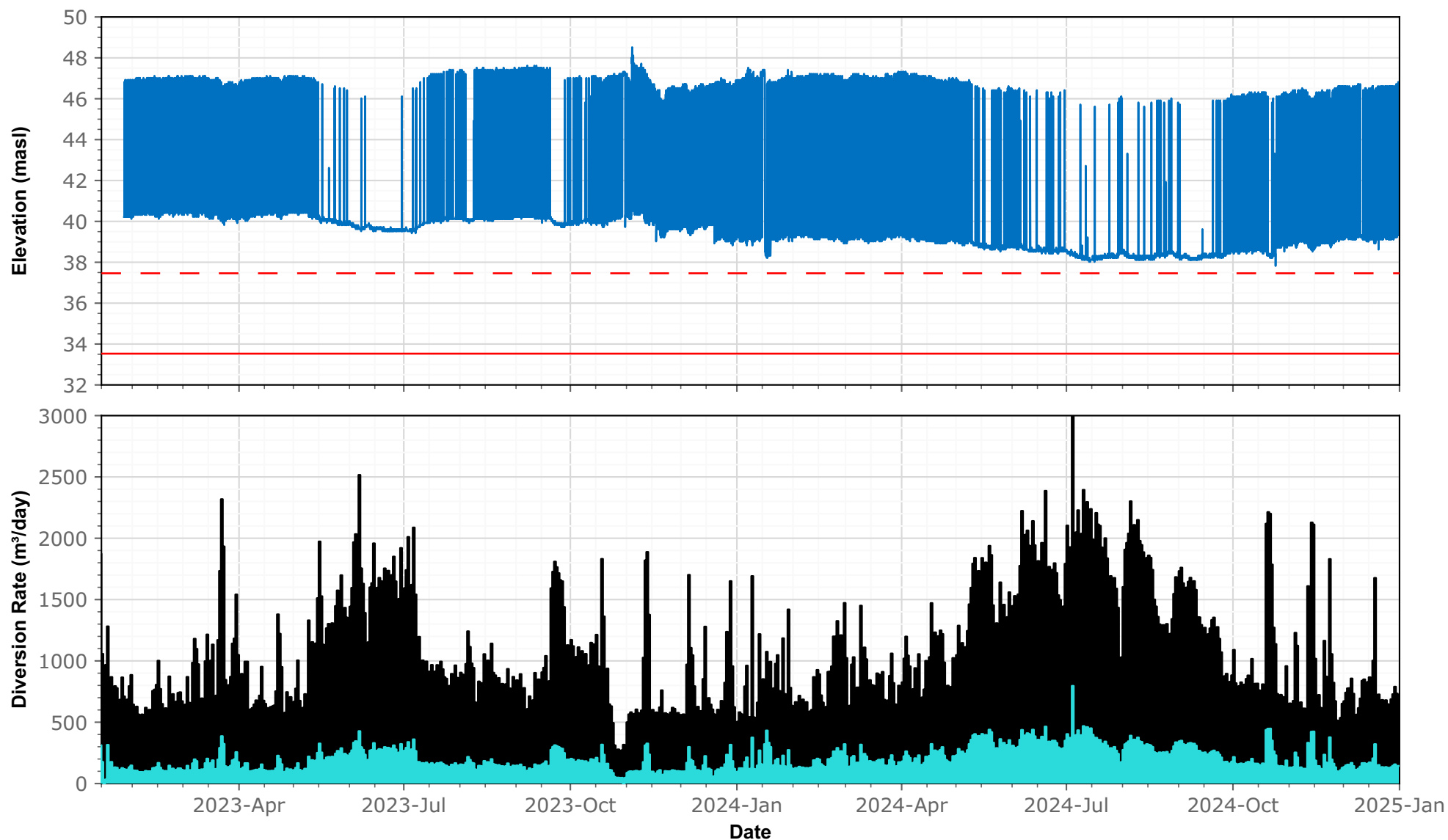
### Short-Term Groundwater Level & Use - Railway Station Well 5



|                                       |
|---------------------------------------|
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FIGURE A5





— Railway Station Well 6 - Pumping Water Level  
 - - - 70% of Available Head Elevation  
 — Top of Screen Elevation  
 — Railway Station Well Field - Cumulative Use  
 — Railway Station Well 6 - Groundwater Use

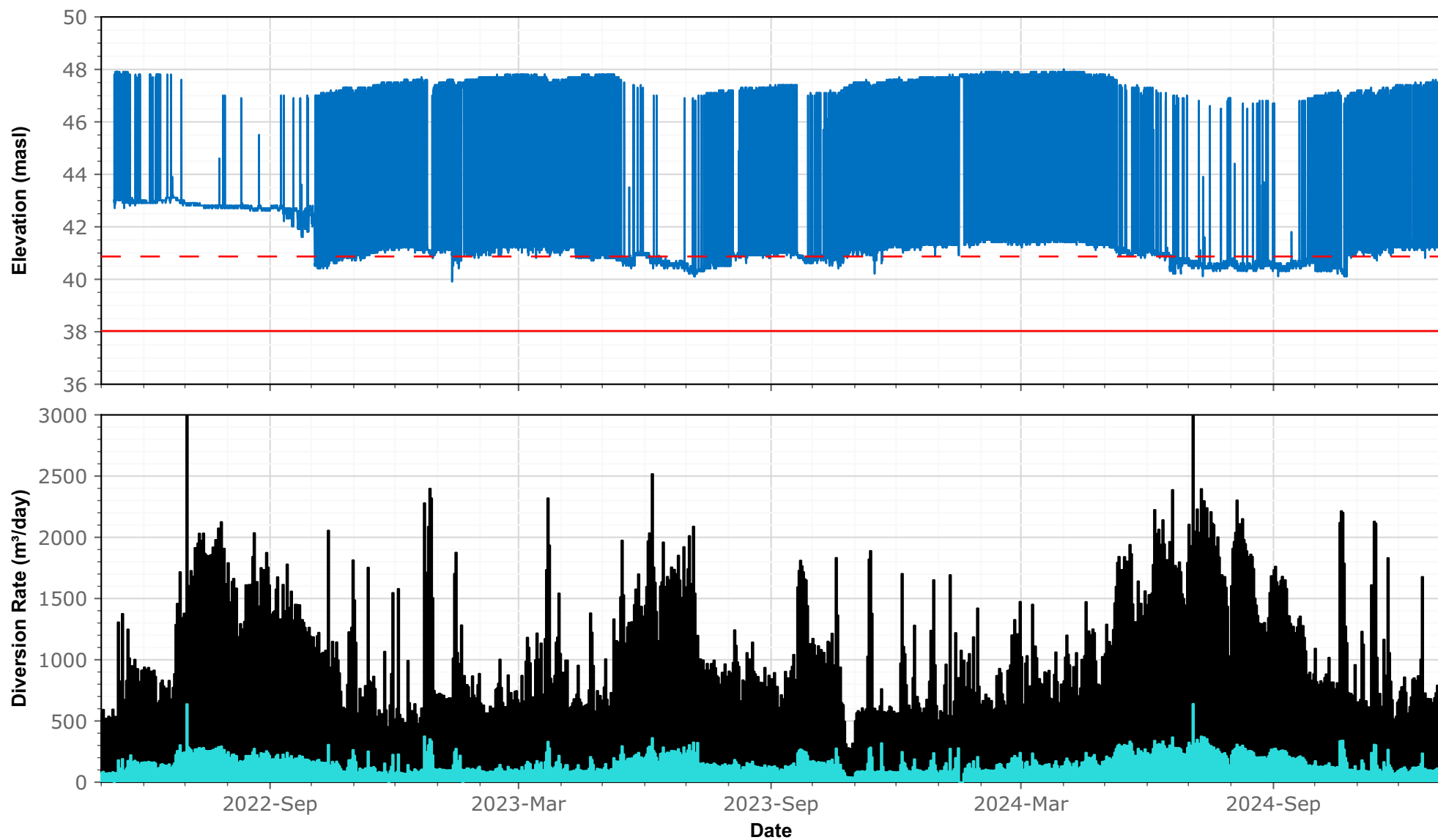
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### Short-Term Groundwater Level & Use - Railway Station Well 6



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FIGURE A6



- Railway Station Well 7 - Pumping Water Level
- 70% of Available Head Elevation
- Top of Screen Elevation
- Railway Station Well Field - Cumulative Use
- Railway Station Well 7 - Groundwater Use

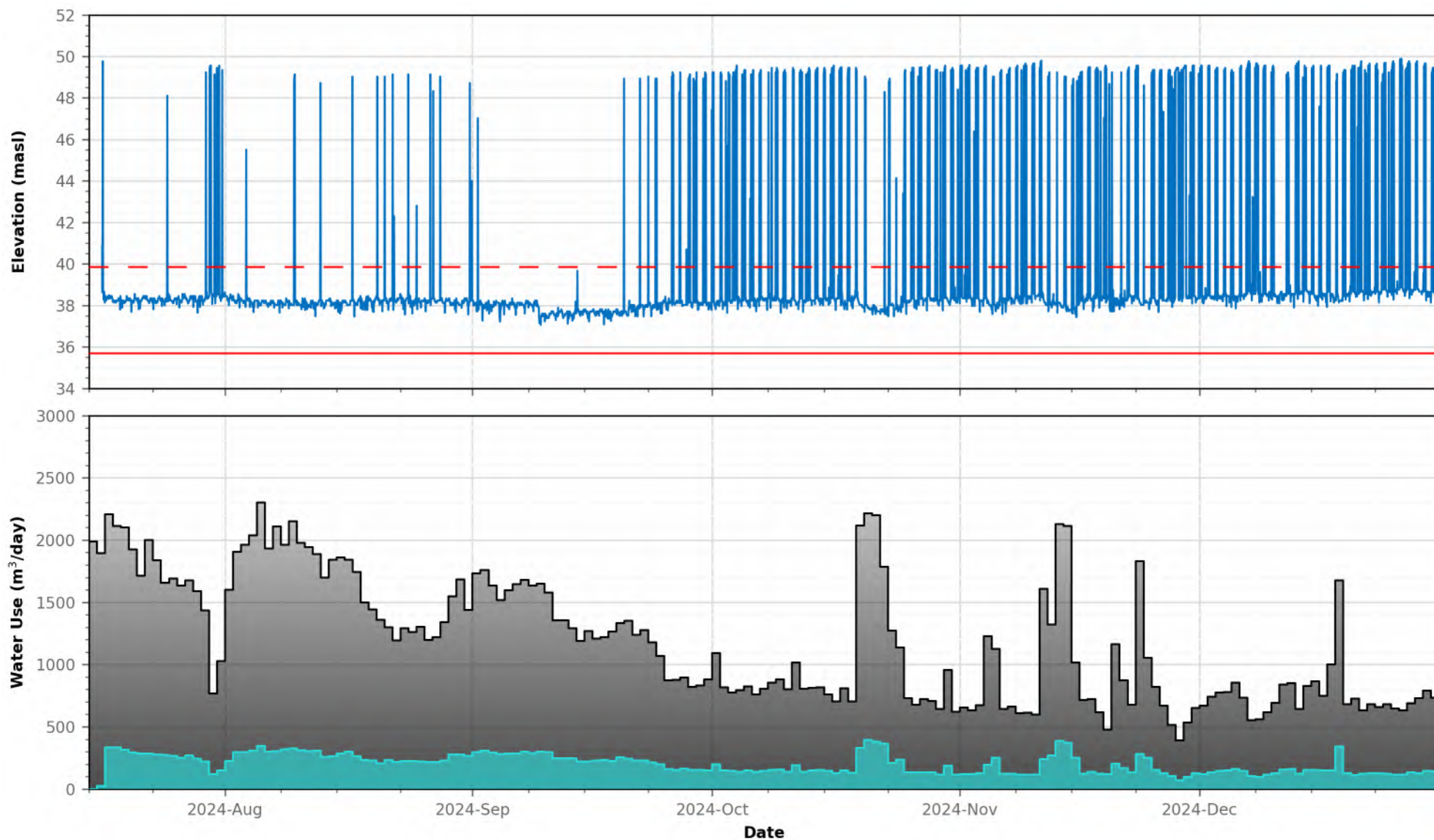
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### Short-Term Groundwater Level & Use - Railway Station Well 7



|                                       |
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**FIGURE A7**



- Railway Station Well 8 - Pumping Water Level
- - - 70% of Available Head Elevation
- Top of Screen Elevation
- Railway Station Well Field - Cumulative Use
- Railway Station Well 8 - Groundwater Use

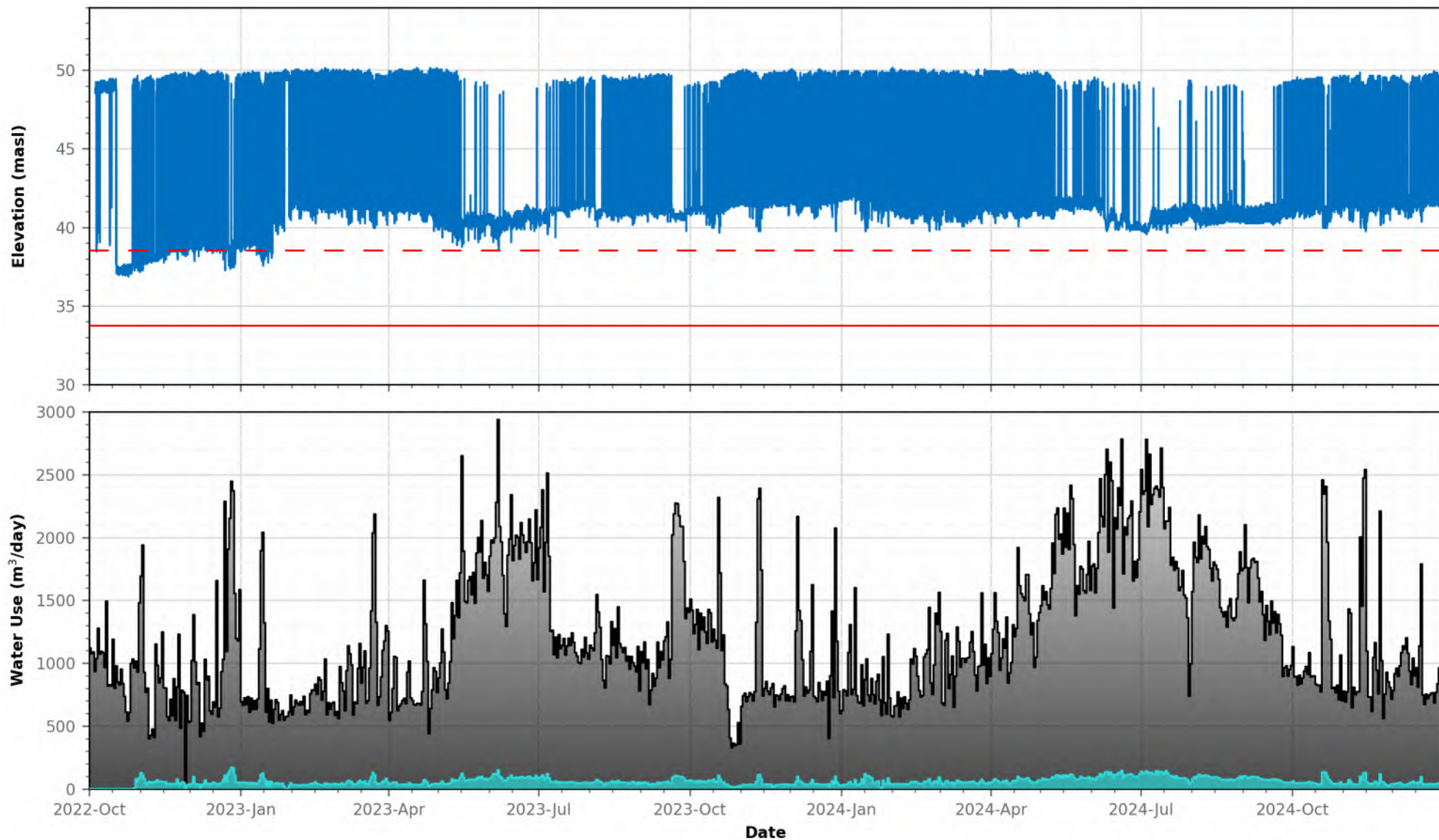
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### Short-Term Groundwater Level & Use - Railway Station Well 8



|                                       |
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FIGURE A8



- Springwood Well 1 - Pumping Water Level
- - - 70% of Available Head Elevation
- Top of Screen Elevation
- Springwood Well Field - Cumulative Use
- Springwood Well 1 - Groundwater Use

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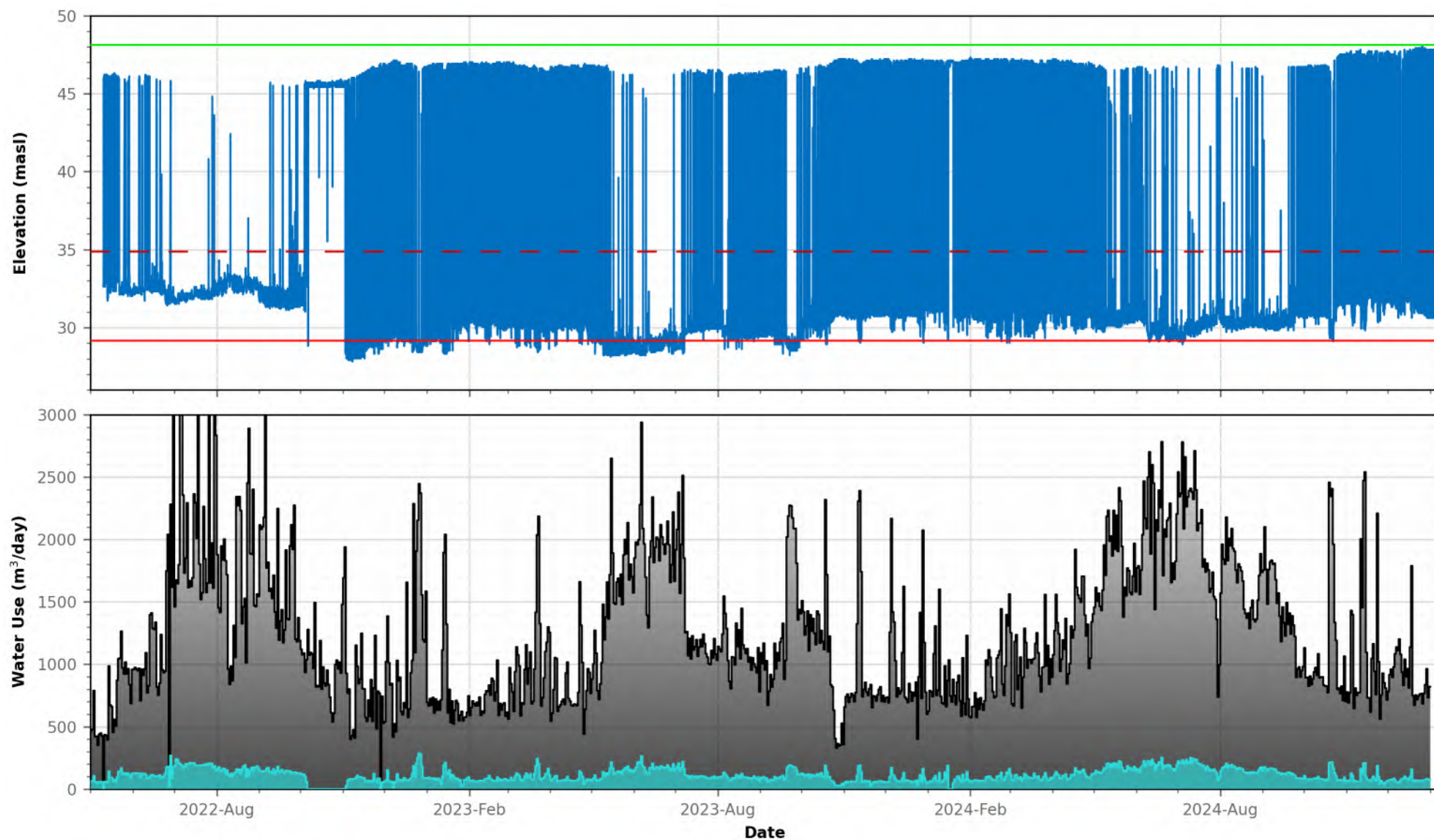
### Short-Term Groundwater Level & Use - Springwood Well 1



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FIGURE A9





- Springwood Well 3 - Pumping Water Level
- Top of Casing Elevation
- - - 70% of Available Head Elevation
- Top of Screen Elevation
- Springwood Well Field - Cumulative Use
- Springwood Well 3 - Groundwater Use

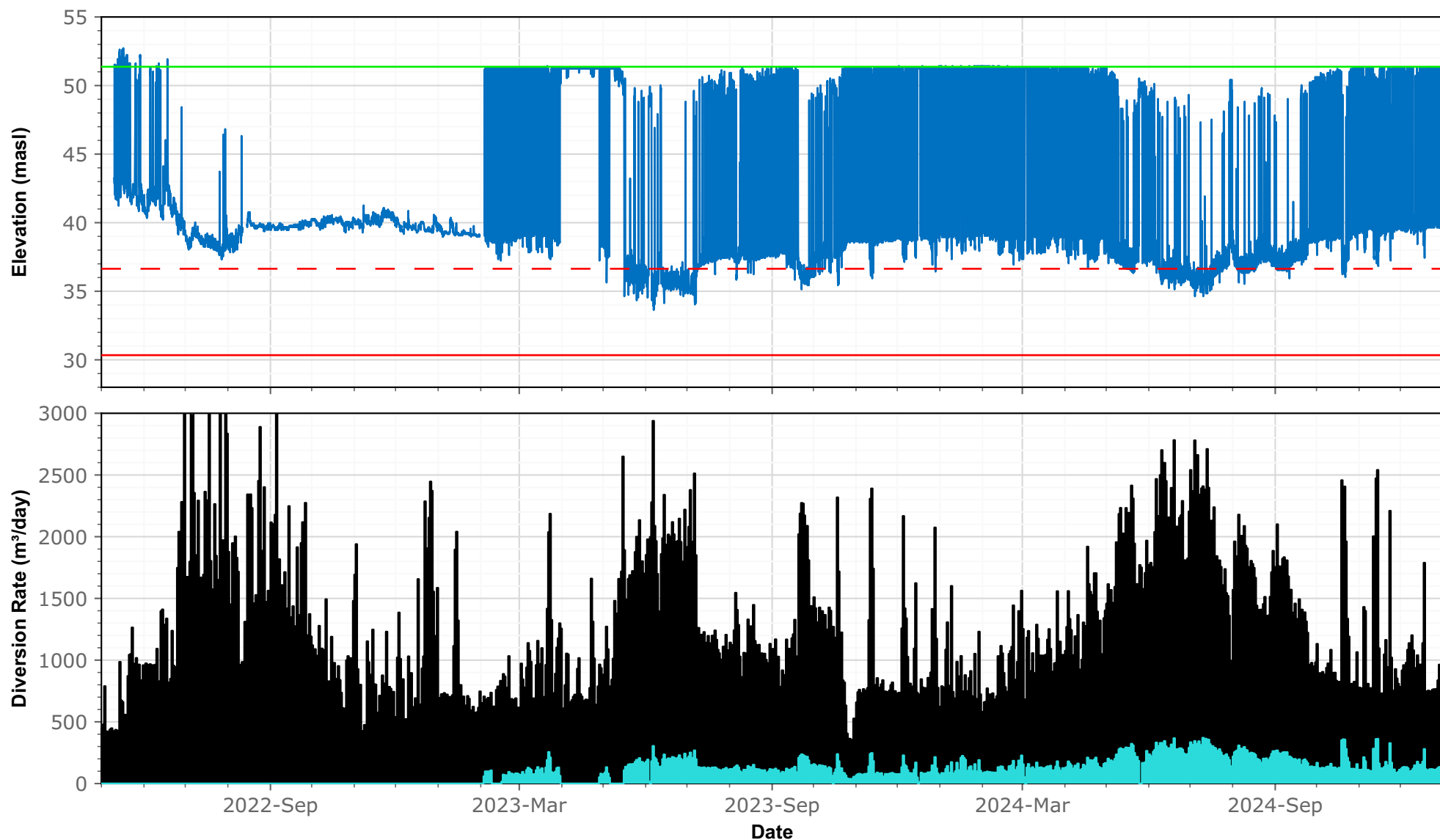
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### Short-Term Groundwater Level & Use - Springwood Well 3



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COMPILED BY: Hydrachem  
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FIGURE A10



- Springwood Well 5 - Pumping Water Level
- Top of Casing Elevation
- - - 70% of Available Head Elevation
- Top of Screen Elevation
- Springwood Well Field - Cumulative Use
- Springwood Well 5 - Groundwater Use

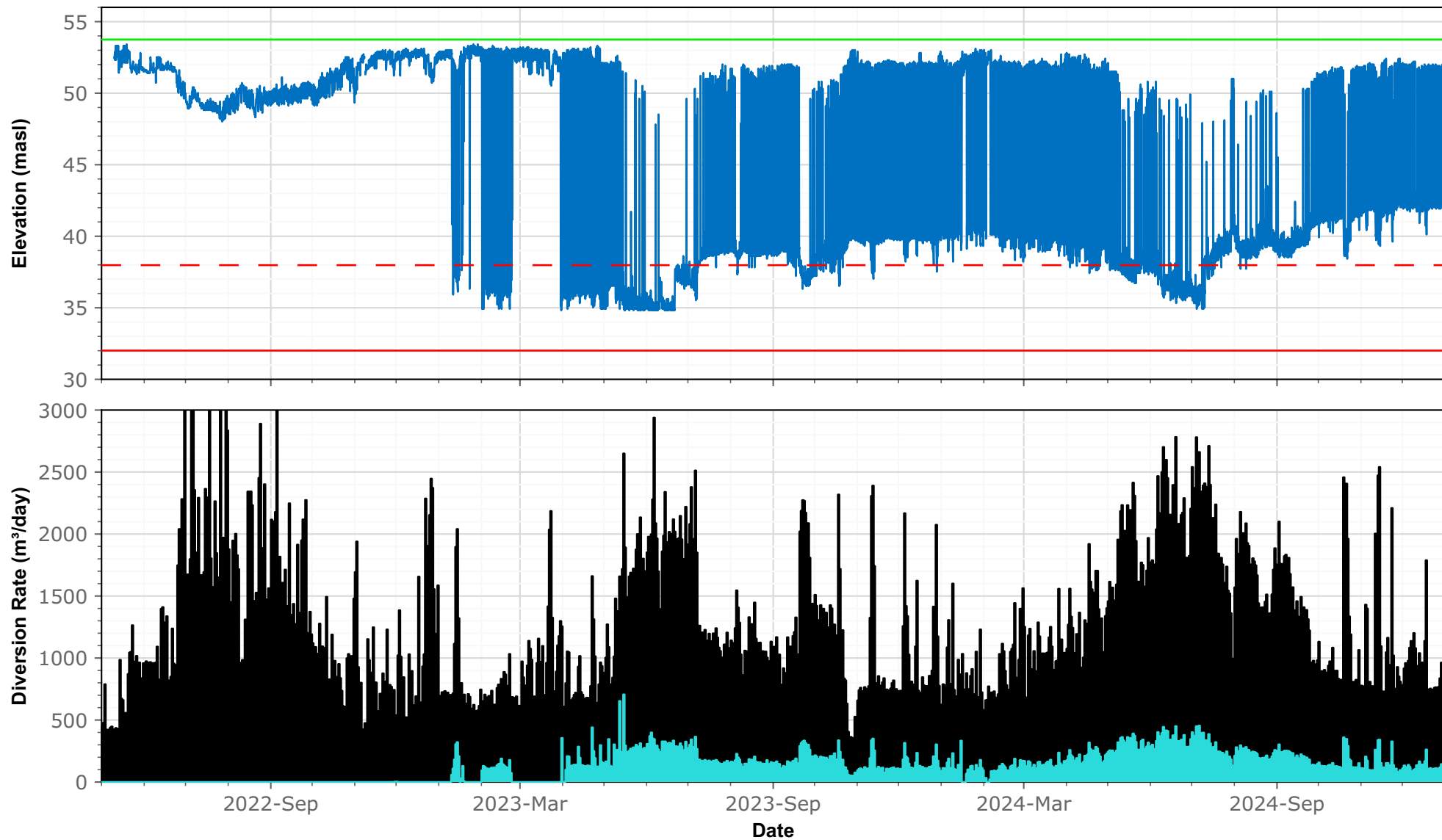
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### Short-Term Groundwater Levels & Precipitation - Springwood Well 5



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FIGURE A11



- Springwood Well 6 - Pumping Water Level
- Top of Casing Elevation
- - - 70% of Available Head Elevation
- Top of Screen Elevation
- Springwood Well Field - Cumulative Use
- Springwood Well 6 - Groundwater Use

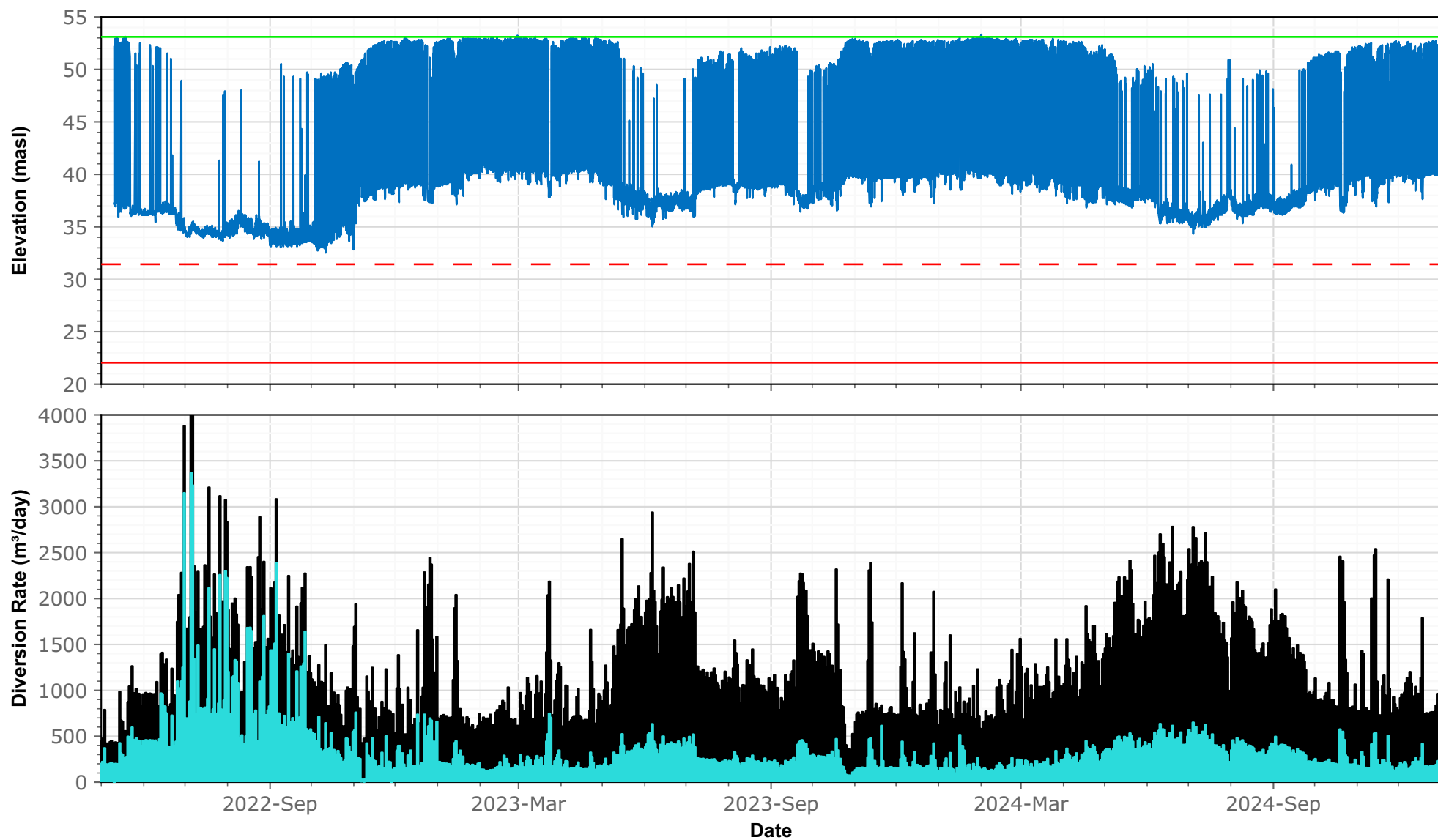
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### Short-Term Groundwater Levels & Precipitation - Springwood Well 6



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FIGURE A12



- Springwood Well 7 - Pumping Water Level
- Top of Casing Elevation
- - - 70% of Available Head Elevation
- Top of Screen Elevation
- Springwood Well Field - Cumulative Use
- Springwood Well 7 - Groundwater Use

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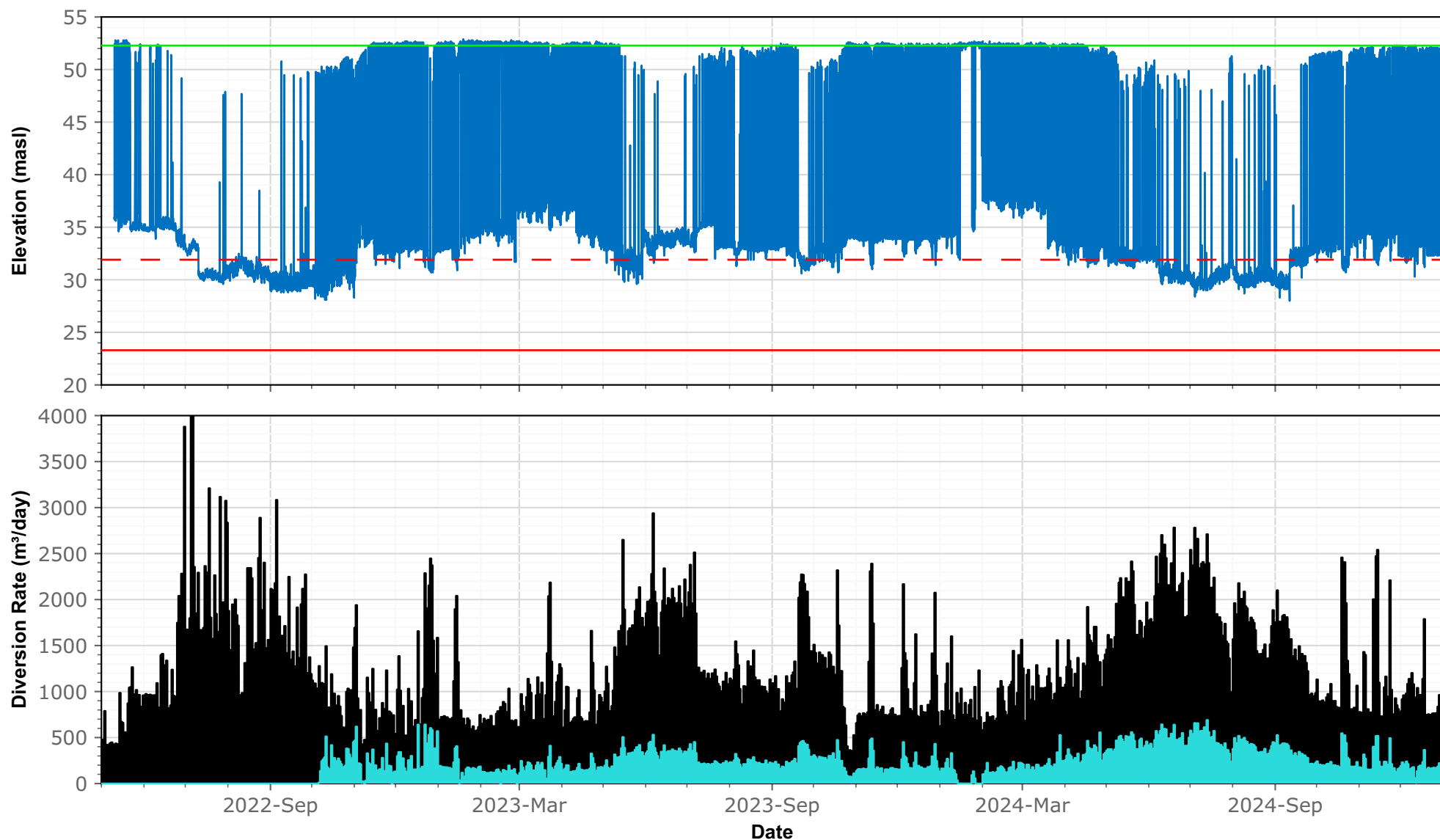
### Short-Term Groundwater Levels & Precipitation - Springwood Well 7



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FIGURE A13





- Springwood Well 8 - Pumping Water Level
- Top of Casing Elevation
- - - 70% of Available Head Elevation
- Top of Screen Elevation
- Springwood Well Field - Cumulative Use
- Springwood Well 8 - Groundwater Use

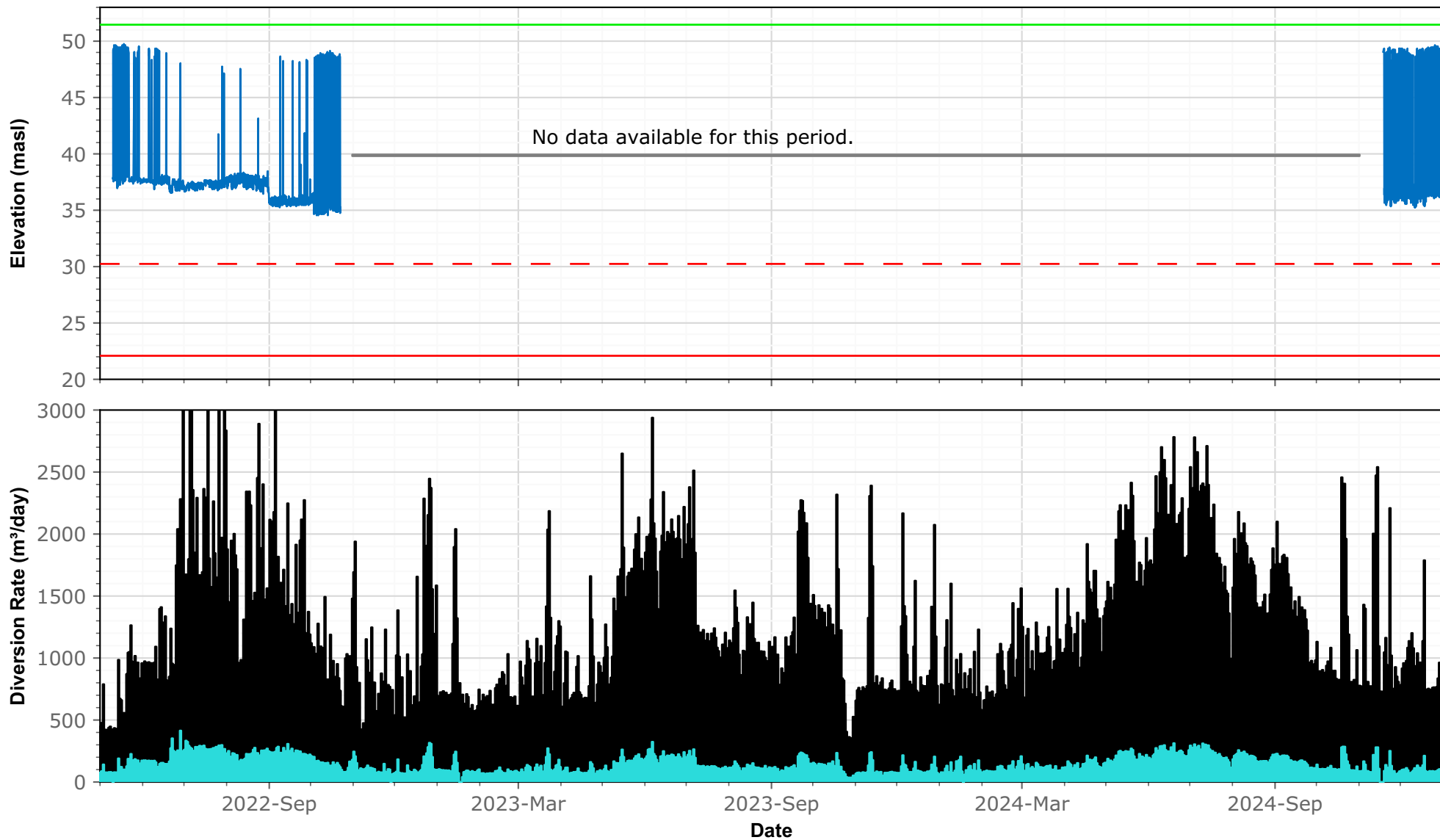
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### Short-Term Groundwater Levels & Precipitation - Springwood Well 8



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FIGURE A14



- Springwood Well 10 - Pumping Water Level
- Top of Casing Elevation
- - - 70% of Available Head Elevation
- Top of Screen Elevation
- Springwood Well Field - Cumulative Use
- Springwood Well 10 - Groundwater Use

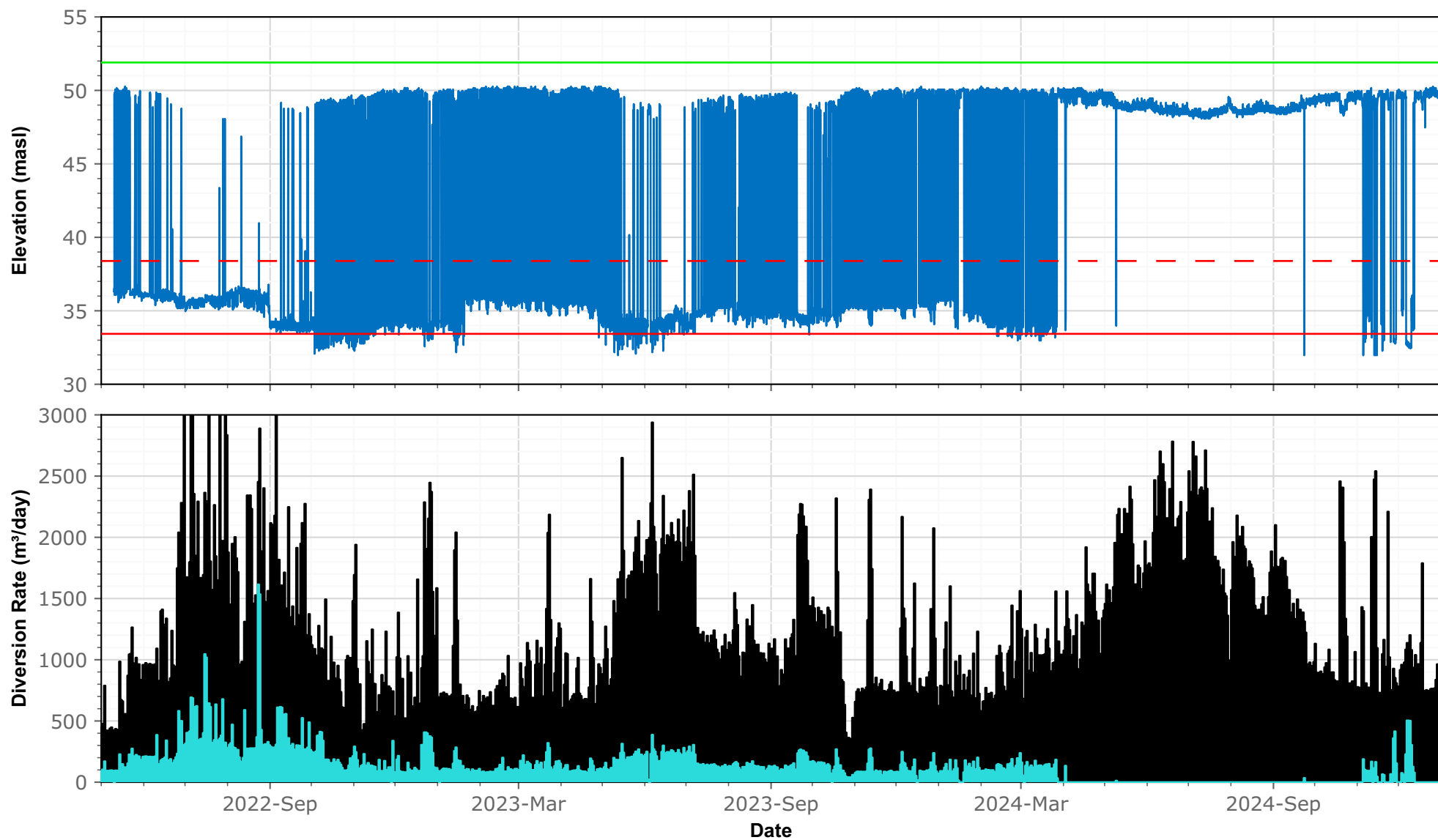
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### Short-Term Groundwater Levels & Precipitation - Springwood Well 10



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FIGURE A15



- Springwood Well 11 - Pumping Water Level
- Top of Casing Elevation
- - - 70% of Available Head Elevation
- Top of Screen Elevation
- Springwood Well Field - Cumulative Use
- Springwood Well 11 - Groundwater Use

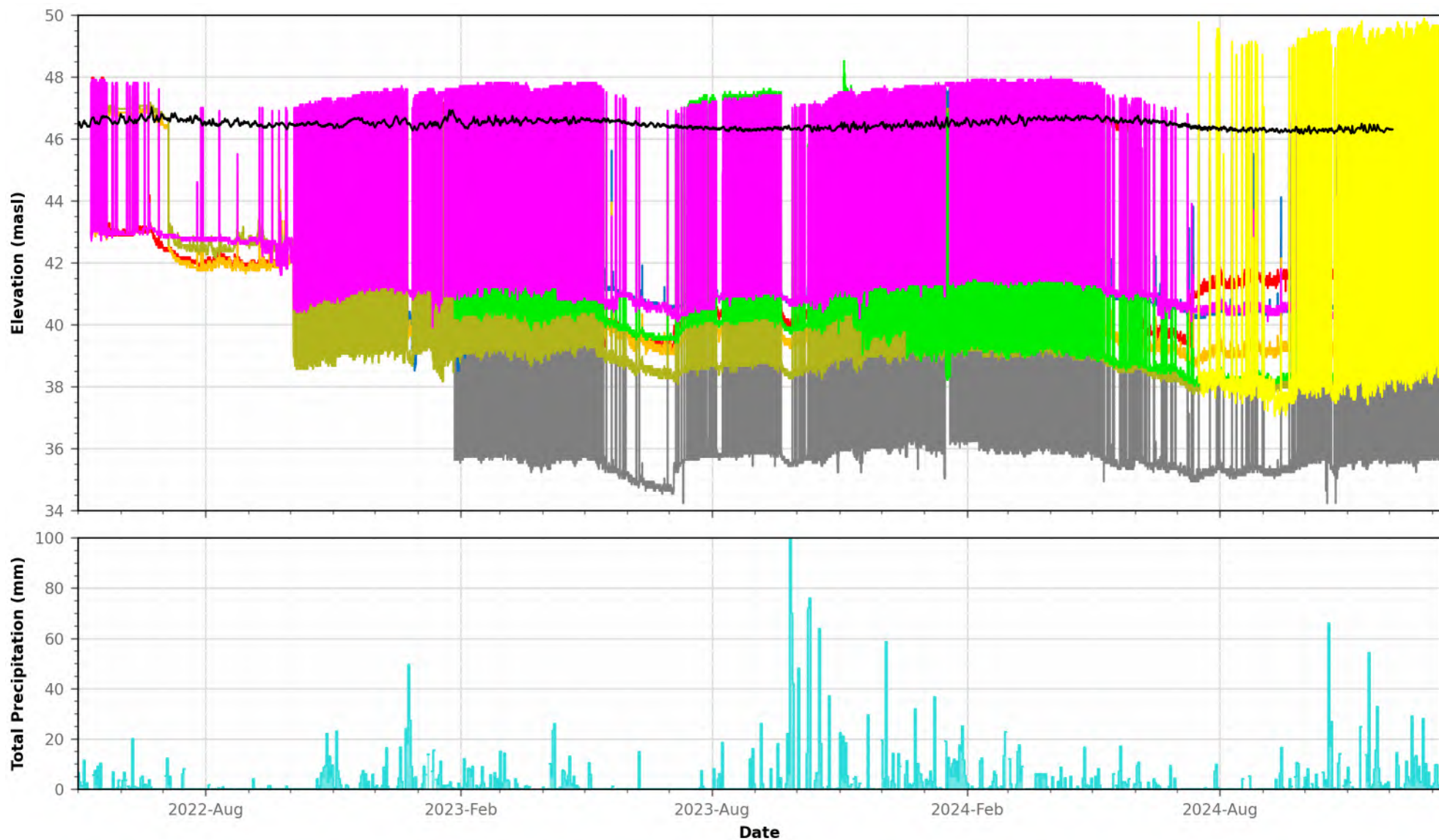
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### Short-Term Groundwater Levels & Precipitation - Springwood Well 11



|                                       |
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FIGURE A16



- Railway Station Well 1 - Pumping Water Level
- Railway Station Well 2 - Pumping Water Level
- Railway Station Well 3 - Pumping Water Level
- Railway Station Well 4 - Pumping Water Level
- Railway Station Well 5 - Pumping Water Level
- Railway Station Well 6 - Pumping Water Level
- Railway Station Well 7 - Pumping Water Level
- Railway Station Well 8 - Pumping Water Level
- OW398 - Groundwater Level
- Qualicum R Fish Research - Total Precipitation

Climate data obtained from Environment and Climate Change Canada.

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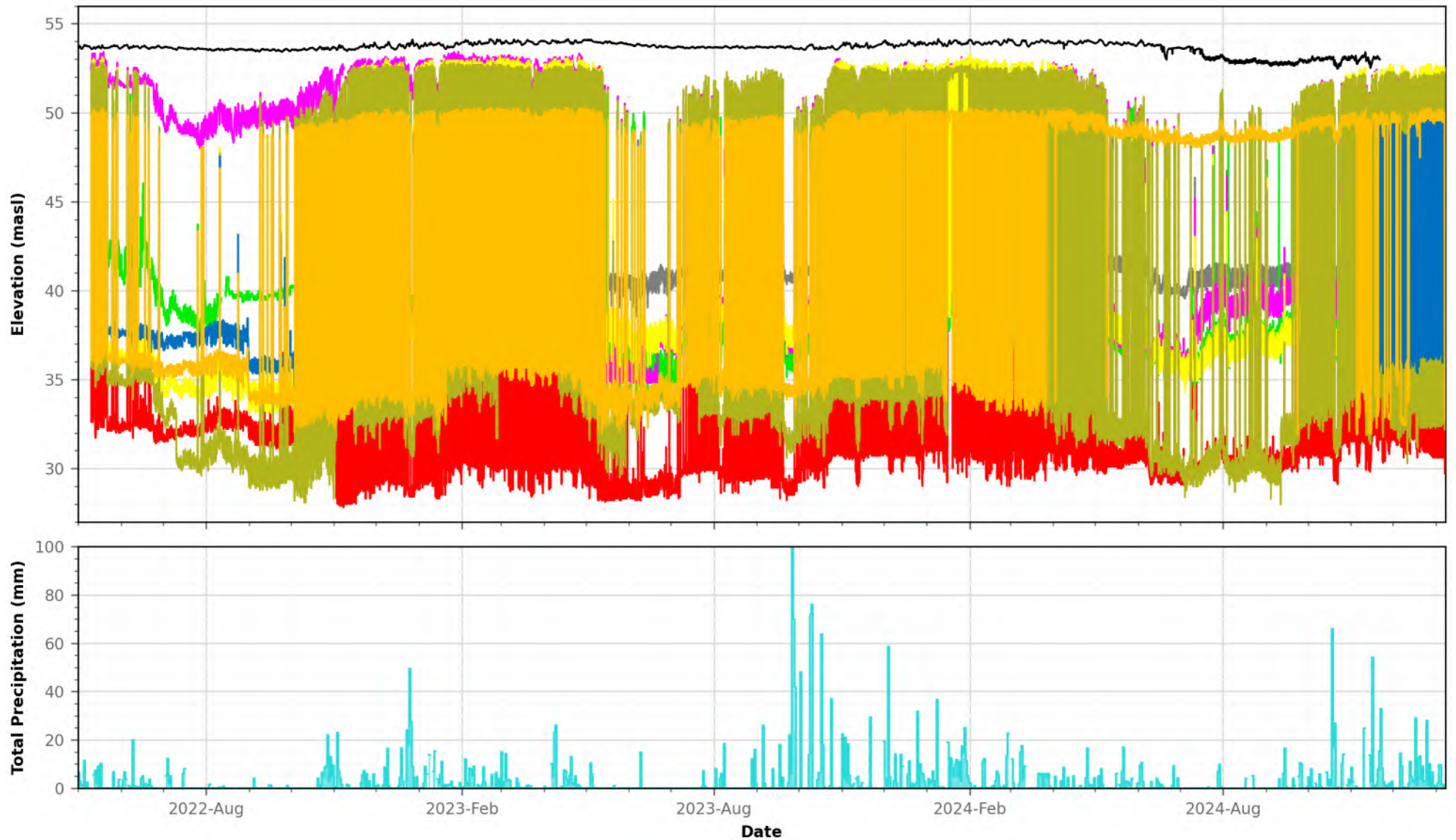
## Short-Term Groundwater Levels & Precipitation - Railway Station Well Field



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| PREPARED BY: Waterline Resources Inc. |
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| COMPILED BY: Hydrachem                |
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**FIGURE A17**





— Springwood Well 1 - Pumping Water Level  
 — Springwood Well 3 - Pumping Water Level  
 — Springwood Well 5 - Pumping Water Level  
 — Springwood Well 6 - Pumping Water Level  
 — Springwood Well 7 - Pumping Water Level  
 — Springwood Well 8 - Pumping Water Level  
 — Springwood Well 10 - Pumping Water Level  
 — Springwood Well 11 - Pumping Water Level  
 — OW304 - Groundwater Level  
 — Qualicum R Fish Research - Total Precipitation

Climate data obtained from Environment and Climate Change Canada.

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## Short-Term Groundwater Levels & Precipitation - Springwood Well Field



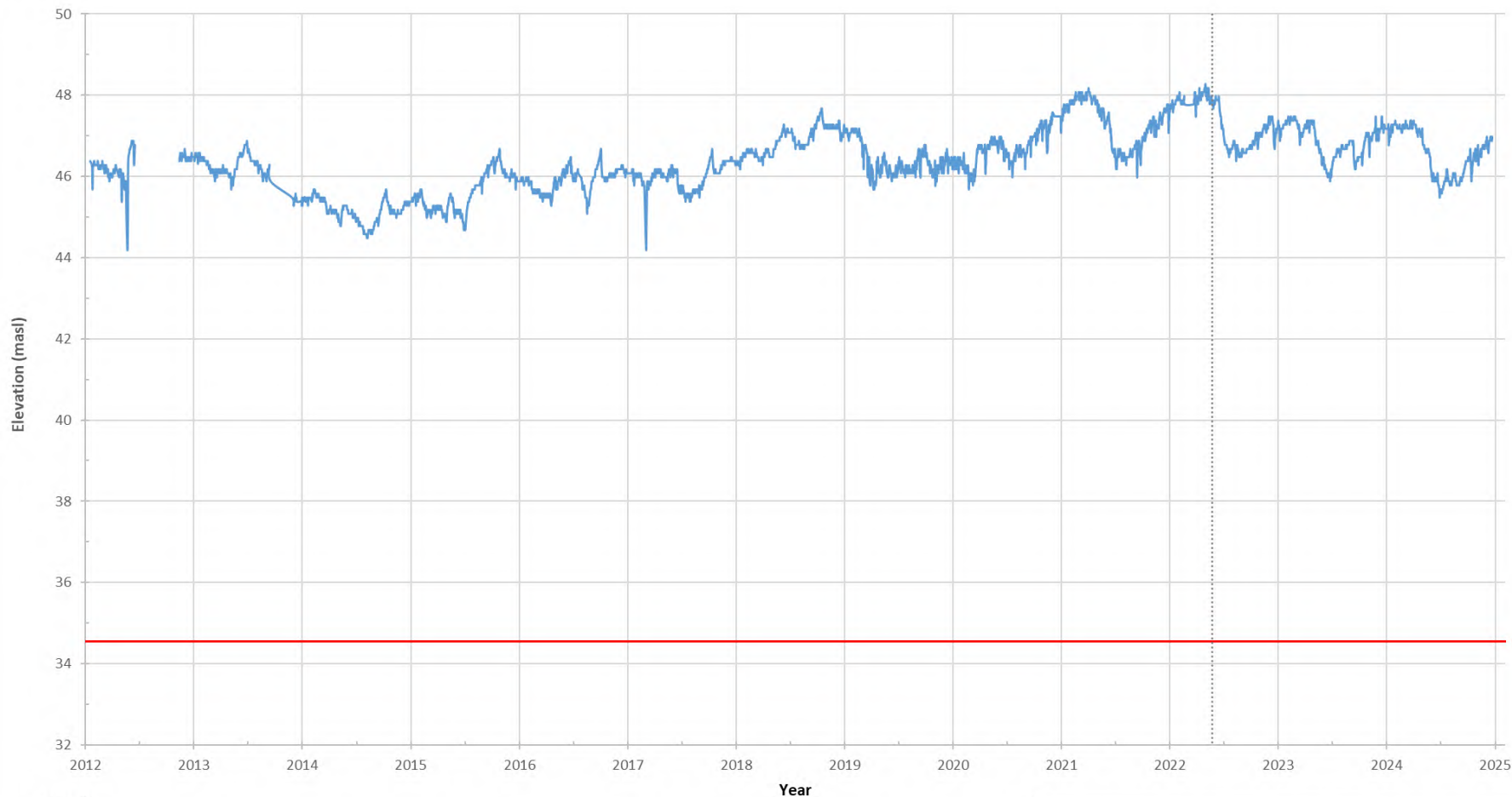
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 PROJECT: 3917-24-001  
 COMPILED BY: Hydrachem  
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FIGURE A18

## **Appendix B**

### **Long-Term Groundwater Level Hydrographs**





**LEGEND:**

- Groundwater Level (Max)
- Top of Screen Elevation
- ..... New SCADA System

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**Long-term Groundwater Level Hydrograph - Railway Station Well 1**



Prepared By: Waterline Resources Inc.  
Project Number: 2017-20-001  
Compiled By: wright  
Date Issued: March 2025  
Date Revised:

**FIGURE B1**



**LEGEND:**

— Groundwater Level (Max)

— Top of Screen Elevation

..... New SCADA System

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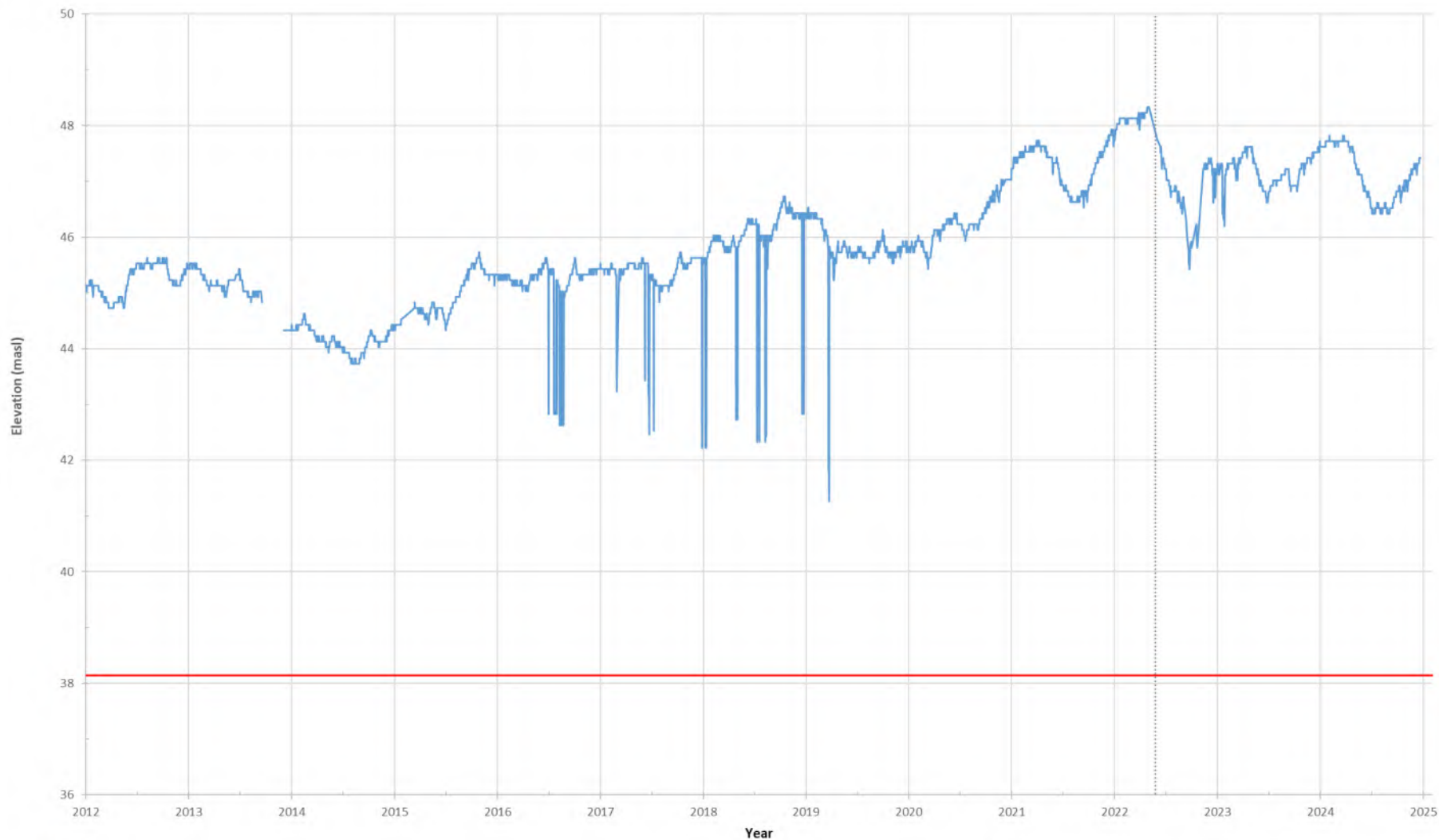
**Long-term Groundwater Level Hydrograph -  
Railway Station Well 2**



Prepared By: Waterline Resources Inc.  
Project Number: 2017-04-001  
Compiled By: wright  
Date Issued: March 2025  
Date Revised:

**FIGURE B2**





**LEGEND:**

— Groundwater Level (Max)

— Top of Screen Elevation

..... New SCADA System

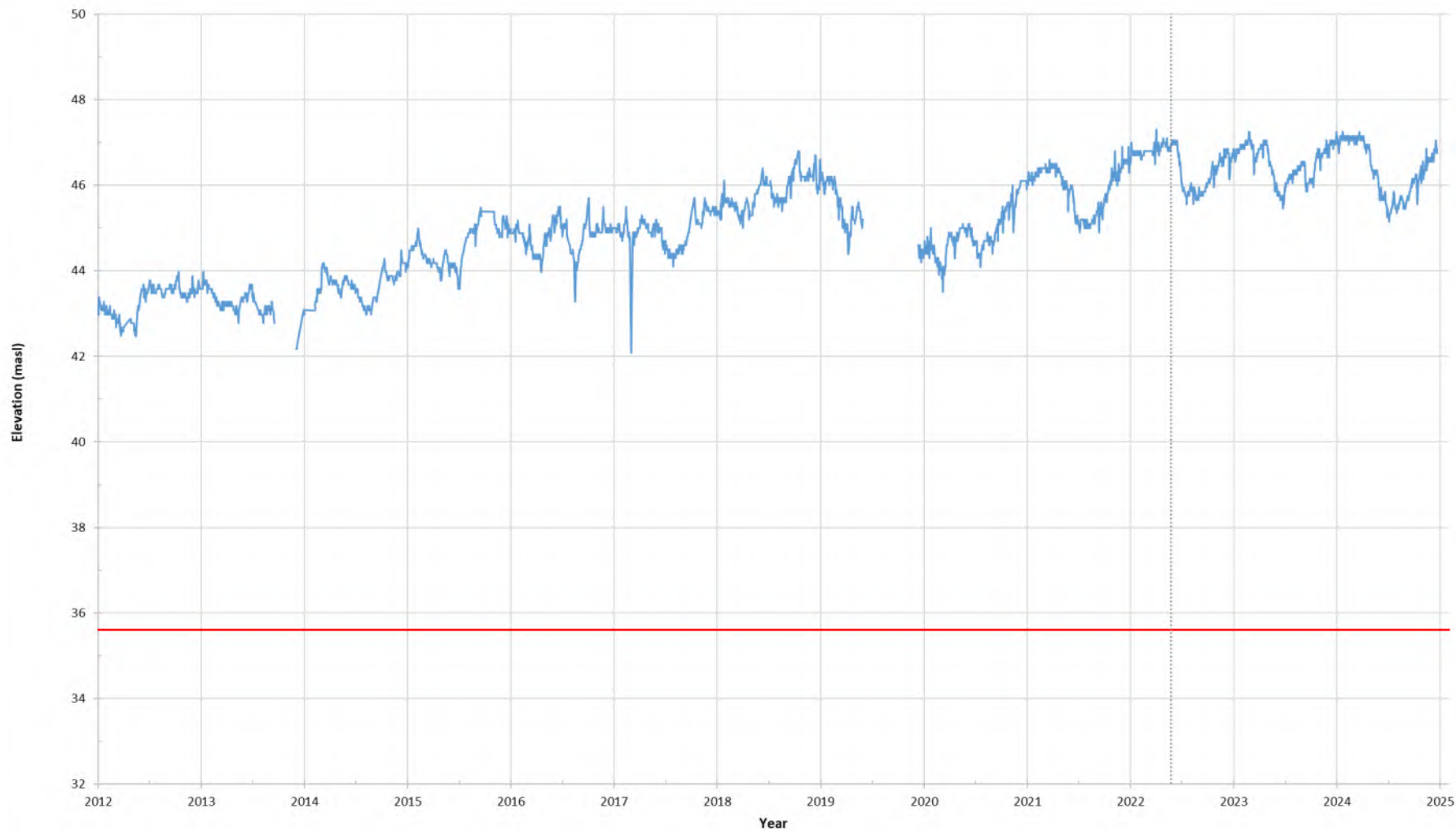
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**Long-term Groundwater Level Hydrograph -  
Railway Station Well 3**



|                                      |
|--------------------------------------|
| Prepared By: Waterline Resource Inc. |
| Project Number: 2017-04-001          |
| Compiled By: wright                  |
| Date Issued: March 2025              |
| Date Revised:                        |

**FIGURE B3**



**LEGEND:**

- Groundwater Level (Max)
- Top of Screen Elevation
- ..... New SCADA System

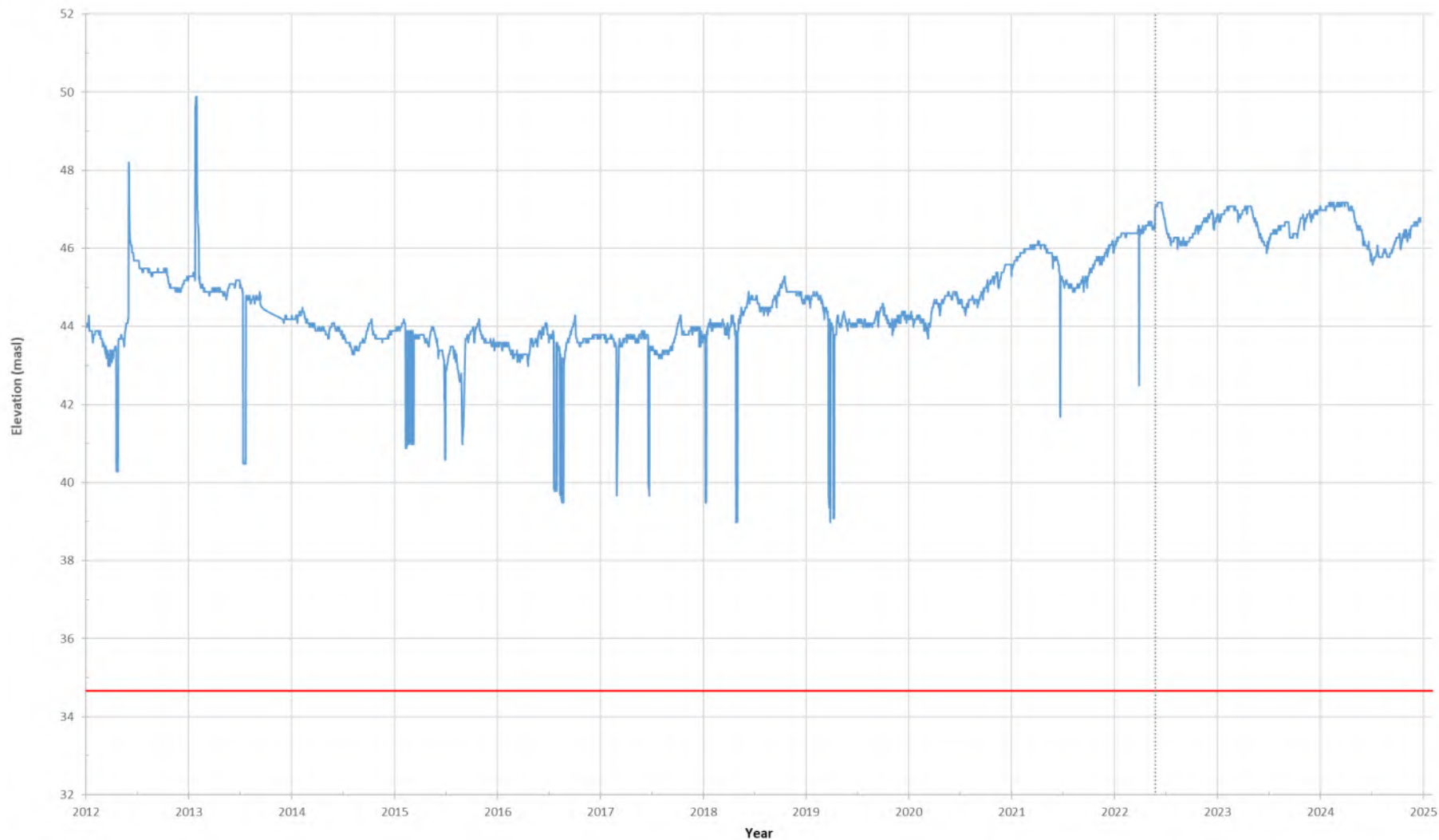
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Submitted to Kerr Wood Leidal Consulting Engineers

**Long-term Groundwater Level Hydrograph -  
Railway Station Well 4**



Prepared By: Waterline Resources Inc.  
Project Number: 2017-04-001  
Compiled By: wlg  
Date Issued: March 2020  
Date Revised:

**FIGURE B4**



**LEGEND:**

— Groundwater Level (Max)

— Top of Screen Elevation

..... New SCADA System

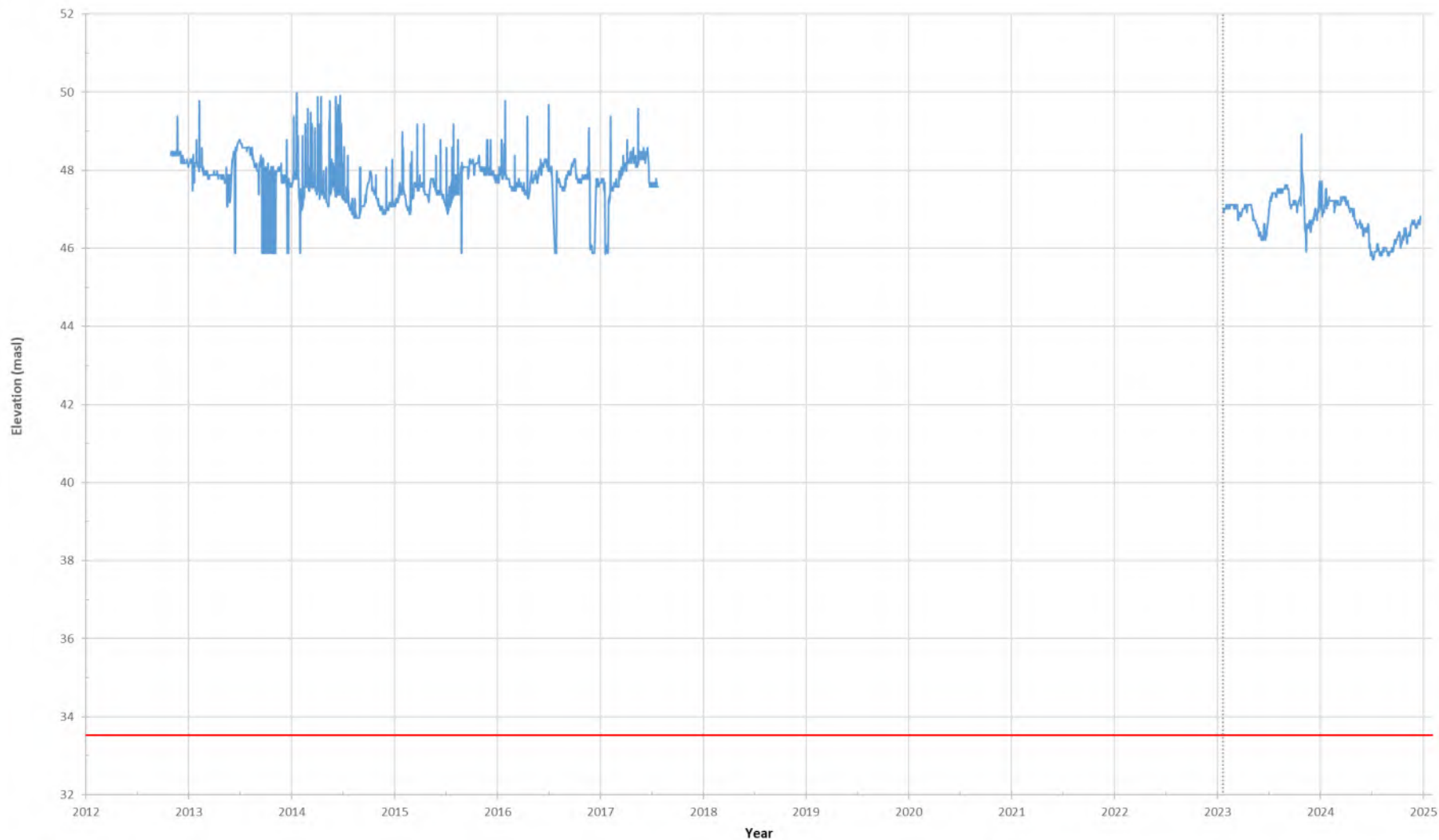
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**Long-term Groundwater Level Hydrograph -  
Railway Station Well 5**



|                                      |
|--------------------------------------|
| Prepared By: Waterline Resource Inc. |
| Project Number: 2017-04-001          |
| Compiled By: wright                  |
| Date Issued: March 2025              |
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**FIGURE B5**



**LEGEND:**

— Groundwater Level (Max)

— Top of Screen Elevation

..... New SCADA System

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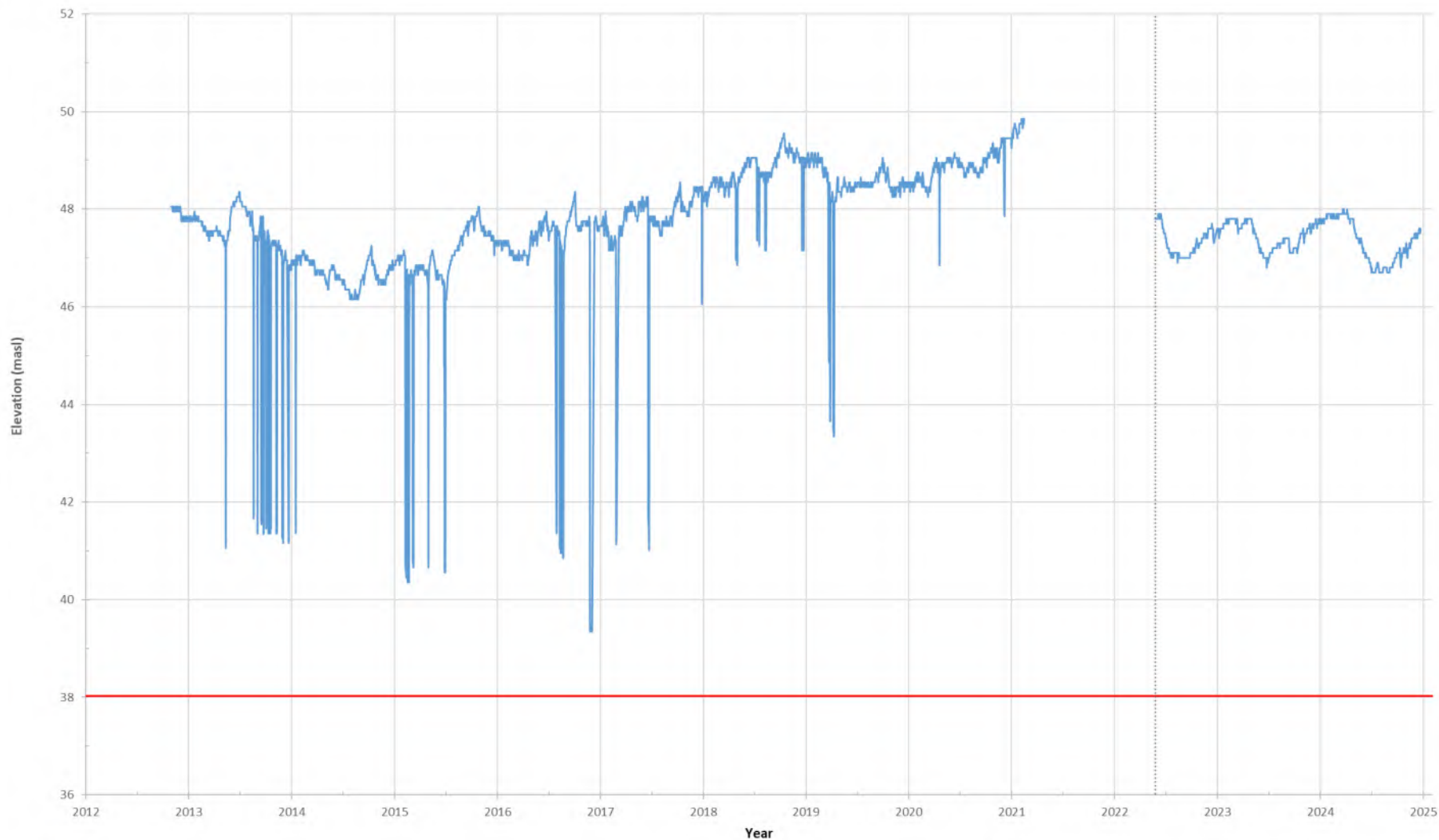
**Long-term Groundwater Level Hydrograph -  
Railway Station Well 6**



|                                      |
|--------------------------------------|
| Prepared By: Waterline Resource Inc. |
| Project Number: 2017-04-001          |
| Compiled By: wright                  |
| Date Issued: March 2025              |
| Date Revised:                        |

**FIGURE B6**





**LEGEND:**

- Groundwater Level (Max)
- Top of Screen Elevation
- ..... New SCADA System

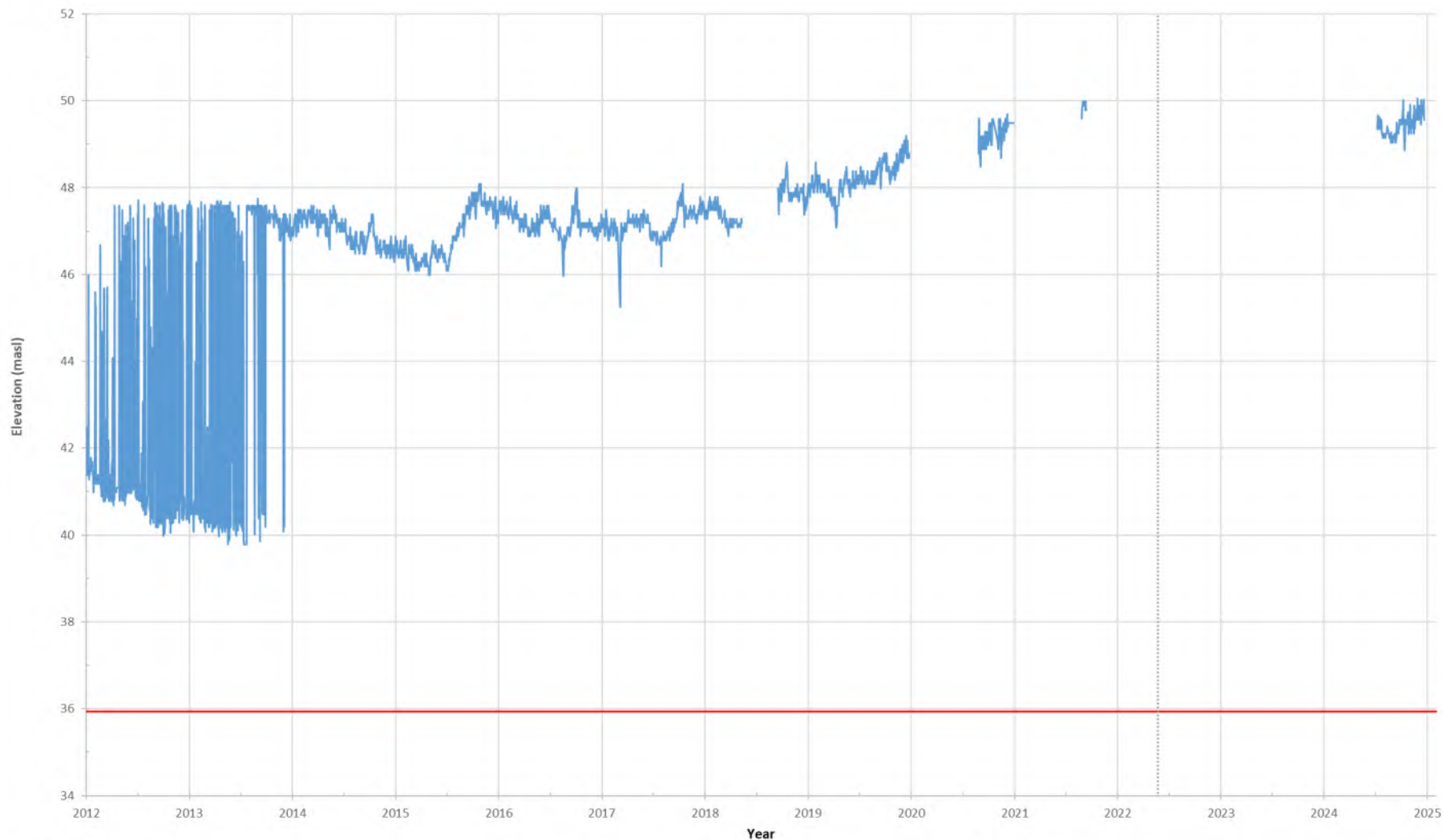
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**Long-term Groundwater Level Hydrograph -  
Railway Station Well 7**



|                                      |
|--------------------------------------|
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| Project Number: 2017-04-001          |
| Compiled By: wright                  |
| Date Issued: March 2025              |
| Date Revised:                        |

**FIGURE B7**



**LEGEND:**

- Groundwater Level (Max)
- Top of Screen Elevation
- ..... New SCADA System

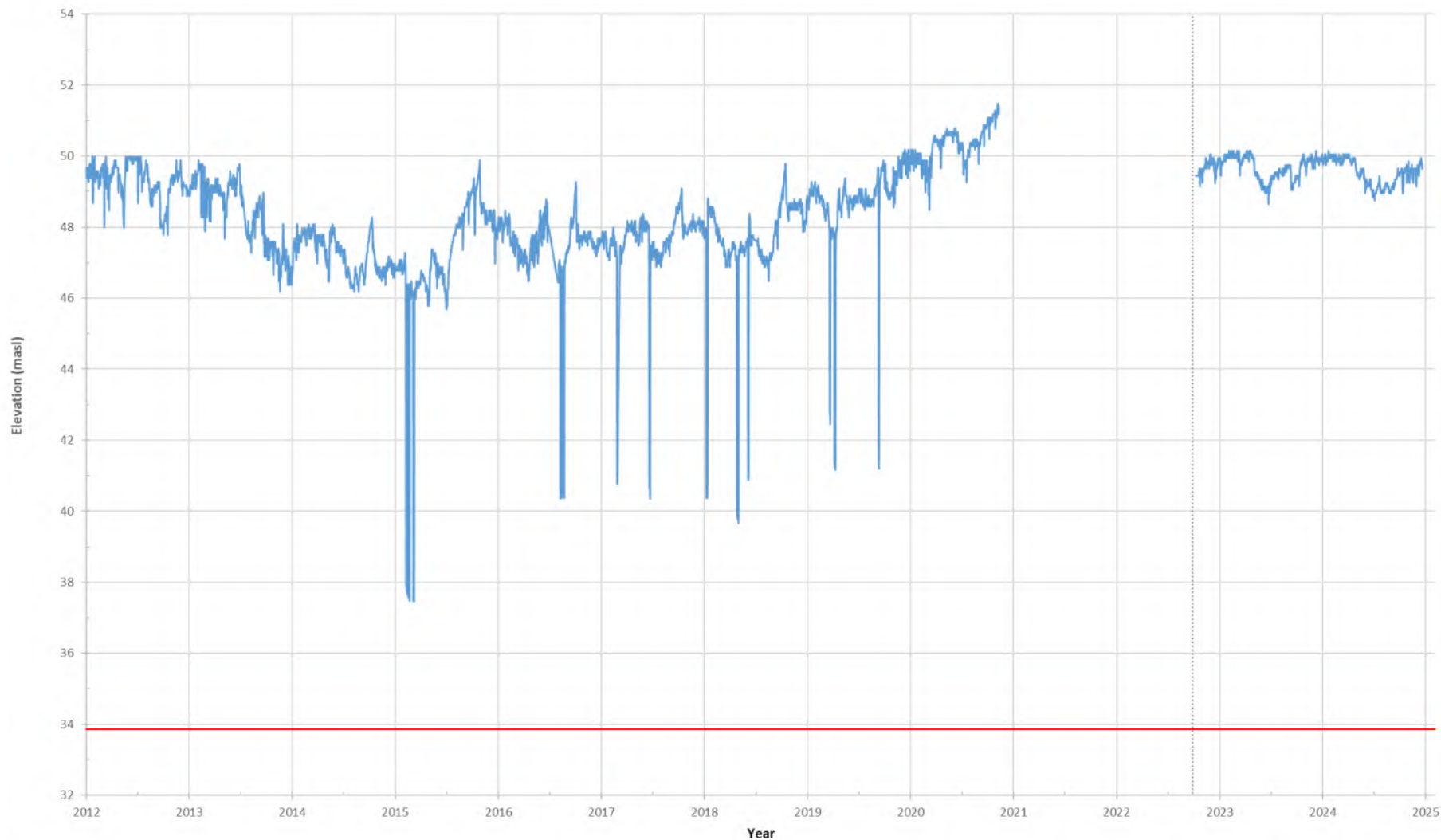
**Task 2 - Hydrogeological Assessment of Parksville's WSW Operations and the Englishman River Aquifers for the City of Parksville, BC**  
Submitted to Kerr Wood Leidal Consulting Engineers

**Long-term Groundwater Level Hydrograph -  
Railway Station Well 8**



Prepared By: Waterline Resources Inc.  
Project Number: 2017-04-001  
Compiled By: wright  
Date Issued: March 2020  
Date Revised:

**FIGURE B8**



**LEGEND:**

- Groundwater Level (Max)
- Top of Screen Elevation
- ..... New SCADA System

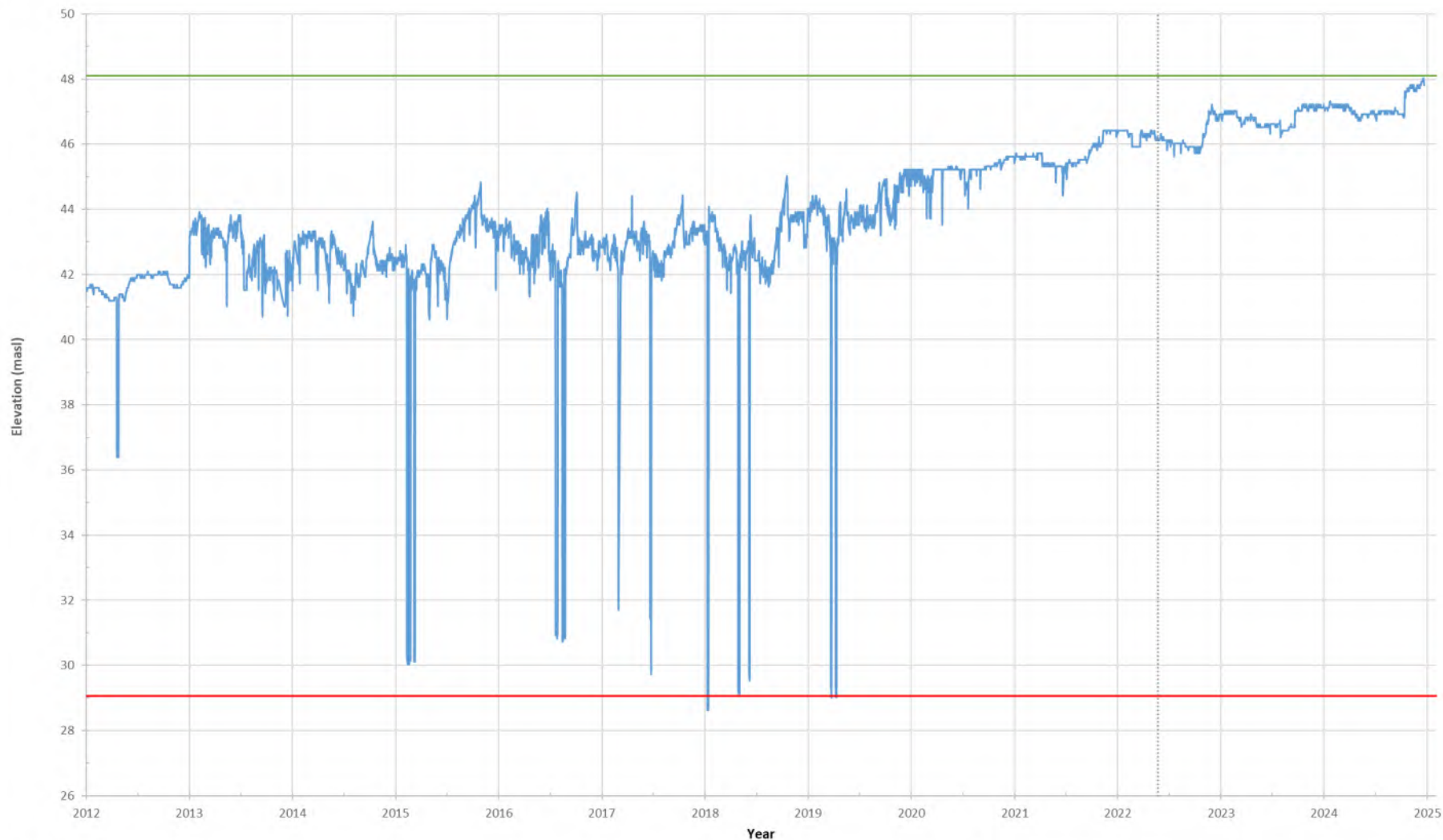
**Task 2 - Hydrogeological Assessment of Parksville's WSW Operations and the Englishman River Aquifers for the City of Parksville, BC**  
Submitted to Kerr Wood Leidal Consulting Engineers

**Long-term Groundwater Level Hydrograph -  
Springwood Well 1**



|                                       |
|---------------------------------------|
| Prepared By: Waterline Resources Inc. |
| Project Number: 2017-24-001           |
| Compiled By: wright                   |
| Date Issued: March 2025               |
| Date Revised:                         |

**FIGURE B9**



**LEGEND:**

- Groundwater Level (Max)
- Top of Casing Elevation
- Top of Screen Elevation
- ..... New SCADA System

**Task 2 - Hydrogeological Assessment of Parksville's WSW Operations and the Englishman River Aquifers for the City of Parksville, BC**  
Submitted to Kerr Wood Leidal Consulting Engineers

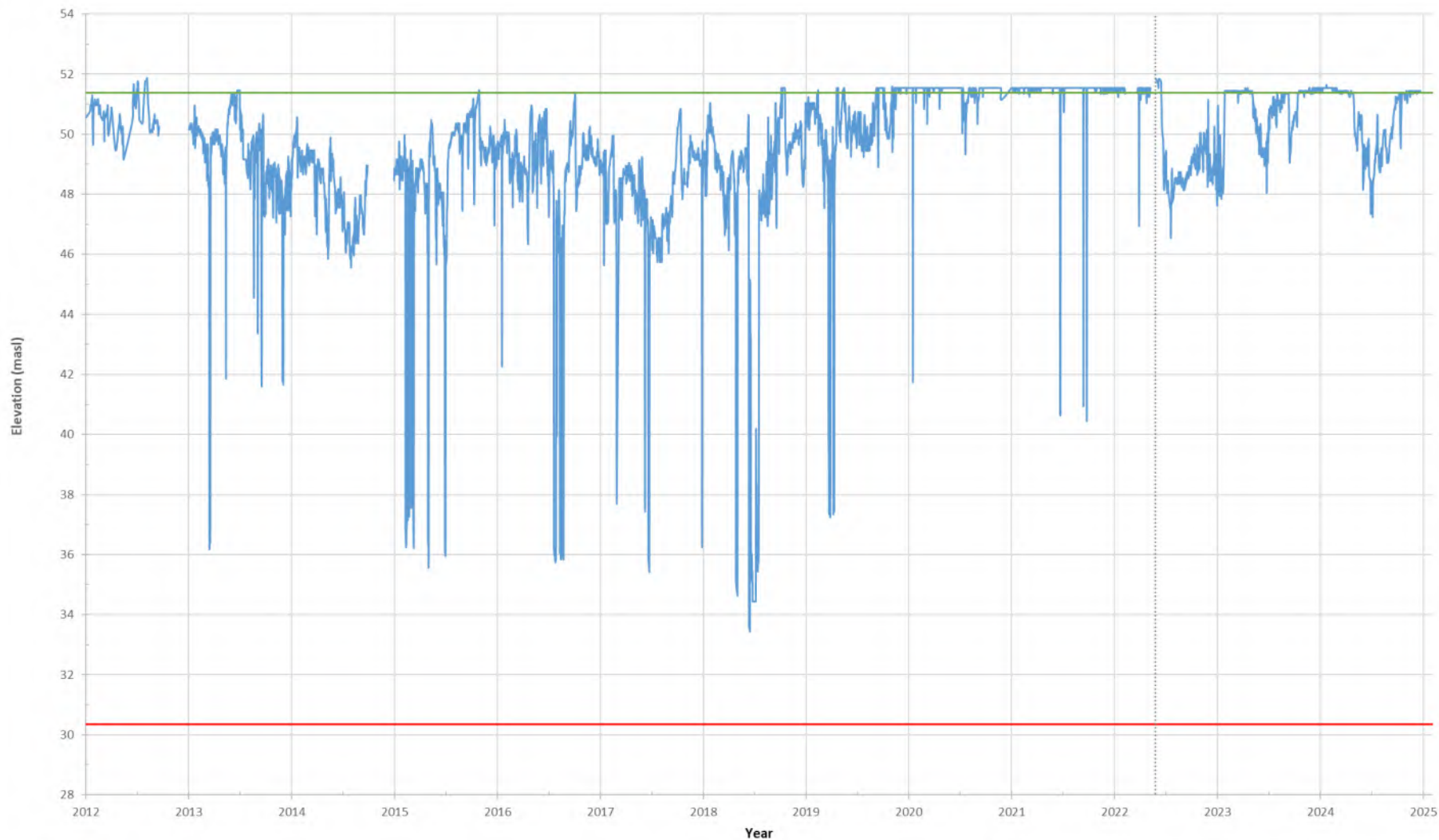
**Long-term Groundwater Level Hydrograph -  
Springwood Well 3**



Prepared By: Waterline Resources Inc.  
Project Number: 2017-04-001  
Compiled By: wright  
Date Issued: March 2020  
Date Revised:

**FIGURE B10**





**LEGEND:**

- Groundwater Level (Max)
- Top of Casing Elevation
- Top of Screen Elevation
- ..... New SCADA System

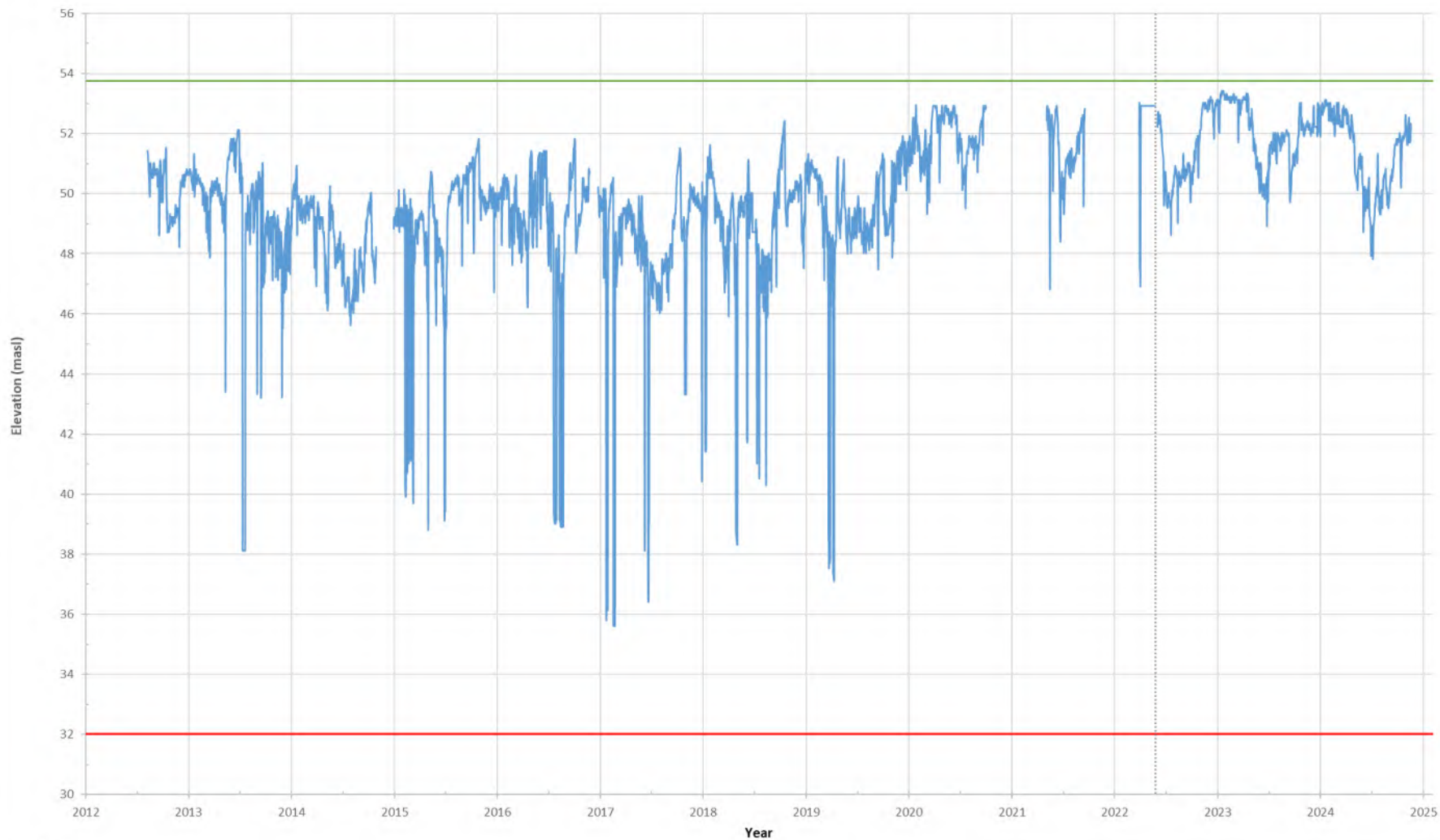
**Task 2 - Hydrogeological Assessment of Parksville's WSW Operations and the Englishman River Aquifers for the City of Parksville, BC**  
Submitted to Kerr Wood Leidal Consulting Engineers

**Long-term Groundwater Level Hydrograph - Springwood Well 5**



|                                      |
|--------------------------------------|
| Prepared By: Waterline Resource Inc. |
| Project Number: 2017-04-001          |
| Compiled By: wright                  |
| Date Issued: March 2020              |
| Date Revised:                        |

**FIGURE B11**



**LEGEND:**

- Groundwater Level (Max)
- Top of Casing Elevation
- Top of Screen Elevation
- ..... New SCADA System

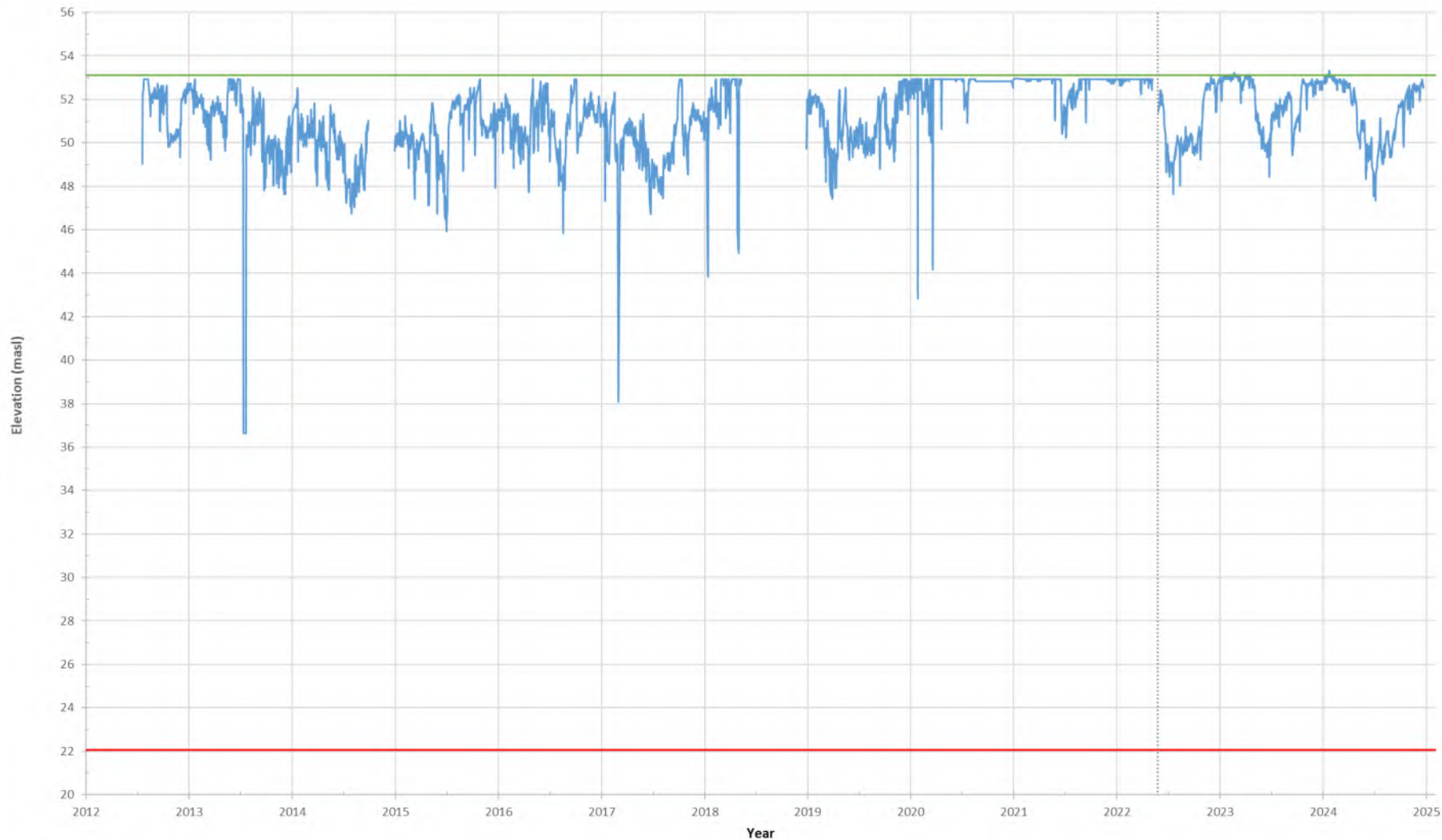
Task 2 - Groundwater System Analysis and Englishman River Aquifer Assessment for the City of Parksville,  
British Columbia  
Submitted to Kerr Wood Leidal Consulting Engineers

**Long-term Groundwater Level Hydrograph - Springwood  
Well 6**



|                                       |
|---------------------------------------|
| Prepared By: Waterline Resources Inc. |
| Project Number: 2017-20-001           |
| Consulted By: JRGH                    |
| Date Issued: March 2025               |
| Date Revised:                         |

**FIGURE B12**



**LEGEND:**

- Groundwater Level (Max)
- Top of Casing Elevation
- Top of Screen Elevation
- ..... New SCADA System

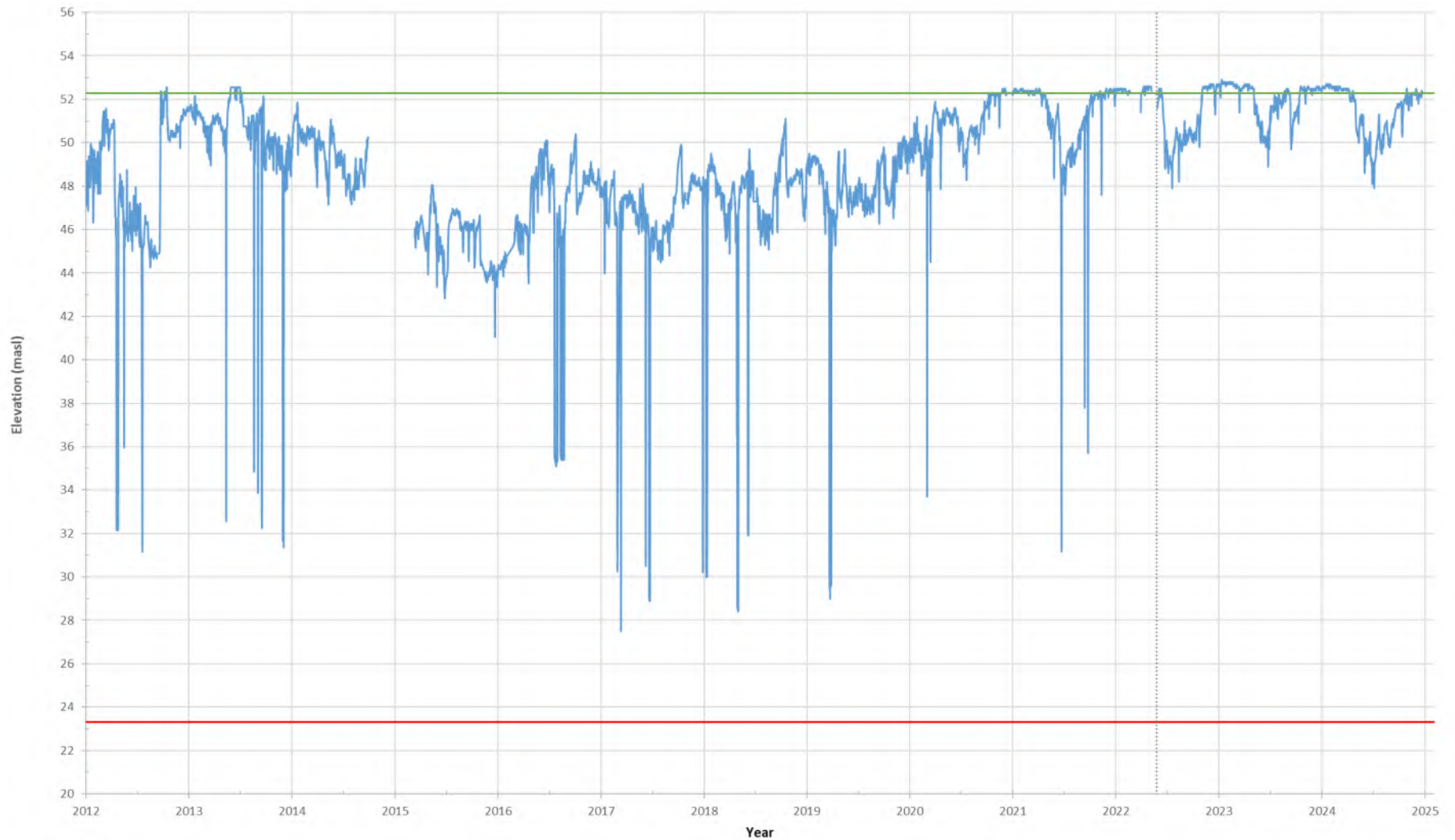
**Task 2 - Hydrogeological Assessment of Parksville's WSW Operations and the Englishman River Aquifers for the City of Parksville, BC**  
Submitted to Kerr Wood Leidal Consulting Engineers

**Long-term Groundwater Level Hydrograph - Springwood Well 7**



|                                      |
|--------------------------------------|
| Prepared By: Waterline Resource Inc. |
| Project Number: 2017-04-001          |
| Compiled By: wright                  |
| Date Issued: March 2025              |
| Date Revised:                        |

**FIGURE B13**



**LEGEND:**

- Groundwater Level (Max)
- Top of Casing Elevation
- Top of Screen Elevation
- ..... New SCADA System

**Task 2 - Hydrogeological Assessment of Parksville's WSW Operations and the Englishman River Aquifers for the City of Parksville, BC**  
Submitted to Kerr Wood Leidal Consulting Engineers

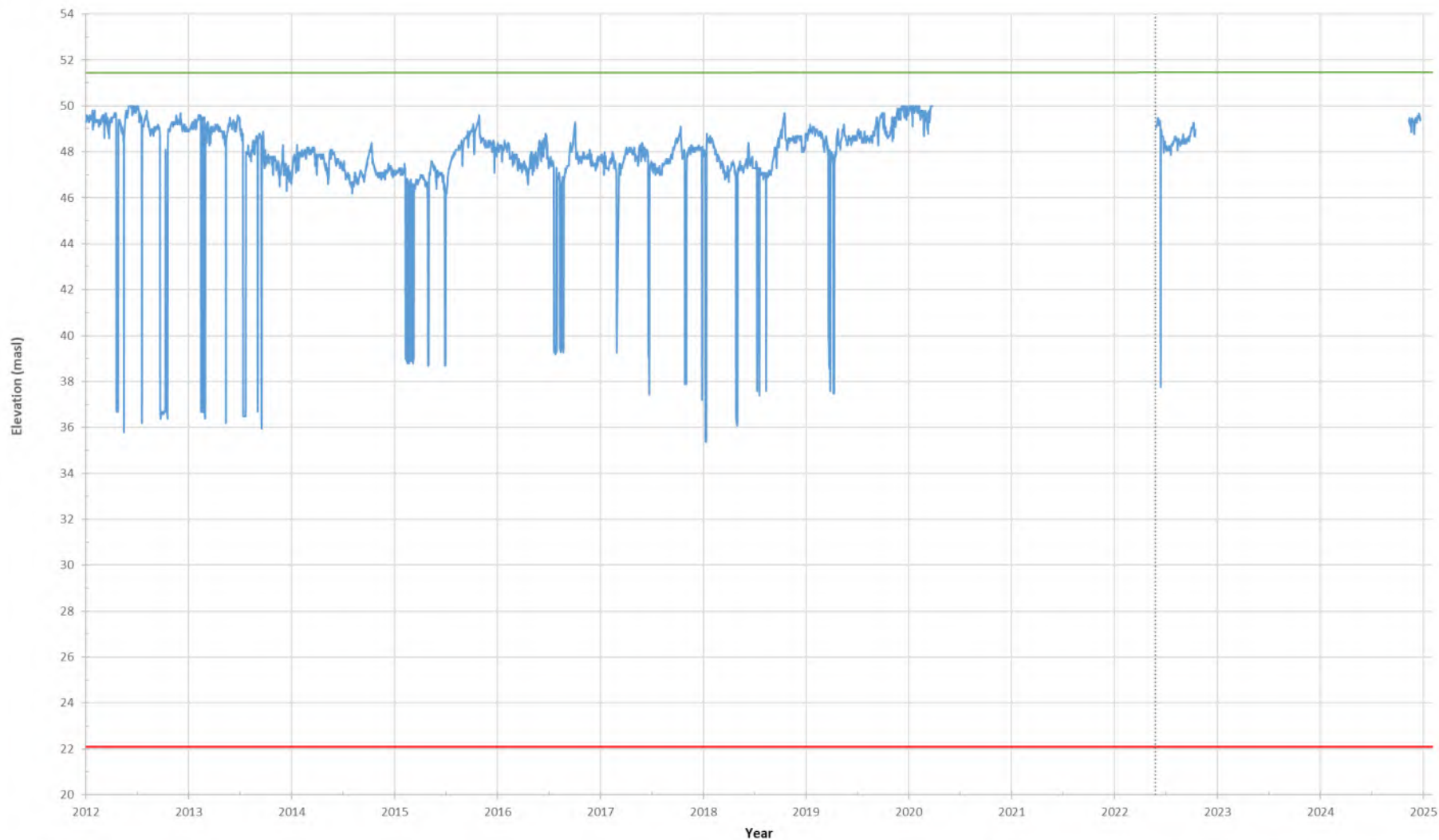
**Long-term Groundwater Level Hydrograph - Springwood Well 8**



|                                      |
|--------------------------------------|
| Prepared By: Waterline Resource Inc. |
| Project Number: 2017-04-001          |
| Compiled By: wright                  |
| Date Issued: March 2025              |
| Date Revised:                        |

**FIGURE B14**





**LEGEND:**

- Groundwater Level (Max)
- Top of Casing Elevation
- Top of Screen Elevation
- ⋯ New SCADA System

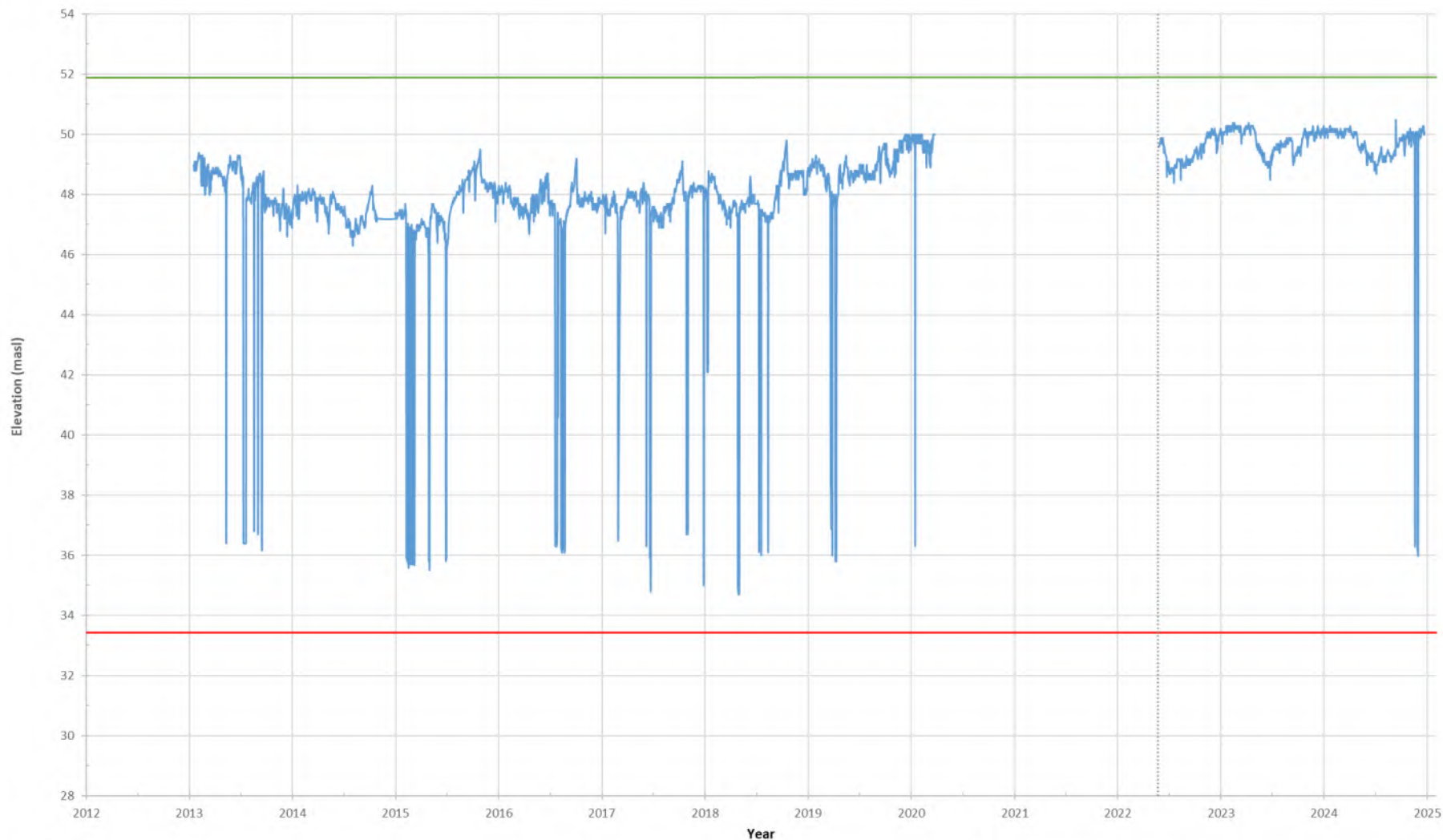
**Task 2 - Hydrogeological Assessment of Parksville's WSW Operations and the Englishman River Aquifers for the City of Parksville, BC**  
Submitted to Kerr Wood Leidal Consulting Engineers

**Long-term Groundwater Level Hydrograph - Springwood Well 10**



|                                      |
|--------------------------------------|
| Prepared By: Waterline Resource Inc. |
| Project Number: 2017-04-001          |
| Compiled By: wrt                     |
| Date Issued: March 2025              |
| Date Revised:                        |

**FIGURE B15**



**LEGEND:**

- Groundwater Level (Max)
- Top of Casing Elevation
- Top of Screen Elevation
- ..... New SCADA System

**Task 2 - Hydrogeological Assessment of Parksville's WSW Operations and the Englishman River Aquifers for the City of Parksville, BC**  
Submitted to Kerr Wood Leidal Consulting Engineers

**Long-term Groundwater Level Hydrograph -  
Springwood Well 11**



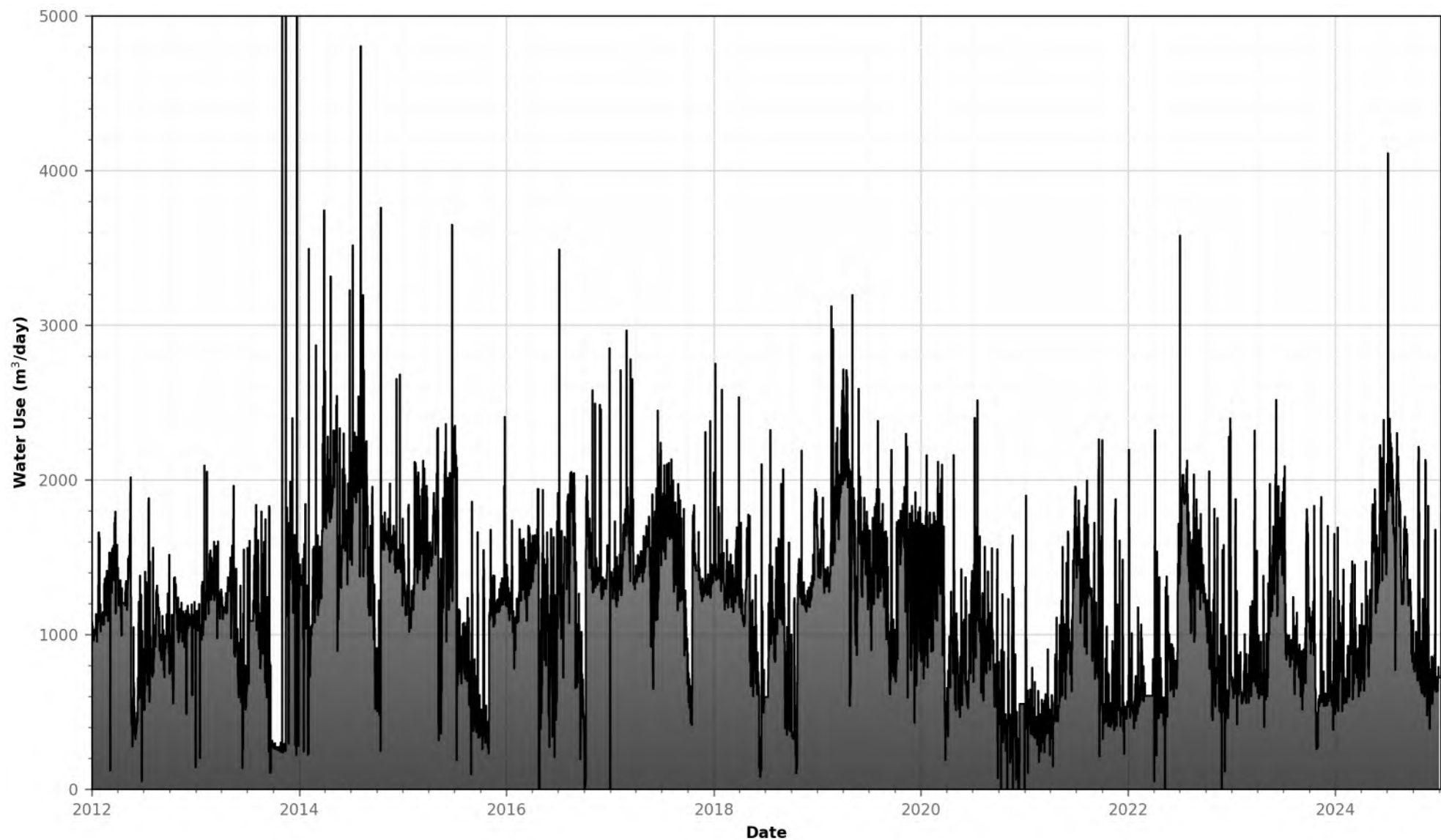
|                                       |
|---------------------------------------|
| Prepared By: Waterline Resources Inc. |
| Project Number: 2017-04-001           |
| Compiled By: wright                   |
| Date Issued: March 2020               |
| Date Revised:                         |

**FIGURE B16**

## **Appendix C**

### **Long-Term Groundwater Use Charts**





— Railway Station Well Field - Cumulative Use

Task 2 - Hydrogeological Assessment of Parksville's WSW Operations  
and the Englishman River Aquifers for the City of Parksville, BC  
Submitted to Kerr Wood Leidal Consulting Engineers

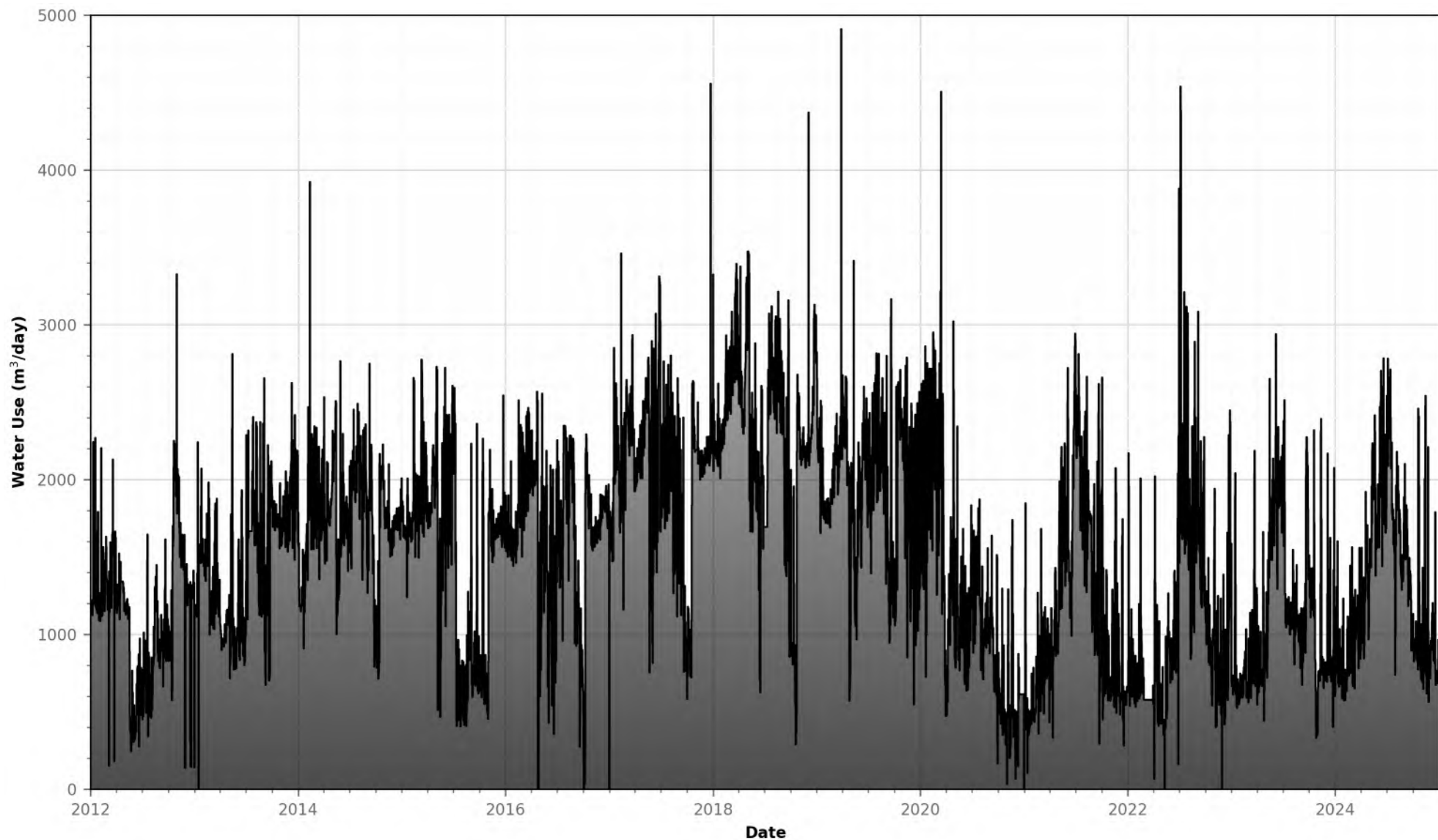
### Long-Term Groundwater Use - Railway Station Well Field



|                                       |
|---------------------------------------|
| PREPARED BY: Waterline Resources Inc. |
| PROJECT: 3917-24-001                  |
| COMPILED BY: Hydrachem                |
| DATE ISSUED: 2025-Mar-26              |
| REVISED: -                            |

**FIGURE C1**





— Springwood Well Field - Cumulative Use

Task 2 - Hydrogeological Assessment of Parksville's WSW Operations  
and the Englishman River Aquifers for the City of Parksville, BC  
Submitted to Kerr Wood Leidal Consulting Engineers

### Long-Term Groundwater Use - Springwood Well Field



|                                       |
|---------------------------------------|
| PREPARED BY: Waterline Resources Inc. |
| PROJECT: 3917-24-001                  |
| COMPILED BY: Hydrachem                |
| DATE ISSUED: 2025-Mar-26              |
| REVISED: -                            |

FIGURE C2

## **Appendix D**

### **Groundwater Chemistry Tables**

**Table D1: General Chemistry, Major Ions, Nutrients and Other Organics**

**Table D2: Total Metals**

**Table D3: Microbiology**

Table D1: General Chemistry, Major Ions, Nutrients and Other Organics

|                 |                        |                        | General Chemistry |                                           |                   |                                  |                                     |             |        | Major Ions    |              |                             | Nutrients |           | Organics           |
|-----------------|------------------------|------------------------|-------------------|-------------------------------------------|-------------------|----------------------------------|-------------------------------------|-------------|--------|---------------|--------------|-----------------------------|-----------|-----------|--------------------|
| Well Field      | Sample Location        | Sample Date            | Colour            | Alkalinity, Total (as CaCO <sub>3</sub> ) | Conductivity (EC) | Hardness (as CaCO <sub>3</sub> ) | Total Dissolved Solids - Calculated | Turbidity   | pH     | Chloride (Cl) | Fluoride (F) | Sulphate (SO <sub>4</sub> ) | Nitrate-N | Nitrite-N | Cyanide (CN)-Total |
| Units           |                        |                        | TCU               | mg/L                                      | µS/cm             | mg/L                             | mg/L                                | NTU         | -      | mg/L          | mg/L         | mg/L                        | mg/L      | mg/L      | mg/L               |
| Guidelines      |                        | GCDWQ AO               | 15                | -                                         | -                 | -                                | 500                                 | 1.0         | 7-10.5 | 250           | -            | 500                         | -         | -         | -                  |
|                 |                        | GCDWQ MAC              | -                 | -                                         | -                 | -                                | -                                   | -           | -      | -             | 1.5          | -                           | 10        | 1         | 0.2                |
|                 |                        | Saltwater Intrusion OO | -                 | -                                         | 1000              | -                                | 700                                 | -           | -      | 150           | -            | -                           | -         | -         | -                  |
| Railway Station | Railway Station Well 1 | 2013-Nov-25            | -                 | 108                                       | 296               | 141                              | 170                                 | -           | 7.87   | 23            | 0.058        | 6.21                        | 0.95      | <0.005    | -                  |
|                 | Railway Station Well 1 | 2017-Oct-16            | <5                | 118                                       | 313               | 135                              | 157                                 | 0.25        | 7.59   | 24.3          | <0.1         | 5.2                         | 0.705     | <0.01     | <0.002             |
|                 | Railway Station Well 1 | 2021-Jul-27            | <5                | 115                                       | 300               | 119                              | 173                                 | 0.11        | 7.87   | 23.1          | <0.01        | 4.7                         | 0.36      | <0.01     | <0.002             |
|                 | Railway Station Well 1 | 2023-Nov-15            | <5                | 121                                       | 353               | 161                              | 211                                 | 0.12        | 7.61   | 32            | 0.03         | 7.4                         | 1.36      | <0.01     | <0.002             |
|                 | Railway Station Well 1 | 2024-Mar-18            | <5                | 123                                       | 337               | 160                              | 209                                 | 0.32        | 7.59   | 32.1          | <0.01        | 7.3                         | 1.23      | <0.01     | <0.002             |
|                 | Railway Station Well 1 | 2024-Sep-04            | <5                | 122                                       | 368               | 153                              | 204                                 | 0.11        | 7.99   | 30.8          | 0.02         | 6.9                         | 1.16      | <0.01     | <0.002             |
|                 | Railway Station Well 2 | 2010-Oct-20            | <5                | 116                                       | 390               | 166                              | 204                                 | 0.4         | 7.2    | 31            | 0.04         | 2                           | 0.937     | <0.002    | -                  |
|                 | Railway Station Well 2 | 2018-Aug-20            | <5                | 142                                       | 438               | 183                              | 219                                 | 0.25        | 7.67   | 48.6          | <0.1         | 6.3                         | 1.38      | <0.01     | <0.002             |
|                 | Railway Station Well 2 | 2023-Jul-11            | <5                | 137                                       | 428               | 174                              | 236                                 | <0.1        | 7.5    | 41.3          | 0.03         | 5.5                         | 1.15      | <0.01     | <0.002             |
|                 | Railway Station Well 3 | 2011-Nov-21            | <5                | 88.7                                      | 284               | 115                              | 152                                 | 0.32        | 7.86   | 33            | 0.044        | 5                           | 0.739     | <0.005    | -                  |
|                 | Railway Station Well 3 | 2013-Nov-25            | -                 | 94.9                                      | 365               | 163                              | 224                                 | -           | 7.85   | 52            | 0.05         | 5.27                        | 0.861     | <0.005    | -                  |
|                 | Railway Station Well 3 | 2016-Oct-31            | <5                | 114                                       | 369               | 176                              | 184                                 | 0.12        | 7.77   | 38.8          | <0.1         | 3.5                         | 1.03      | <0.01     | <0.002             |
|                 | Railway Station Well 3 | 2020-Feb-11            | <5                | 120                                       | 419               | 190                              | 237                                 | 0.14        | 7.82   | 50.7          | <0.01        | 4                           | 1.13      | <0.01     | <0.002             |
|                 | Railway Station Well 3 | 2024-Mar-18            | <5                | 127                                       | 369               | 170                              | 226                                 | <0.1        | 7.61   | 43            | <0.01        | 3.8                         | 1.03      | <0.01     | <0.002             |
|                 | Railway Station Well 4 | 2014-Nov-03            | <5                | 107                                       | 281               | 134                              | 170                                 | 0.14        | 7.82   | 15            | 0.039        | 14.2                        | 1.1       | <0.005    | -                  |
|                 | Railway Station Well 4 | 2022-Sep-06            | <5                | 126                                       | 336               | 152                              | 198                                 | <0.1        | 7.58   | 17.9          | 0.05         | 11.9                        | 0.73      | <0.01     | <0.002             |
|                 | Railway Station Well 5 | 2011-Nov-21            | <5                | 126                                       | 382               | 167                              | 200                                 | <0.1        | 7.9    | 43            | 0.047        | 7.4                         | 1.24      | <0.005    | -                  |
|                 | Railway Station Well 5 | 2016-Oct-31            | <5                | 110                                       | 302               | 139                              | 153                                 | 0.16        | 7.76   | 24.1          | <0.1         | 4.1                         | 0.611     | <0.01     | <0.002             |
|                 | Railway Station Well 5 | 2018-Aug-20            | <5                | 127                                       | 368               | 150                              | 190                                 | 0.2         | 7.68   | 32.5          | <0.1         | 7.8                         | 2.19      | <0.01     | <0.002             |
|                 | Railway Station Well 5 | 2022-Sep-06            | <5                | 124                                       | 407               | 166                              | 228                                 | <0.1        | 7.68   | 36.9          | 0.05         | 9.2                         | 1.52      | <0.01     | <0.002             |
|                 | Railway Station Well 6 | 2010-Oct-20            | <5                | 106                                       | 319               | 121                              | 177                                 | 0.4         | 7.3    | 23            | 0.05         | 2.9                         | 0.339     | <0.002    | -                  |
|                 | Railway Station Well 6 | 2019-Oct-01            | <5                | 123                                       | 325               | 130                              | 186                                 | 0.34        | 7.78   | 24.7          | 0.08         | 5.1                         | 0.57      | <0.01     | <0.002             |
|                 | Railway Station Well 6 | 2023-Nov-15            | <5                | 110                                       | 300               | 130                              | 186                                 | 0.15        | 7.49   | 25.3          | 0.03         | 4.9                         | 0.86      | <0.01     | <0.002             |
|                 | Railway Station Well 7 | 2014-Nov-03            | <5                | 164                                       | 483               | 221                              | 256                                 | 0.18        | 7.96   | 52            | 0.033        | 5.24                        | 1.82      | <0.005    | -                  |
|                 | Railway Station Well 7 | 2020-Feb-11            | <5                | 151                                       | 449               | 200                              | 262                                 | <0.1        | 7.76   | 44.1          | <0.01        | 5.9                         | 1.65      | <0.01     | <0.002             |
|                 | Railway Station Well 7 | 2024-Sep-04            | <5                | 145                                       | 475               | 200                              | 268                                 | <0.1        | 7.86   | 54            | <0.1         | 6                           | 2.1       | <0.1      | <0.002             |
|                 | Railway Station Well 8 | 2017-Oct-16            | <5                | 118                                       | 340               | 151                              | 172                                 | <0.1        | 7.56   | 31.7          | <0.1         | 7.2                         | 0.524     | <0.01     | <0.002             |
|                 | Railway Station Well 8 | 2024-Sep-04            | <5                | 127                                       | 398               | 173                              | 222                                 | <0.1        | 7.91   | 37.1          | 0.02         | 10.8                        | 0.68      | <0.01     | <0.002             |
| Springwood      | Springwood Well 1      | 2013-Nov-25            | -                 | 101                                       | 258               | 126                              | 170                                 | -           | 7.66   | 15            | 0.062        | 5.28                        | 1.37      | <0.005    | -                  |
|                 | Springwood Well 1      | 2017-Oct-16            | <5                | 101                                       | 260               | 115                              | 137                                 | <0.1        | 7.19   | 18.4          | <0.1         | 4.5                         | 1.41      | <0.01     | <0.002             |
|                 | Springwood Well 1      | 2023-Jul-11            | <5                | 88                                        | 246               | 96                               | 150                                 | <0.1        | 7.4    | 15.5          | 0.05         | 4.1                         | 1.56      | <0.01     | <0.002             |
|                 | Springwood Well 3      | 2010-Oct-20            | <5                | 98                                        | 265               | 122                              | 153                                 | 0.2         | 7.2    | 16            | 0.05         | 2.6                         | 0.46      | <0.002    | -                  |
|                 | Springwood Well 3      | 2013-Nov-25            | -                 | 107                                       | 258               | 137                              | 170                                 | -           | 7.66   | 15            | 0.058        | 5.28                        | 0.883     | 0.0101    | -                  |
|                 | Springwood Well 3      | 2020-Feb-11            | <5                | 120                                       | 308               | 142                              | 195                                 | <0.1        | 7.8    | 20.7          | <0.01        | 6.7                         | 1.14      | <0.01     | <0.002             |
|                 | Springwood Well 3      | 2024-Mar-18            | <5                | 114                                       | 289               | 136                              | 188                                 | 0.12        | 7.33   | 19.2          | <0.01        | 7.5                         | 1.22      | <0.01     | <0.002             |
|                 | Springwood Well 5      | 2011-Nov-21            | <5                | 128                                       | 303               | 127                              | 160                                 | <u>2.12</u> | 7.9    | 19            | -            | -                           | 0.719     | 0.008     | -                  |
|                 | Springwood Well 5      | 2016-Oct-31            | <5                | 189                                       | 427               | 197                              | 234                                 | 0.19        | 7.63   | 18.3          | <0.1         | 7.9                         | 1.48      | <0.01     | <0.002             |
|                 | Springwood Well 5      | 2018-Aug-20            | <5                | 204                                       | 443               | 179                              | 236                                 | 0.69        | 7.62   | 18.9          | <0.1         | 7.8                         | 1.82      | <0.01     | <0.002             |
|                 | Springwood Well 5      | 2022-Jun-20            | <5                | 177                                       | 428               | 174                              | 246                                 | 0.5         | 7.69   | 18.3          | 0.05         | 7.9                         | 1.51      | <0.01     | <0.002             |
|                 | Springwood Well 5      | 2024-Sep-11            | <5                | 181                                       | 453               | 200                              | 261                                 | <u>1.3</u>  | 7.37   | 19.3          | 0.01         | 8.6                         | 1.97      | <0.01     | <0.002             |
|                 | Springwood Well 6      | 2011-Nov-21            | <5                | 137                                       | 330               | 152                              | 172                                 | <0.1        | 7.59   | 16            | 0.036        | 9.16                        | 1.37      | <0.005    | -                  |
|                 | Springwood Well 6      | 2016-Oct-31            | <5                | 132                                       | 319               | 159                              | 168                                 | <u>1.08</u> | 7.51   | 14.8          | <0.1         | 6.5                         | 1.21      | <0.01     | <0.002             |
|                 | Springwood Well 6      | 2020-Feb-11            | <5                | 135                                       | 336               | 157                              | 214                                 | 0.5         | 7.65   | 19.8          | <0.01        | 7.1                         | 1.41      | <0.01     | <0.002             |
|                 | Springwood Well 6      | 2024-Mar-18            | <5                | 134                                       | 303               | 170                              | 213                                 | 0.18        | 7.35   | 16.2          | <0.01        | 5.3                         | 0.89      | <0.01     | <0.002             |
|                 | Springwood Well 7      | 2010-Oct-20            | <5                | 92                                        | 239               | 126                              | 145                                 | 0.4         | 7.3    | 11            | 0.05         | 2.3                         | 0.583     | <0.002    | -                  |
|                 | Springwood Well 7      | 2019-Oct-01            | <5                | 149                                       | 369               | 157                              | 213                                 | 0.31        | 7.72   | 20.4          | 0.08         | 7.2                         | 1.03      | <0.01     | <0.002             |
|                 | Springwood Well 7      | 2023-Nov-15            | <5                | 199                                       | 456               | 220                              | 273                                 | 0.25        | 7.47   | 22.1          | 0.02         | 8.2                         | 1.14      | <0.01     | <0.002             |
|                 | Springwood Well 8      | 2014-Nov-03            | <5                | 138                                       | 326               | 159                              | 186                                 | 0.35        | 7.88   | 16            | 0.036        | 7.13                        | 1.13      | <0.005    | -                  |
|                 | Springwood Well 8      | 2017-Oct-16            | <5                | 143                                       | 330               | 151                              | 173                                 | 0.39        | 7.56   | 16.6          | <0.1         | 6.7                         | 1.02      | <0.01     | <0.002             |
|                 | Springwood Well 8      | 2021-Jul-27            | <5                | 152                                       | 366               | 155                              | 211                                 | 0.4         | 7.79   | 19.7          | <0.01        | 7.2                         | 1.21      | <0.01     | <0.002             |
|                 | Springwood Well 8      | 2024-Sep-11            | <5                | 160                                       | 393               | 190                              | 233                                 | <u>2.15</u> | 7.65   | 20            | 0.02         | 9.5                         | 1.46      | <0.01     | <0.002             |
|                 | Springwood Well 10     | 2018-Aug-20            | <5                | 109                                       | 279               | 119                              | 145                                 | <0.1        | 7.5    | 17.1          | <0.1         | 10.6                        | 1.12      | <0.01     | <0.002             |
|                 | Springwood Well 10     | 2022-Jun-20            | <5                | 101                                       | 272               | 111                              | 167                                 | 0.18        | 7.65   | 15.6          | 0.06         | 5.6                         | 1.43      | <0.01     | <0.002             |
|                 | Springwood Well 11     | 2014-Nov-03            | <5                | 110                                       | 296               | 132                              | 190                                 | -           | 7.78   | 22            | 0.037        | 5.18                        | 1.38      | <0.005    | -                  |
|                 | Springwood Well 11     | 2019-Oct-01            | <5                | 106                                       | 293               | 115                              | 175                                 | 0.45        | 7.63   | 21.5          | 0.08         | 5.4                         | 1.36      | <0.01     | <0.002             |
|                 | Springwood Well 11     | 2022-Sep-06            | <5                | 105                                       | 295               | 127                              | 180                                 | <0.1        | 7.48   | 18.6          | 0.05         | 6.6                         | 1.5       | <0.01     | <0.002             |

**Notes:**

GCDWQ represents the Guidelines for Canadian Drinking Water Quality, Summary Table (Health Canada, October 2024). Guidelines are health based and listed as maximum acceptable concentrations (MAC), or based on aesthetic considerations and listed as aesthetic objectives (AO).

Saltwater Intrusion represents the Best Practices for Prevention of Saltwater Intrusion (FLNRORD, 2016). Guidelines are for coastal British Columbia and listed as operational objectives (OO).

Underline - Value exceeds the Aesthetic Objectives (AO).

**Red text** - Value exceeds the Maximum Acceptable Concentration (MAC).

**Bold text** - Value exceeds the Operational Objectives (OO).

**TCU** denotes true colour unit; **mg/L** denotes milligrams per litre; **µS/cm** denotes microSiemens per centimetre; **NTU** denotes nephelometric turbidity units; - denotes no data

Table D2: Total Metals

| Well Field         | Sample Location        | Sample Date | Aluminum (Al)-<br>Total | Antimony (Sb)-<br>Total | Arsenic (As)-<br>Total | Barium (Ba)-<br>Total | Boron (B)-<br>Total | Cadmium (Cd)-<br>Total | Calcium (Ca)-<br>Total | Chromium (Cr)-<br>Total | Copper (Cu)-<br>Total | Iron (Fe)-Total | Lead (Pb)-Total | Magnesium<br>(Mg)-Total | Manganese<br>(Mn)-Total | Mercury (Hg)-<br>Total | Potassium (K)-<br>Total | Selenium (Se)-<br>Total | Silicon (Si)-<br>Total | Sodium (Na)-<br>Total | Strontium (Sr)-<br>Total | Uranium (U)-<br>Total | Zinc (Zn)-Total |
|--------------------|------------------------|-------------|-------------------------|-------------------------|------------------------|-----------------------|---------------------|------------------------|------------------------|-------------------------|-----------------------|-----------------|-----------------|-------------------------|-------------------------|------------------------|-------------------------|-------------------------|------------------------|-----------------------|--------------------------|-----------------------|-----------------|
|                    |                        | Units       | mg/L                    | mg/L                    | mg/L                   | mg/L                  | mg/L                | mg/L                   | mg/L                   | mg/L                    | mg/L                  | mg/L            | mg/L            | mg/L                    | mg/L                    | mg/L                   | mg/L                    | mg/L                    | mg/L                   | mg/L                  | mg/L                     | mg/L                  | mg/L            |
| Guidelines         |                        | GCDWQ AO    | 0.1                     | -                       | -                      | -                     | -                   | -                      | -                      | -                       | 1                     | 0.1             | -               | -                       | 0.02                    | -                      | -                       | -                       | -                      | 200                   | -                        | -                     | 5               |
|                    |                        | GCDWQ MAC   | 2.9                     | 0.006                   | 0.01                   | 2                     | 5                   | 0.007                  | -                      | 0.05                    | 2                     | -               | 0.005           | -                       | 0.12                    | 0.001                  | -                       | 0.05                    | -                      | -                     | 7                        | 0.02                  | -               |
| Railway<br>Station | Railway Station Well 1 | 2013-Nov-25 | <0.003                  | <0.0005                 | 0.00028                | 0.0161                | <0.05               | <0.00001               | 30.5                   | <0.001                  | 0.00042               | 0.0219          | <0.0002         | 15.9                    | 0.0069                  | <0.00005               | 0.82                    | 0.00018                 | 11.1                   | 8.16                  | 0.0943                   | 0.00023               | <0.005          |
|                    | Railway Station Well 1 | 2017-Oct-16 | <0.005                  | <0.0002                 | <0.0005                | 0.0155                | 0.0171              | 0.000014               | 29.5                   | 0.00105                 | 0.00114               | 0.029           | <0.0002         | 15                      | 0.00892                 | <0.00001               | 0.72                    | <0.0005                 | -                      | 7.87                  | 0.0896                   | 0.000288              | 0.0049          |
|                    | Railway Station Well 1 | 2021-Jul-27 | 0.001                   | 0.00002                 | 0.0004                 | 0.015                 | 0.015               | <0.00001               | 30                     | 0.00087                 | 0.0006                | 0.011           | 0.00027         | 15                      | 0.005                   | <0.00001               | 0.82                    | <0.0002                 | 10                     | 7.9                   | 0.087                    | 0.00031               | 0.0023          |
|                    | Railway Station Well 1 | 2023-Nov-15 | 0.005                   | 0.00002                 | 0.0004                 | 0.018                 | 0.014               | <0.00001               | 34                     | 0.0011                  | 0.0018                | 0.081           | 0.00021         | 17                      | 0.009                   | <0.00001               | 0.93                    | 0.0002                  | 11                     | 8.2                   | 0.11                     | 0.00037               | 0.004           |
|                    | Railway Station Well 1 | 2024-Mar-18 | 0.001                   | 0.00002                 | 0.0004                 | 0.018                 | 0.013               | <0.00001               | 35                     | 0.00097                 | 0.0026                | 0.095           | 0.00046         | 19                      | 0.14                    | <0.00001               | 0.84                    | 0.0002                  | 11                     | 8.2                   | 0.1                      | 0.00033               | 0.012           |
|                    | Railway Station Well 1 | 2024-Sep-04 | 0.087                   | 0.00003                 | 0.0005                 | 0.018                 | 0.014               | <0.00001               | 36                     | 0.001                   | 0.0008                | 0.028           | 0.00011         | 17                      | 0.006                   | <0.00001               | 0.84                    | <0.0002                 | 11                     | 8.3                   | 0.11                     | 0.00033               | 0.011           |
|                    | Railway Station Well 2 | 2010-Oct-20 | 0.004                   | <0.0005                 | 0.0002                 | 0.015                 | <0.05               | <0.00001               | 35.1                   | <0.001                  | 0.0012                | 0.055           | <0.0002         | 19.1                    | 0.017                   | <0.00002               | 0.86                    | <0.0001                 | 11.9                   | 8.96                  | 0.103                    | 0.0002                | 0.011           |
|                    | Railway Station Well 2 | 2018-Aug-20 | <0.005                  | <0.0002                 | <0.0005                | 0.0191                | 0.0205              | 0.00001                | 38.3                   | 0.00107                 | 0.00505               | 0.273           | 0.0008          | 21.2                    | 0.0466                  | <0.00001               | 0.81                    | <0.0005                 | -                      | 11.2                  | 0.136                    | 0.000368              | 0.0076          |
|                    | Railway Station Well 2 | 2023-Jul-11 | 0.003                   | 0.00004                 | 0.0003                 | 0.082                 | 0.018               | 0.00003                | 41                     | 0.00072                 | 0.0012                | 0.015           | 0.00039         | 21                      | 0.006                   | <0.00001               | 0.96                    | <0.0002                 | 12                     | 12                    | 0.13                     | 0.00034               | 0.17            |
|                    | Railway Station Well 3 | 2011-Nov-21 | <0.003                  | <0.0005                 | 0.00023                | 0.0056                | <0.05               | <0.00001               | 25.6                   | <0.001                  | 0.00687               | 0.106           | 0.00023         | 12.5                    | 0.013                   | <0.00005               | 0.678                   | <0.0001                 | -                      | 6.06                  | -                        | 0.00012               | 0.0065          |
|                    | Railway Station Well 3 | 2013-Nov-25 | <0.003                  | <0.0005                 | 0.00025                | 0.0083                | <0.05               | <0.00001               | 36.3                   | <0.001                  | 0.0007                | <0.005          | <0.0002         | 17.5                    | 0.0239                  | <0.00005               | 0.78                    | <0.0001                 | 11.1                   | 8.52                  | 0.106                    | 0.00014               | <0.005          |
|                    | Railway Station Well 3 | 2016-Oct-31 | <0.05                   | <0.001                  | <0.005                 | <0.05                 | <0.04               | 0.0001                 | 38                     | <0.005                  | 0.0083                | <0.1            | <0.001          | 19.8                    | 0.16                    | <0.00002               | 0.86                    | <0.005                  | -                      | 8.69                  | -                        | 0.00022               | <0.04           |
|                    | Railway Station Well 3 | 2020-Feb-11 | <0.001                  | <0.00002                | 0.0003                 | 0.0078                | 0.01                | <0.00001               | 38                     | 0.00049                 | 0.0017                | 0.004           | 0.00073         | 17                      | 0.021                   | <0.00001               | 0.79                    | <0.0002                 | 10                     | 9.8                   | 0.11                     | 0.00024               | 0.026           |
|                    | Railway Station Well 3 | 2024-Mar-18 | <0.001                  | <0.00002                | 0.0004                 | 0.009                 | 0.011               | <0.00001               | 38                     | 0.0006                  | 0.0007                | 0.011           | 0.00015         | 19                      | 0.035                   | <0.00001               | 0.78                    | <0.0002                 | 12                     | 10                    | 0.12                     | 0.00034               | 0.013           |
|                    | Railway Station Well 4 | 2014-Nov-03 | <0.003                  | <0.0005                 | 0.00022                | 0.0106                | <0.05               | <0.00001               | 30.5                   | <0.001                  | 0.00099               | <0.005          | <0.0002         | 14                      | 0.0108                  | <0.00001               | 0.684                   | 0.00039                 | 12.8                   | 7.02                  | -                        | <0.00018              | <0.005          |
|                    | Railway Station Well 4 | 2022-Sep-06 | 0.004                   | 0.00006                 | 0.0003                 | 0.013                 | 0.012               | 0.00082                | 34                     | 0.00043                 | 0.0027                | 0.005           | 0.00017         | 16                      | 0.018                   | <0.00001               | 0.75                    | 0.0004                  | 11                     | 7.3                   | 0.094                    | 0.00028               | 0.0049          |
|                    | Railway Station Well 5 | 2011-Nov-21 | <0.003                  | <0.0005                 | 0.00038                | 0.0227                | <0.05               | <0.00001               | 38.3                   | <0.001                  | 0.00493               | 0.0593          | 0.00182         | 17.3                    | 0.007                   | <0.00005               | 0.924                   | 0.00024                 | -                      | 11.3                  | -                        | 0.00034               | <0.005          |
|                    | Railway Station Well 5 | 2016-Oct-31 | <0.05                   | <0.001                  | <0.005                 | <0.05                 | <0.04               | <0.0001                | 30.6                   | <0.005                  | 0.0117                | <0.1            | <0.001          | 15.2                    | 0.0066                  | <0.00002               | 0.72                    | <0.005                  | -                      | 8.05                  | -                        | 0.00038               | <0.04           |
|                    | Railway Station Well 5 | 2018-Aug-20 | <0.005                  | <0.0002                 | <0.0005                | 0.02                  | 0.0253              | <0.00001               | 32.1                   | 0.00076                 | 0.00655               | 0.028           | <0.0002         | 16.9                    | 0.0149                  | <0.00001               | 0.84                    | <0.0005                 | -                      | 12.7                  | 0.108                    | 0.000333              | 0.0043          |
|                    | Railway Station Well 5 | 2022-Sep-06 | 0.003                   | 0.00002                 | 0.0005                 | 0.021                 | 0.017               | <0.00001               | 37                     | 0.0056                  | 0.0014                | 0.032           | 0.00018         | 17                      | 0.005                   | <0.00001               | 0.97                    | <0.0002                 | 11                     | 14                    | 0.1                      | 0.00026               | 0.0045          |
|                    | Railway Station Well 6 | 2010-Oct-20 | 0.008                   | <0.0005                 | 0.0005                 | 0.018                 | 0.062               | <0.00001               | 27.4                   | <0.001                  | 0.001                 | 0.025           | <0.0002         | 12.7                    | 0.006                   | <0.00002               | 0.71                    | <0.0001                 | 10.1                   | 7.22                  | 0.082                    | 0.0007                | <0.005          |
|                    | Railway Station Well 6 | 2019-Oct-01 | 0.007                   | 0.00004                 | 0.0009                 | 0.015                 | 0.013               | <0.00001               | 30                     | 0.0012                  | 0.013                 | 0.48            | 0.0021          | 15                      | 0.026                   | <0.00001               | 0.75                    | <0.0002                 | 10                     | 8.7                   | 0.088                    | 0.00058               | 0.0077          |
|                    | Railway Station Well 6 | 2023-Nov-15 | 0.005                   | 0.00003                 | 0.0005                 | 0.017                 | 0.013               | 0.00003                | 28                     | 0.00073                 | 0.0005                | 0.026           | 0.00003         | 14                      | 0.005                   | <0.00001               | 0.95                    | <0.0002                 | 12                     | 9.1                   | 0.086                    | 0.00034               | 0.0013          |
|                    | Railway Station Well 7 | 2014-Nov-03 | <0.003                  | <0.0005                 | 0.00028                | 0.0187                | <0.05               | <0.00001               | 47.9                   | <0.001                  | 0.00046               | <0.005          | <0.0002         | 24.5                    | 0.0058                  | <0.00001               | 0.952                   | <0.0001                 | 12.2                   | 10.7                  | -                        | 0.00046               | <0.005          |
|                    | Railway Station Well 7 | 2020-Feb-11 | <0.001                  | <0.00002                | 0.0003                 | 0.015                 | 0.011               | <0.00001               | 42                     | 0.00078                 | 0.0016                | 0.01            | 0.00068         | 20                      | 0.007                   | <0.00001               | 0.89                    | <0.0002                 | 11                     | 11                    | 0.12                     | 0.0003                | 0.013           |
|                    | Railway Station Well 7 | 2024-Sep-04 | 0.001                   | 0.00003                 | 0.0005                 | 0.018                 | 0.019               | <0.00001               | 45                     | 0.00071                 | 0.0018                | 0.018           | 0.00057         | 22                      | 0.007                   | <0.00001               | 0.99                    | <0.0002                 | 12                     | 13                    | 0.14                     | 0.00028               | 0.0058          |
|                    | Railway Station Well 8 | 2017-Oct-16 | <0.005                  | <0.0002                 | <0.0005                | 0.0076                | 0.0107              | 0.000044               | 33.6                   | 0.00081                 | 0.0482                | <0.01           | 0.0317          | 16.2                    | 0.0202                  | <0.00001               | 0.6                     | <0.0005                 | -                      | 8.12                  | 0.0913                   | 0.000189              | 0.0501          |
|                    | Railway Station Well 8 | 2024-Sep-04 | <0.001                  | <0.00002                | 0.0004                 | 0.011                 | 0.007               | 0.00001                | 41                     | 0.00075                 | 0.0005                | 0.013           | 0.00025         | 19                      | 0.027                   | <0.00001               | 0.67                    | 0.0003                  | 11                     | 8                     | 0.11                     | 0.00025               | 0.0031          |



Table D2: Total Metals

| Well Field | Sample Location    | Sample Date | Aluminum (Al)-<br>Total | Antimony (Sb)-<br>Total | Arsenic (As)-<br>Total | Barium (Ba)-<br>Total | Boron (B)-<br>Total | Cadmium (Cd)-<br>Total | Calcium (Ca)-<br>Total | Chromium (Cr)-<br>Total | Copper (Cu)-<br>Total | Iron (Fe)-Total | Lead (Pb)-Total | Magnesium<br>(Mg)-Total | Manganese<br>(Mn)-Total | Mercury (Hg)-<br>Total | Potassium (K)-<br>Total | Selenium (Se)-<br>Total | Silicon (Si)-<br>Total | Sodium (Na)-<br>Total | Strontium (Sr)-<br>Total | Uranium (U)-<br>Total | Zinc (Zn)-Total |
|------------|--------------------|-------------|-------------------------|-------------------------|------------------------|-----------------------|---------------------|------------------------|------------------------|-------------------------|-----------------------|-----------------|-----------------|-------------------------|-------------------------|------------------------|-------------------------|-------------------------|------------------------|-----------------------|--------------------------|-----------------------|-----------------|
|            |                    | Units       | mg/L                    | mg/L                    | mg/L                   | mg/L                  | mg/L                | mg/L                   | mg/L                   | mg/L                    | mg/L                  | mg/L            | mg/L            | mg/L                    | mg/L                    | mg/L                   | mg/L                    | mg/L                    | mg/L                   | mg/L                  | mg/L                     | mg/L                  | mg/L            |
| Guidelines |                    | GCDWQ AO    | 0.1                     | -                       | -                      | -                     | -                   | -                      | -                      | -                       | 1                     | 0.1             | -               | -                       | 0.02                    | -                      | -                       | -                       | -                      | 200                   | -                        | -                     | 5               |
|            |                    | GCDWQ MAC   | 2.9                     | 0.006                   | 0.01                   | 2                     | 5                   | 0.007                  | -                      | 0.05                    | 2                     | -               | 0.005           | -                       | 0.12                    | 0.001                  | -                       | 0.05                    | -                      | -                     | 7                        | 0.02                  | -               |
| Springwood | Springwood Well 1  | 2013-Nov-25 | <0.003                  | <0.0005                 | 0.00011                | 0.0034                | <0.05               | <0.00001               | 28                     | <0.001                  | 0.00144               | <0.005          | 0.00032         | 13.6                    | 0.0189                  | <0.00005               | 0.549                   | 0.00011                 | 12.3                   | 7.24                  | 0.0766                   | <0.0001               | <0.005          |
|            | Springwood Well 1  | 2017-Oct-16 | <0.005                  | <0.0002                 | <0.0005                | <0.005                | 0.013               | <0.00001               | 25.4                   | <0.0005                 | 0.00108               | <0.01           | <0.0002         | 12.6                    | 0.0154                  | <0.00001               | 0.52                    | <0.0005                 | -                      | 7.57                  | 0.0763                   | 0.00007               | <0.004          |
|            | Springwood Well 1  | 2023-Jul-11 | 0.009                   | 0.00003                 | 0.0002                 | 0.074                 | 0.008               | <0.00001               | 23                     | 0.00033                 | 0.0007                | 0.019           | 0.00006         | 11                      | 0.007                   | <0.00001               | 0.46                    | <0.0002                 | 12                     | 7.4                   | 0.071                    | 0.00006               | 0.19            |
|            | Springwood Well 3  | 2010-Oct-20 | 0.004                   | <0.0005                 | 0.0005                 | 0.006                 | <0.05               | <0.00001               | 26.1                   | <0.0001                 | 0.0006                | 0.034           | 0.0002          | 1.76                    | 0.056                   | <0.00002               | 0.2                     | <0.0001                 | 12.9                   | 5.83                  | 0.069                    | 0.0001                | <0.005          |
|            | Springwood Well 3  | 2013-Nov-25 | 0.0763                  | <0.0005                 | 0.00104                | 0.0088                | <0.05               | <0.00003               | 29.8                   | 0.0022                  | 0.00179               | 0.331           | 0.0003          | 15.1                    | 0.119                   | <0.00005               | 0.854                   | 0.00016                 | 12                     | 10.2                  | 0.0877                   | 0.00025               | <0.005          |
|            | Springwood Well 3  | 2020-Feb-11 | <0.001                  | 0.00002                 | 0.0004                 | 0.0058                | 0.012               | <0.00001               | 28                     | 0.00046                 | 0.0019                | 0.01            | 0.00081         | 13                      | 0.035                   | <0.00001               | 0.76                    | <0.0002                 | 11                     | 8.6                   | 0.077                    | 0.00013               | 0.0048          |
|            | Springwood Well 3  | 2024-Mar-18 | <0.001                  | <0.00002                | 0.0005                 | 0.0074                | 0.011               | <0.00001               | 31                     | 0.00057                 | 0.0024                | 0.018           | 0.00049         | 15                      | 0.04                    | <0.00001               | 0.84                    | <0.0002                 | 12                     | 9.5                   | 0.086                    | 0.00015               | 0.011           |
|            | Springwood Well 5  | 2011-Nov-21 | <0.003                  | <0.0005                 | 0.00023                | 0.006                 | <0.05               | <0.00001               | 28.7                   | <0.001                  | 0.00085               | 0.173           | <0.0002         | 13.5                    | 0.0174                  | <0.00005               | 0.808                   | <0.0001                 | -                      | 9.09                  | -                        | 0.00014               | 0.0155          |
|            | Springwood Well 5  | 2016-Oct-31 | <0.05                   | <0.001                  | <0.005                 | <0.05                 | <0.04               | <0.0001                | 43.5                   | <0.005                  | 0.0337                | 0.11            | 0.0021          | 21.5                    | 0.0296                  | <0.00002               | 1.02                    | <0.005                  | -                      | 19.2                  | -                        | 0.00026               | <0.04           |
|            | Springwood Well 5  | 2018-Aug-20 | <0.005                  | <0.0002                 | <0.0005                | 0.0107                | 0.0196              | <0.00001               | 38.4                   | 0.00059                 | 0.00335               | 0.073           | 0.0005          | 20.1                    | 0.0381                  | <0.00001               | 0.97                    | <0.0005                 | -                      | 17.8                  | 0.144                    | 0.000295              | 0.0062          |
|            | Springwood Well 5  | 2022-Jun-20 | 0.004                   | <0.00002                | 0.0003                 | 0.011                 | 0.014               | <0.00001               | 42                     | 0.00031                 | 0.0012                | 0.089           | 0.00063         | 20                      | 0.038                   | <0.00001               | 0.89                    | <0.0002                 | 13                     | 13                    | 0.12                     | 0.00023               | 0.0059          |
|            | Springwood Well 5  | 2024-Sep-11 | 0.001                   | <0.00002                | 0.0004                 | 0.014                 | 0.014               | 0.00002                | 46                     | 0.00032                 | 0.0013                | 0.12            | 0.00033         | 22                      | 0.045                   | <0.00001               | 1.1                     | <0.0002                 | 14                     | 12                    | 0.14                     | 0.00026               | 0.01            |
|            | Springwood Well 6  | 2011-Nov-21 | <0.003                  | <0.0005                 | 0.00029                | 0.0062                | <0.05               | <0.00001               | 34.6                   | <0.001                  | 0.00054               | 0.0135          | <0.0002         | 15.9                    | 0.0076                  | <0.00005               | 0.874                   | <0.0001                 | -                      | 9.61                  | -                        | 0.00021               | <0.005          |
|            | Springwood Well 6  | 2016-Oct-31 | <0.05                   | <0.001                  | <0.005                 | <0.05                 | <0.04               | <0.0001                | 34.9                   | <0.005                  | 0.0073                | 0.21            | 0.0028          | 17.4                    | 0.0313                  | <0.00002               | 0.86                    | <0.005                  | -                      | 7.48                  | -                        | 0.00022               | <0.04           |
|            | Springwood Well 6  | 2020-Feb-11 | 0.001                   | <0.00002                | 0.0003                 | 0.006                 | 0.012               | <0.00001               | 33                     | 0.00045                 | 0.0029                | 0.045           | 0.00033         | 14                      | 0.011                   | <0.00001               | 0.78                    | <0.0002                 | 12                     | 8.9                   | 0.089                    | 0.00011               | 0.033           |
|            | Springwood Well 6  | 2024-Mar-18 | 0.001                   | 0.00002                 | 0.0003                 | 0.007                 | 0.01                | 0.00003                | 33                     | 0.00056                 | 0.0078                | 0.04            | 0.00099         | 16                      | 0.01                    | <0.00001               | 0.83                    | <0.0002                 | 13                     | 8.3                   | 0.095                    | 0.00013               | 0.12            |
|            | Springwood Well 7  | 2010-Oct-20 | 0.009                   | <0.0005                 | 0.0003                 | 0.004                 | <0.05               | 0.00002                | 25.3                   | 0.001                   | 0.0038                | 0.024           | 0.0004          | 15.2                    | 0.015                   | <0.00002               | 1.01                    | <0.0001                 | 13.9                   | 7.37                  | 0.063                    | <0.0001               | 0.011           |
|            | Springwood Well 7  | 2019-Oct-01 | 0.004                   | 0.00004                 | 0.0002                 | 0.006                 | 0.01                | <0.00001               | 38                     | 0.00076                 | 0.001                 | 0.015           | 0.00027         | 18                      | 0.01                    | <0.00001               | 0.81                    | <0.0002                 | 12                     | 7.6                   | 0.098                    | 0.00023               | 0.0027          |
|            | Springwood Well 7  | 2023-Nov-15 | 0.002                   | 0.00009                 | 0.0003                 | 0.0087                | 0.011               | <0.00001               | 48                     | 0.00073                 | 0.0023                | 0.037           | 0.00062         | 24                      | 0.016                   | <0.00001               | 1.1                     | <0.0002                 | 12                     | 8.7                   | 0.13                     | 0.00045               | 0.0024          |
|            | Springwood Well 8  | 2014-Nov-03 | <0.003                  | <0.0005                 | 0.00017                | 0.0072                | <0.05               | <0.00001               | 35.5                   | <0.001                  | 0.00025               | 0.0551          | <0.0002         | 17.1                    | 0.011                   | <0.00001               | 0.955                   | <0.0001                 | 12.8                   | 7.04                  | -                        | <0.00026              | <0.005          |
|            | Springwood Well 8  | 2017-Oct-16 | <0.005                  | <0.0002                 | <0.0005                | 0.0073                | 0.0136              | <0.00001               | 33                     | 0.00117                 | 0.00214               | 0.074           | 0.00037         | 16.5                    | 0.0123                  | <0.00001               | 0.85                    | <0.0005                 | -                      | 7.65                  | 0.0897                   | 0.000251              | 0.0058          |
|            | Springwood Well 8  | 2021-Jul-27 | 0.001                   | 0.00002                 | 0.0003                 | 0.0074                | 0.012               | <0.00001               | 38                     | 0.00087                 | 0.0009                | 0.069           | 0.00011         | 19                      | 0.012                   | <0.00001               | 0.98                    | <0.0002                 | 11                     | 7.5                   | 0.099                    | 0.00031               | 0.0013          |
|            | Springwood Well 8  | 2024-Sep-11 | 0.063                   | <0.00002                | 0.0005                 | 0.0089                | 0.011               | <0.00001               | 42                     | 0.0013                  | 0.0014                | 0.38            | 0.00002         | 20                      | 0.018                   | <0.00001               | 0.97                    | <0.0002                 | 12                     | 7.7                   | 0.11                     | 0.00038               | 0.0028          |
|            | Springwood Well 10 | 2018-Aug-20 | <0.005                  | <0.0002                 | <0.0005                | 0.0084                | 0.0144              | <0.00001               | 25.5                   | 0.00077                 | 0.00215               | <0.01           | 0.00028         | 0.0195                  | 0.0195                  | <0.00001               | 0.53                    | <0.0005                 | -                      | 6.81                  | 0.0977                   | 0.000079              | 0.0065          |
|            | Springwood Well 10 | 2022-Jun-20 | 0.001                   | 0.00002                 | 0.0002                 | 0.0073                | 0.01                | <0.00001               | 26                     | 0.00031                 | 0.0009                | 0.012           | 0.0001          | 12                      | 0.02                    | <0.00001               | 0.62                    | <0.0002                 | 13                     | 7.2                   | 0.083                    | 0.00006               | 0.0007          |
|            | Springwood Well 11 | 2014-Nov-03 | <0.003                  | <0.0005                 | 0.00028                | 0.0073                | <0.05               | 0.000016               | 30.8                   | <0.001                  | <0.0005               | <0.005          | <0.0002         | 13.4                    | 0.0316                  | <0.00001               | 0.76                    | 0.00014                 | 14                     | 8.58                  | -                        | <0.0001               | <0.0005         |
|            | Springwood Well 11 | 2019-Oct-01 | 0.004                   | 0.00004                 | 0.0003                 | 0.0065                | 0.012               | 0.00001                | 29                     | 0.00054                 | 0.0022                | 0.01            | 0.00035         | 13                      | 0.026                   | <0.00001               | 0.68                    | <0.0002                 | 12                     | 8.1                   | 0.089                    | 0.00008               | 0.0067          |
|            | Springwood Well 11 | 2022-Sep-06 | 0.002                   | 0.00003                 | 0.0003                 | 0.0063                | 0.011               | <0.00001               | 29                     | 0.00041                 | 0.0018                | 0.009           | 0.00022         | 13                      | 0.023                   | <0.00001               | 0.7                     | <0.0002                 | 12                     | 8.4                   | 0.083                    | 0.00009               | 0.0051          |

**Notes:** GCDWQ represents the Guidelines for Canadian Drinking Water Quality, Summary Table (Health Canada, October 2024). Guidelines are health based and listed as maximum acceptable concentrations (MAC), or based on aesthetic considerations and listed as aesthetic objectives (AO).  
Underline - Value exceeds the Aesthetic Objectives (AO).  
**Red text** - Value exceeds the Maximum Acceptable Concentration (MAC).  
**mg/L** denotes milligrams per litre; - denotes no data available.

Table D3: Microbiology

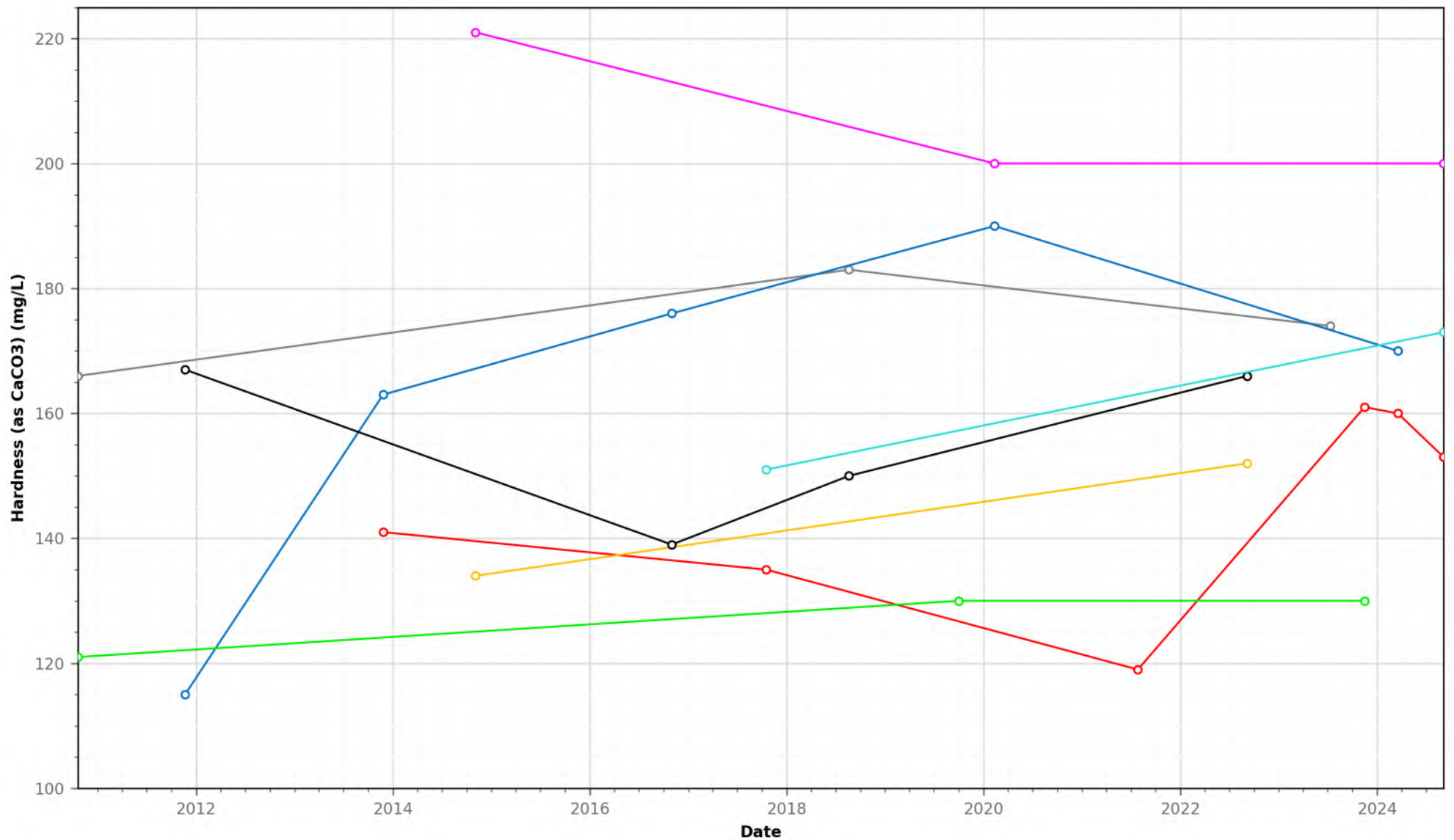
| Well Field         | Sample Location        | Sample Date       | E. Coli           | Total Coliforms   |
|--------------------|------------------------|-------------------|-------------------|-------------------|
|                    |                        | Units             |                   |                   |
| Guidelines         |                        | GCDWQ MAC         | 0                 | 0                 |
| Railway Station    | Railway Station Well 1 | 2013-Nov-25       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 1 | 2017-Oct-16       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 1 | 2021-Jul-27       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 1 | 2023-Nov-15       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 1 | 2024-Mar-18       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 1 | 2024-Sep-04       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 2 | 2010-Oct-20       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 2 | 2018-Aug-20       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 2 | 2023-Jul-11       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 3 | 2013-Nov-25       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 3 | 2016-Oct-31       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 3 | 2020-Feb-11       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 3 | 2024-Mar-18       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 4 | 2014-Nov-03       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 4 | 2022-Sep-06       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 5 | 2016-Oct-31       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 5 | 2018-Aug-20       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 5 | 2022-Sep-06       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 6 | 2010-Oct-20       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 6 | 2019-Oct-01       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 6 | 2023-Nov-15       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 7 | 2014-Nov-03       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 7 | 2020-Feb-11       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 7 | 2024-Sep-04       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 8 | 2017-Oct-16       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Railway Station Well 8 | 2024-Sep-04       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
| Springwood         | Springwood Well 1      | 2013-Nov-25       | <2 <sup>(a)</sup> | <2 <sup>(a)</sup> |
|                    | Springwood Well 1      | 2017-Oct-16       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 1      | 2023-Jul-11       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 3      | 2010-Oct-20       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 3      | 2013-Nov-25       | <2 <sup>(a)</sup> | <2 <sup>(a)</sup> |
|                    | Springwood Well 3      | 2020-Feb-11       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 3      | 2024-Mar-18       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 5      | 2016-Oct-31       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 5      | 2018-Aug-20       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 5      | 2022-Jun-20       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 5      | 2024-Sep-11       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 6      | 2011-Nov-21       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 6      | 2016-Oct-31       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 6      | 2020-Feb-11       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 6      | 2024-Mar-18       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 7      | 2010-Oct-20       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 7      | 2019-Oct-01       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 7      | 2023-Nov-15       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 8      | 2014-Nov-03       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 8      | 2017-Oct-16       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 8      | 2021-Jul-27       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 8      | 2024-Sep-11       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 10     | 2018-Aug-20       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 10     | 2022-Jun-20       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 11     | 2014-Nov-03       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
|                    | Springwood Well 11     | 2019-Oct-01       | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |
| Springwood Well 11 | 2022-Sep-06            | <1 <sup>(a)</sup> | <1 <sup>(a)</sup> |                   |

**Notes:**  
GCDWQ represents the Guidelines for Canadian Drinking Water Quality, Summary Table (Health Canada, October 2024). Guidelines are health based and listed as maximum acceptable concentrations (MAC), or based on aesthetic considerations and listed as aesthetic objectives (AO).  
<sup>(a)</sup>Laboratory results that were less than detection limits and greater than the applied guidelines are not shown as exceedances.  
**Red text** - Value exceeds the Maximum Acceptable Concentration (MAC).  
**MPN/100mL** denotes most probable number per 100 millilitres.

## **Appendix E**

### **Groundwater Chemistry Charts**





- Railway Station Well 1 Chemistry
- Railway Station Well 2 Chemistry
- Railway Station Well 3 Chemistry
- Railway Station Well 4 Chemistry
- Railway Station Well 5 Chemistry
- Railway Station Well 6 Chemistry
- Railway Station Well 7 Chemistry
- Railway Station Well 8 Chemistry

Task 2 - Hydrogeological Assessment of Parksville's WSW Operations  
and the Englishman River Aquifers for the City of Parksville, BC  
Submitted to Kerr Wood Leidal Consulting Engineers

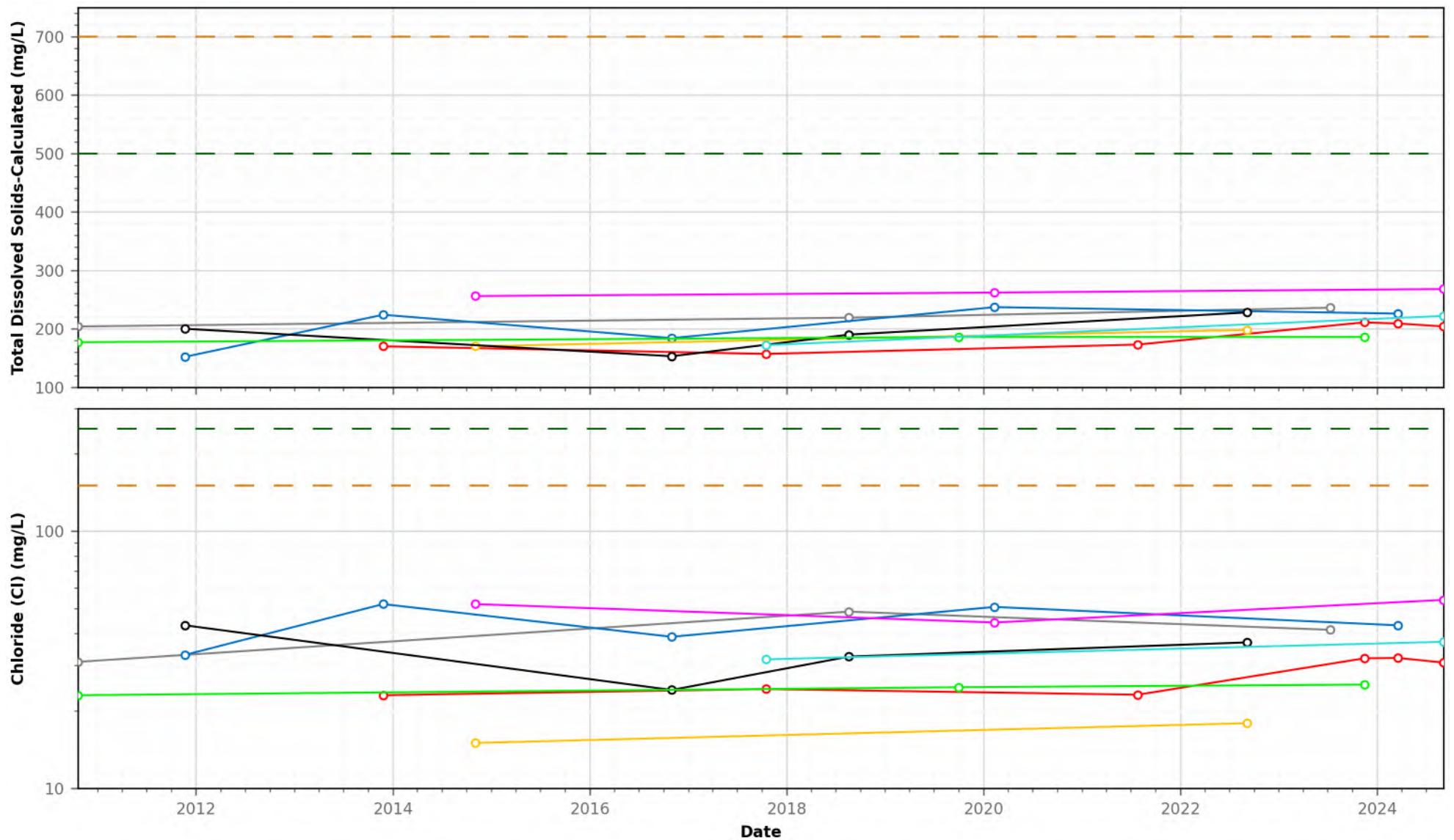
### Water Hardness - Railway Station Well Field



|                                       |
|---------------------------------------|
| PREPARED BY: Waterline Resources Inc. |
| PROJECT: 3917-24-001                  |
| COMPILED BY: Hydrachem                |
| DATE ISSUED: 2025-Mar-26              |
| REVISED: -                            |

FIGURE E1





- Railway Station Well 1 Chemistry
- Railway Station Well 2 Chemistry
- Railway Station Well 3 Chemistry
- Railway Station Well 4 Chemistry
- Railway Station Well 5 Chemistry
- Railway Station Well 6 Chemistry
- Railway Station Well 7 Chemistry
- Railway Station Well 8 Chemistry
- GCDWQ AO for TDS: 500 mg/L
- Saltwater Intrusion OO for TDS: 700 mg/L

- GCDWQ AO for Cl: 250 mg/L
- Saltwater Intrusion OO for Cl: 150 mg/L

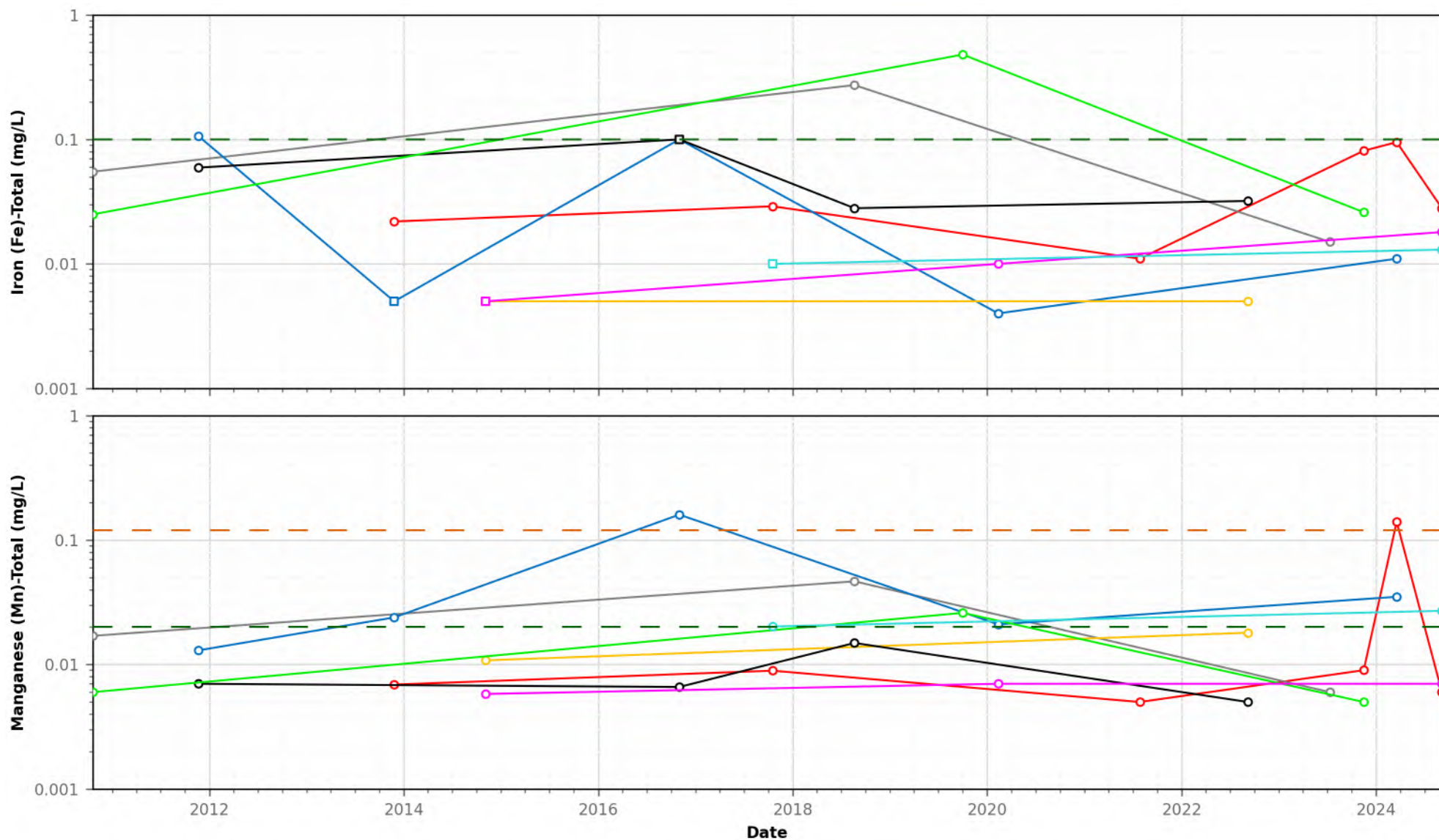
Task 2 - Hydrogeological Assessment of Parksville's WSW Operations  
and the Englishman River Aquifers for the City of Parksville, BC  
Submitted to Kerr Wood Leidal Consulting Engineers

### Saltwater Intrusion Indicator Parameters - Railway Station Well Field



PREPARED BY: Waterline Resources Inc.  
PROJECT: 3917-24-001  
COMPILED BY: Hydrachem  
DATE ISSUED: 2025-Mar-26  
REVISED: -

**FIGURE E2**



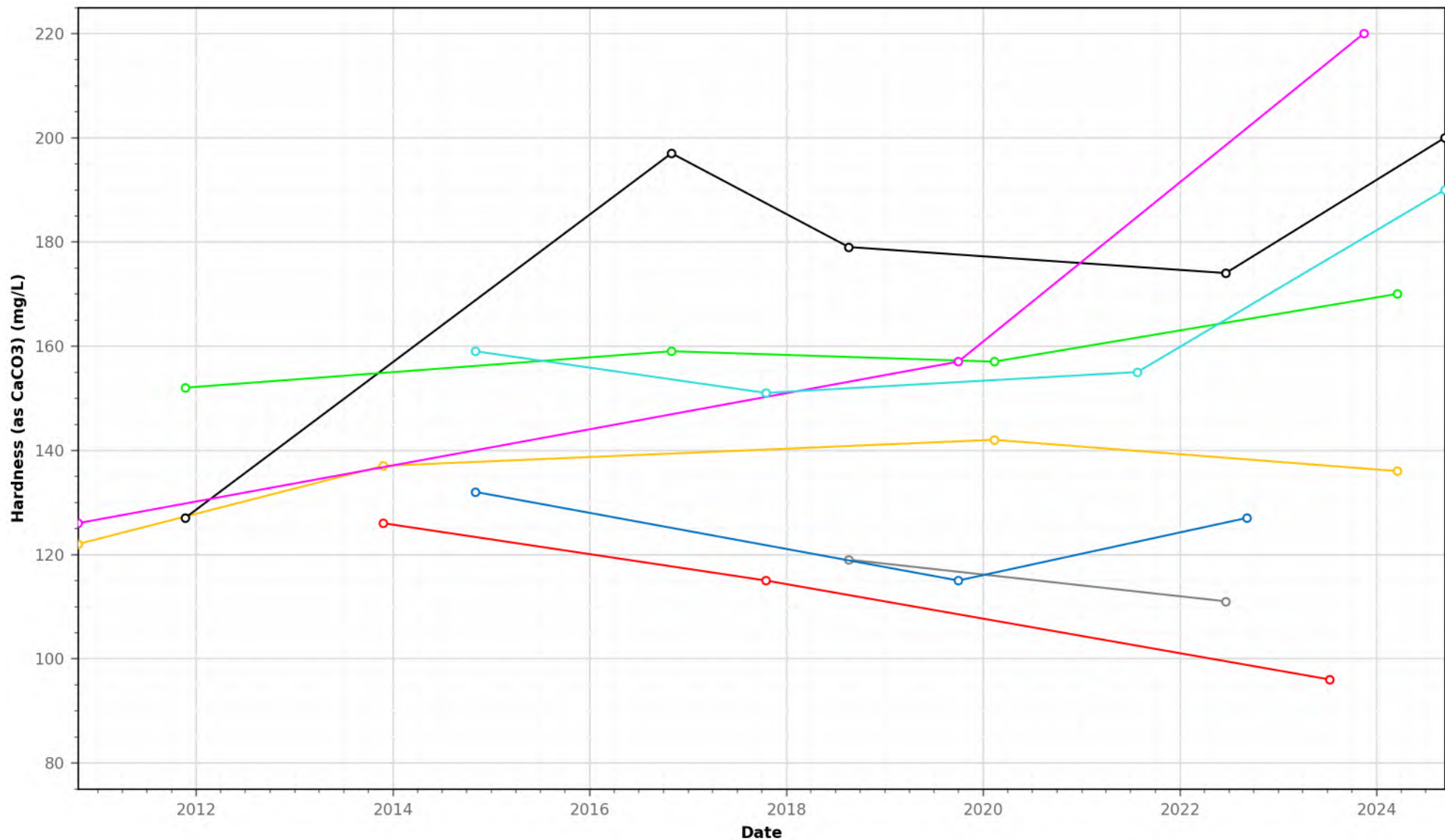
Task 2 - Hydrogeological Assessment of Parksville's WSW Operations and the Englishman River Aquifers for the City of Parksville, BC  
Submitted to Kerr Wood Leidal Consulting Engineers

### Iron & Manganese - Railway Station Well Field



PREPARED BY: Waterline Resources Inc.  
PROJECT: 3917-24-001  
COMPILED BY: Hydrachem  
DATE ISSUED: 2025-Mar-26  
REVISED: -

FIGURE E3



- Springwood Well 1 Chemistry
- Springwood Well 3 Chemistry
- Springwood Well 5 Chemistry
- Springwood Well 6 Chemistry
- Springwood Well 7 Chemistry
- Springwood Well 8 Chemistry
- Springwood Well 10 Chemistry
- Springwood Well 11 Chemistry

Task 2 - Hydrogeological Assessment of Parksville's WSW Operations  
and the Englishman River Aquifers for the City of Parksville, BC  
Submitted to Kerr Wood Leidal Consulting Engineers

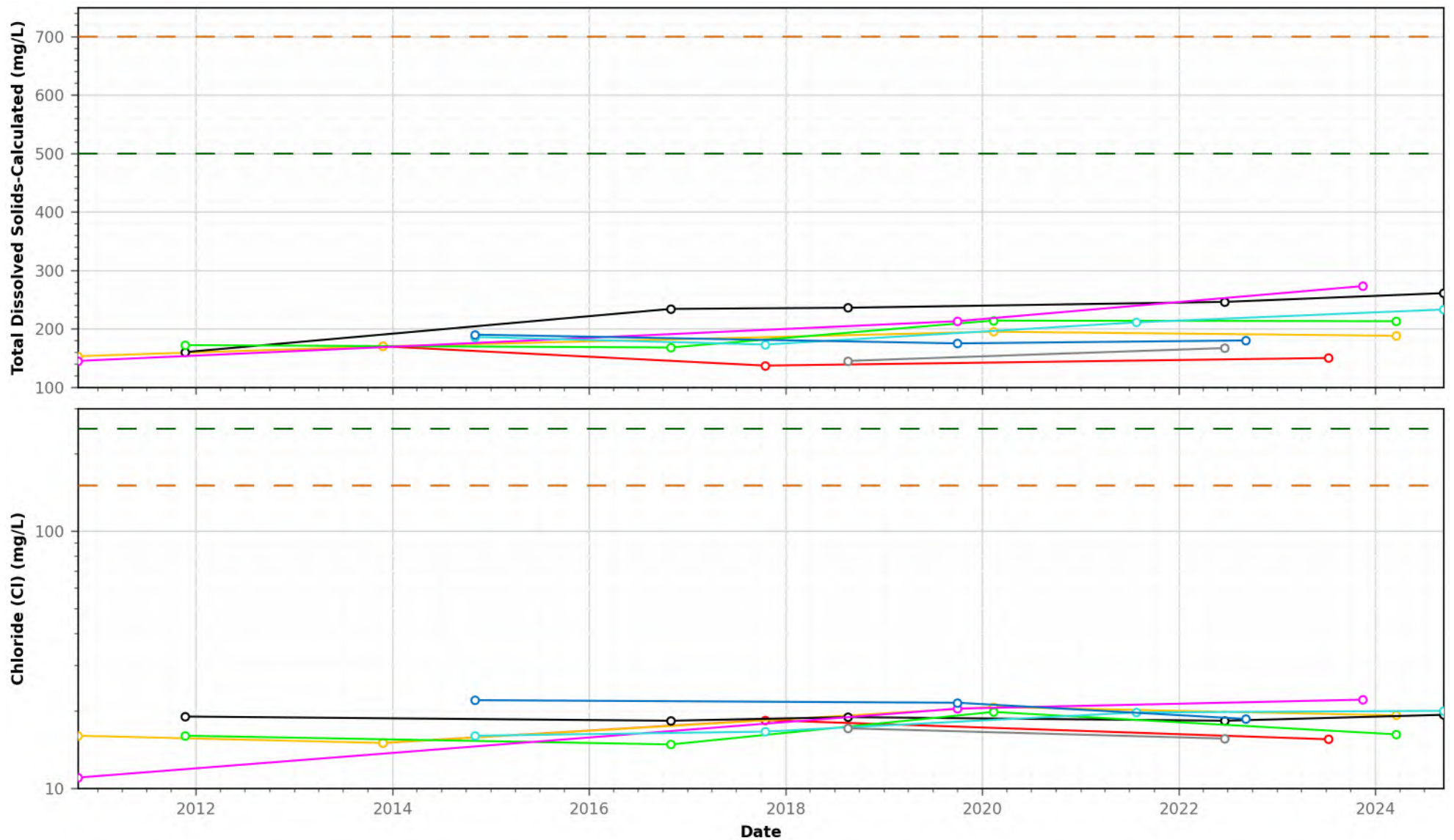
### Water Hardness - Springwood Well Field



PREPARED BY: Waterline Resources Inc.  
PROJECT: 3917-24-001  
COMPILED BY: Hydrachem  
DATE ISSUED: 2025-Mar-26  
REVISED: -

**FIGURE E4**





- Springwood Well 1 Chemistry
- Springwood Well 3 Chemistry
- Springwood Well 5 Chemistry
- Springwood Well 6 Chemistry
- Springwood Well 7 Chemistry
- Springwood Well 8 Chemistry
- Springwood Well 10 Chemistry
- Springwood Well 11 Chemistry
- GCDWQ AO for TDS: 500 mg/L
- Saltwater Intrusion OO for TDS: 700 mg/L

- GCDWQ AO for Cl: 250 mg/L
- Saltwater Intrusion OO for Cl: 150 mg/L

Task 2 - Hydrogeological Assessment of Parksville's WSW Operations and the Englishman River Aquifers for the City of Parksville, BC  
Submitted to Kerr Wood Leidal Consulting Engineers

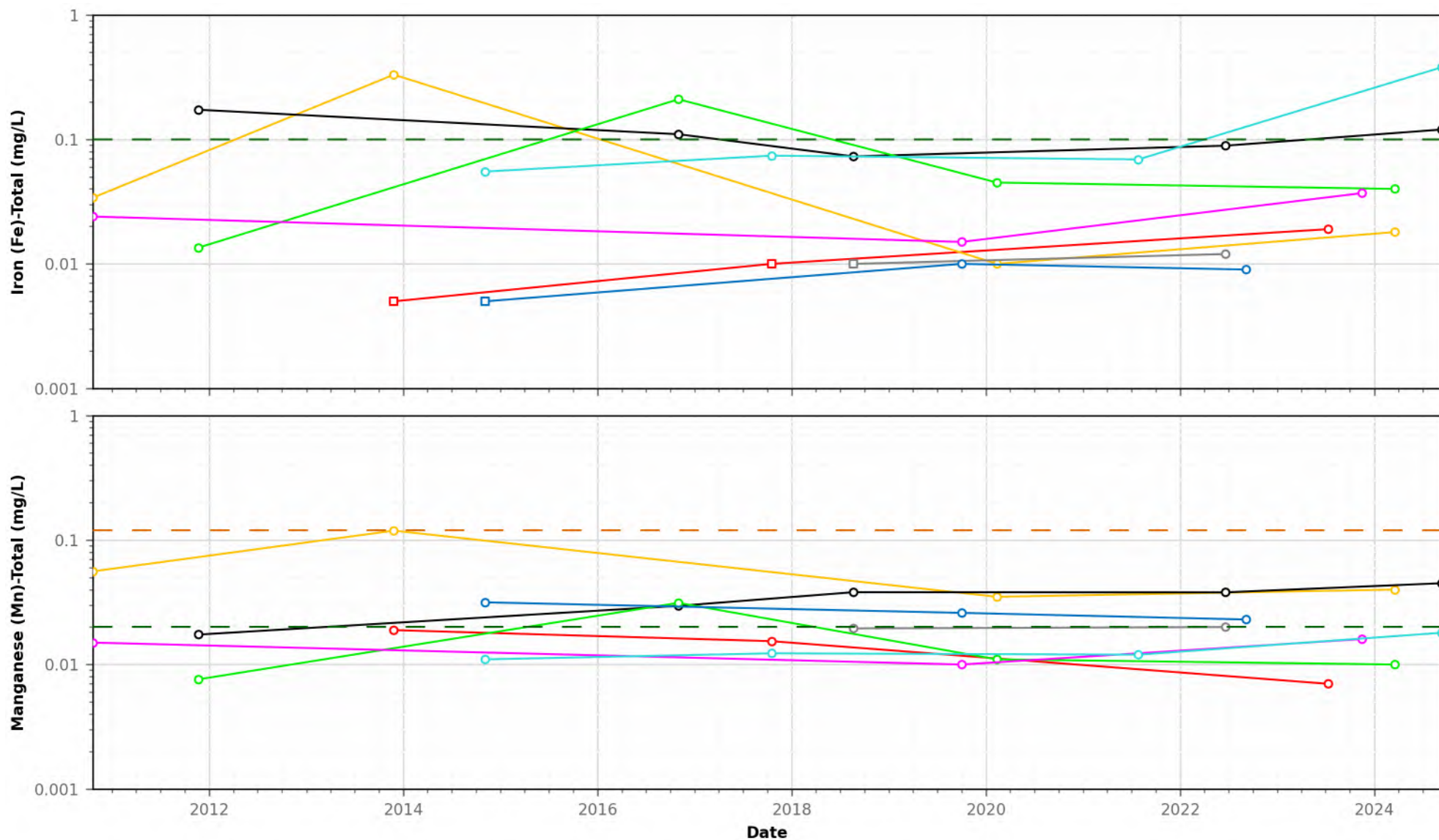
### Saltwater Intrusion Indicator Parameters - Springwood Well Field



PREPARED BY: Waterline Resources Inc.  
PROJECT: 3917-24-001  
COMPILED BY: Hydrachem  
DATE ISSUED: 2025-Mar-26  
REVISED: -

FIGURE E5





Task 2 - Hydrogeological Assessment of Parksville's WSW Operations and the Englishman River Aquifers for the City of Parksville, BC  
Submitted to Kerr Wood Leidal Consulting Engineers

## Iron & Manganese - Springwood Well Field



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PROJECT: 3917-24-001  
COMPILED BY: Hydrachem  
DATE ISSUED: 2025-Mar-26  
REVISED: -

FIGURE E6

Appendix D

## Task 3 – Groundwater Supply Resilience Planning

Waterline Resources Inc.  
March 9, 2026

**TASK 3 – GROUNDWATER SUPPLY RESILIENCE  
PLANNING FOR THE CITY OF PARKSVILLE,  
BRITISH COLUMBIA**

Submitted To:



300A – 4185 Still Creek Drive  
Burnaby BC, V5C 6G9

Submitted By:

Waterline Resources Inc.  
Nanaimo, British Columbia  
March 09, 2026  
3917-24-001



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## **1.0 INTRODUCTION**

### **1.1 Background**

As part of the City of Parksville's (Parksville) Phase 1 Water Use Planning and Management Study (Phase 1 Study), managed by Kerr Wood Leidal Consulting Engineers (KWL), Waterline Resources Inc. (Waterline) was retained to provide technical hydrogeological support and the following reports, with relevant information to be incorporated into the Phase 1 Study:

- *Task 1 – Water Supply Well Data Compilation and Overview of the Englishman River Aquifers*
- *Task 2 – Hydrogeological Assessment of Parksville's Water Supply Well Operations and the Englishman River Aquifers*
- *Task 3 – Groundwater Supply Resilience Planning*

Following Task 1 (data compilation report; Waterline, 2025a) and Task 2 (assessment report; Waterline, 2025b), Waterline was asked to provide input on resiliency planning for Parksville's groundwater supply (Task 3) as the final component to the three-part hydrogeological scope of work.

### **1.2 Objectives and Scope of Work**

The objective of Task 3 was to help Parksville meet future community water demands, by improving their current groundwater supply and investigating new groundwater sources in the Englishman River watershed.

The scope of work completed for Task 3 included:

- Identifying opportunities for optimizing operation of Parksville's water supply wells (WSW);
- Identifying opportunities for enhancing groundwater supply from Aquifer 216; and
- Assessing new groundwater sources in the Englishman River watershed that could be developed by Parksville to increase their groundwater supply.

## **2.0 THE CITY OF PARKSVILLE'S GROUNDWATER SUPPLY**

### **2.1 Parksville's Current Groundwater Supply Status**

Parksville sources groundwater from Aquifer 216 via 16 WSWs, which are split between the Railway Station Well Field and the Springwood Well Field (Figure 1). The wells are operated in a responsible manner, generally maintaining a 30% buffer in available drawdown for seasonal fluctuations. There are some exceptions during periods of peak use, when groundwater levels draw down below the 70% of available head threshold level for the WSWs, but only for short durations. Long-term groundwater level trends for Aquifer 216 near Parksville's well fields are stable to increasing, indicating the local aquifer stress rating could be considered moderate to low, based

on the WSP Canada Inc (WSP) rating scale (WSP, 2023). This is confirmed by groundwater level trends at provincial observation well (OW) 398, located approximately 220 metres (m) east of the Railway Station Well Field, and OW 304, located within the Railway Station Well Field and approximately 160 m east of the Springwood Well Field (Figure 1).

Parksville's groundwater use data supports the observed short-term and long-term groundwater level trends. The 10-year average groundwater production from the WSWs is 2,579 cubic metres per day ( $\text{m}^3/\text{day}$ ; see Table 3 of Waterline, 2025b), which is below the *Water Sustainability Act* (WSA) existing use groundwater licence application diversion volume for combined use from the Railway Station and Springwood Well Fields (3,298  $\text{m}^3/\text{day}$ ; see Table 3 of Waterline, 2025b). It should be noted that the diversion rates applied for are based on Parksville's 2014 and 2016 annual diversion volumes for the Railway Station Wells and the Springwood Wells, respectively (Waterline, 2025a). Well capacity testing has not been done since commissioning for most WSWs (well commissioning dates range from 1977 to 2008; see Table 3 of Waterline, 2025a) to determine if Parksville's existing (historic) groundwater diversion rates are still achievable and are sustainable for the long-term. Additionally, analysis of well interference to assess maximum well field capacity has not been conducted for either well field.

Average groundwater use over the past five years (2,132  $\text{m}^3/\text{day}$ ; see Table 3 of Waterline, 2025b) is lower than the 10-year average (2,579  $\text{m}^3/\text{day}$ ) due to construction of Parksville's new Water treatment plant, which allowed for additional surface water to be treated, reducing the reliance on groundwater (B. Silenieks [Parksville Utilities Technician], personal communication, February 19, 2025). Groundwater diversion has some seasonality, as approximately 42 to 46% of annual groundwater diversion occurs during the four-month summer period (33% of the year) from June 1 to September 30 (see Table 4 of Waterline, 2025b).

Parksville's performance monitoring program, which includes collection of active WSWs' groundwater levels and groundwater use data via their Supervisory Control and Data Acquisition (SCADA) system and sampling of raw groundwater from select WSWs annually, indicates that Railway Station and Springwood WSWs are currently in good condition and are providing high quality water. Although groundwater is "moderately hard" to "very hard", total dissolved solids (TDS) concentrations are low, indicating the water source is fresh and are showing no signs of saltwater intrusion; the closest WSW is approximately 1.7 kilometres (km) from the ocean (i.e., Parksville Bay).

## 2.2 Parksville's Future Groundwater Supply Potential

With Aquifer 216 assigned a "very high" stress rating by WSP (2023), additional groundwater development is considered limited. Furthermore, with the potential for reduced groundwater availability from Aquifer 216 due to climate change predictions, specifically longer and warmer summers, aquifer stress is expected to increase, potentially impacting Parksville's ability to rely on groundwater in the future. Despite predicted water conservation through reduced demand from agriculture land use (i.e., irrigation), the stress on Aquifer 216 is predicted to remain high (WSP, 2023).

At present, the stress rating assigned to Aquifer 216 only considers Parksville's 2021 annual average groundwater use (2,218 m<sup>3</sup>/day; WSP, 2023), which is below the WSA licence application volume (3,298 m<sup>3</sup>/day) and Parksville's 10-year average groundwater use (2,579 m<sup>3</sup>/day). Despite ongoing sustainable groundwater use by Parksville, additional modelling is required to confirm that the WSA licence application diversion volume can be achieved without negative impacts to adjacent users and the receiving environment. In comparing the WSA licence application volume to the 10-year average use, an additional 719 m<sup>3</sup>/day can be extracted from the active WSWs under the current application amount. This additional diversion would be significant for future groundwater supply planning, as it constitutes an increase in current groundwater use by 22%.

Furthermore, as has been documented by Waterline in the Task 1 and Task 2 reporting (Waterline, 2025a and 2025b), new groundwater development should be considered as part of groundwater supply planning. Several bedrock and unconsolidated sediment aquifers have been mapped across the Englishman River watershed. The potential for unmapped groundwater sources also exists within the permeable fluvial and glacial material documented near the South Englishman River sub-watershed (Russell and Benoit, 2016).

### **3.0 GROUNDWATER SUPPLY RESILIENCE PLANNING**

Considering the positive outlook on Parksville's current groundwater supply combined with some uncertainty of groundwater availability for future water use, despite the additional water capacity available via the existing use groundwater licence applications, Waterline suggests that Parksville consider the following groundwater supply planning opportunities to maintain groundwater availability for the community in the short- (<1-year) and medium-term (5-years).

#### **3.1 Performance Monitoring Program for Parksville's Well Fields**

With reduced operation at some WSWs, there is potential for changing well conditions (e.g., fouling), leading to reduced well efficiency. Conversely, the longer and more sustained operation of certain WSWs during the summer could be accelerating well fouling due to the lower operational water levels.

For continued safe operation of both the Railway Station and Springwood Well Fields, Parksville should continue detailed monitoring of groundwater diversion rates, groundwater levels, and water chemistry from the WSWs. As the monitoring program is already being implemented to provide ongoing assessment of aquifer and well conditions, the data should be reviewed regularly, to determine if well maintenance is needed, confirming that the WSWs are operating efficiently.

The performance monitoring program should include the following recommended tasks:

- Measure manual groundwater levels at each WSW to calibrate Parksville's SCADA system data. Manual water levels should be collected on a regular basis (e.g., semi-annually) to help identify where changes in water levels are unrelated to changing aquifer conditions (e.g. change in installation depth or calibration issue of the pressure transducer).

- Compile and review groundwater level and water use data from Parksville's SCADA system to monitor for changes in operational groundwater levels in the WSWs.
- Collect groundwater samples from active WSWs at a greater frequency than currently done (e.g., semi-annual sampling) to better understand seasonal changes in water quality and identify changes in well condition (e.g. well fouling). Parksville should collect key water quality parameters, including sulphate-reducing bacteria (SRB), iron-related bacteria (IRB), hardness, TDS, metals and total/dissolved organic carbon (Hanna, 2016). Detailed field chemistry parameters such as oxidation-reduction potential (ORP), dissolved oxygen (DO) and turbidity are also recommended.
- If changes in groundwater levels and/or groundwater chemistry are observed, assess if the observed changes are associated with well performance issues or aquifer conditions by comparing the data with nearby provincial observation wells.

### 3.2 Parksville Water Supply Well Optimization

For a more realistic understanding of well capacities, considering well performance issues and well interference, Parksville should complete well testing and maintenance programs, in the short- to medium-term, including:

- Perform step rate pumping tests at individual WSWs to assess current well efficiency as a baseline for future assessments and to document changes in efficiency from well yields calculated during well commissioning.
- Analyze the pumping responses from the step-rate tests using analytical modelling software such as AQTESOLV (HydroSOLVE, 2007), to assess well interference and impacts from pumping on adjacent groundwater users and other Parksville WSWs.
- Conduct well rehabilitation programs (if required) to mitigate performance loss, including physical and chemical treatments performed by a registered contractor(s).

The frequency of well testing leading to well rehabilitation varies by WSW and is dependant on the performance monitoring data (Hanna, 2016; see Section 3.1). A well ranking system can be developed to determine when an assessment of well conditions is needed including the following reactions:

- **Immediate Rehab** indicates that work should be performed immediately as WSW conditions have changed and are currently affecting well performance;
- **Plan Rehab** indicates work should be schedule in the next 6-months as WSW conditions are changing and will impact well performance; and
- **Monitor** indicates that work is not required currently as WSW conditions are not changing and or more data is required.



### 3.3 Parksville Wellfield Planning

As was completed for the Nanoose Bay WSWs, using the Nanoose Model (Golder, 2020) commissioned by the Regional District of Nanaimo (RDN), Parksville could run a variety of tailored updates and water use scenarios for Aquifer 216, using WSP's French Creek FEEFLOW 3D groundwater flow model (WSP, 2023). This would provide a more realistic understanding of Parksville's well field capacities based on suggested improvements and known data gaps in the model. The modelling updates and water use scenarios that could benefit Parksville's short- and medium-term assessment of groundwater availability include:

- Improved water budget calculation for Aquifer 216, which would provide a more realistic aquifer stress rating and understanding of groundwater availability. As very few existing or new use groundwater licences have been granted by the Ministry of Water, Land and Resource Stewardship (WLRS) for water diversion from Aquifer 216 (Waterline, 2025a), assessing the total groundwater diversion is challenging. Parksville should field verify that documented domestic and unknown groundwater users are in fact diverting groundwater (see Table 9 of Waterline, 2025a). Groundwater use for agricultural purposes (e.g. irrigation) could be confirmed through land use tracking (Figure 2) or metering, to assess domestic vs. non-domestic use.
- Using the updated model to assess how the Aquifer 216 stress rating changes for varying groundwater diversion volumes from Parksville's well fields (i.e., 5-year and 10-year averages and the WSA licence application amount). The current model is calibrated for the 2021 annual average diversion volume and does not consider the 10-year average or the WSA licence application amount. Results from the assessment of aquifer stress would help confirm future reliance on groundwater as a sustainable water supply.
- Using the updated model to assess how the Aquifer 216 stress rating responds to changes in groundwater diversion by adjacent users. If existing groundwater use is repurposed for municipal water supply or existing users cease operations (Figure 2), how would this boost water availability for Parksville. Potentially, wells that are no longer in operation by their current user(s) could be connected to Parksville's water distribution system.
- 

### 3.4 New Groundwater Source Development

Due to the many groundwater sources available near Parksville in the Englishman River watershed, only groundwater sources with low to moderate aquifer stress ratings and aquifers with reliable productivity should be targeted for new development in the medium-term. Consideration should also be given to unmapped groundwater sources in undeveloped areas. Options for such groundwater sources are highlighted on Figure 3 and include:

1. Aquifer 221 (unconsolidated, unconfined), within Parksville's municipal boundary;
2. Aquifer 1252 (unconsolidated, unconfined), located south of Parksville; and
3. An unmapped sand and gravel aquifer in the South Englishman River sub-watershed.

### 3.4.1 Groundwater Source Evaluation and Ranking

To determine which of the three identified groundwater sources in the Englishman River watershed could best serve as Parksville’s new groundwater source, a preliminary source evaluation and ranking was completed. Five evaluation categories were selected based on standard groundwater development requirements and are outlined in Table 1. Each evaluation category was assigned a weighted ranking to align with Parksville’s groundwater supply planning priorities; the ranking total for the five categories equals 100%.

**Table 1: Selection Matrix – Evaluation Categories and Weighted Rankings**

| Category #   | Evaluation Category                     | Ranking %  |
|--------------|-----------------------------------------|------------|
| 1            | Available Data                          | 15         |
| 2            | Groundwater Supply & Environmental Risk | 35         |
| 3            | Groundwater Quality                     | 10         |
| 4            | Infrastructure Requirements             | 25         |
| 5            | Regulatory Requirements                 | 15         |
| <b>Total</b> |                                         | <b>100</b> |

**Notes:** % denotes percent.

Grades were assigned to each of the groundwater source options based on how each source met the evaluation category criteria. The grading system and grade definitions are provided in Table 2 transcribed from the British Columbia Public Service Agency (BC PSA, 2023).

**Table 2: Selection Matrix – Groundwater Source Option Grading System**

| Category Grade Option | Definition                                                                                                                                                                                                                                                                                  |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                     | <b>Very Poor</b> – Significantly below criteria required; no criteria met; many deficiencies.                                                                                                                                                                                               |
| 2                     | <b>Poor</b> – Generally does not meet criteria required; few criteria met; some deficiencies.                                                                                                                                                                                               |
| 3                     | <b>Good</b> – Meets criteria required; meets several of the major/essential/core criteria or one of two of the minor/additional criteria or acceptable equivalents; some of the major and minor criteria were met; some deficiencies exist in the areas assessed but none of major concern. |
| 4                     | <b>Very Good</b> – Generally exceeds criteria required; meets all the major/essential/core criteria or acceptable equivalents and several of the minor/additional criteria; no major deficiencies.                                                                                          |
| 5                     | <b>Excellent</b> – Significantly above criteria required; surpassed expectations; meets all major/essential/core criteria or acceptable equivalents and met three or more additional criteria.                                                                                              |

**Notes:** BC PSA, 2023.

An overall probability score was assigned to each groundwater source option, to determine which of the identified options has the highest probability for developing a groundwater source that could supplement Parksville's water supply to meet the community's water supply needs. The overall probability scores for each groundwater source option were calculated by multiplying each evaluation category ranking % (Table 1) by the corresponding category grade option (Table 2), adding these values together for each evaluation category, then dividing by the number of grades in the scoring system to achieve a score out of 100%; the formula is included below:

$$S = ((R_n * G_n) + (R_n * G_n) \dots) / V$$

Where: S = groundwater source option probability score  
R = evaluation category ranking (%)  
G = groundwater source category grade option  
n = evaluation category number  
V = number of grades in scoring system

The highest score represents the best probability for developing a groundwater source.

### **3.4.2 Results of the Preliminary Groundwater Source Evaluation**

Results of the preliminary Englishman River watershed groundwater source evaluation for Parksville's groundwater supply planning are summarized below in Table 3.

Table 3: Preliminary Evaluation of the Englishman River Watershed Groundwater Sources

| Evaluation Category                                                                                                                                                                                                                                                                                                                                                                                                               |                                           |                                                                  |           | Groundwater Source Options                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|------------------------------------------------------------------|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| Number                                                                                                                                                                                                                                                                                                                                                                                                                            | Description                               | Sub-Category                                                     | Ranking % | Aquifer 221                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Aquifer 1252                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Unmapped Sand and Gravel Aquifer in the South Englishman River Sub-watershed                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  |
| 1                                                                                                                                                                                                                                                                                                                                                                                                                                 | Data                                      | Data availability                                                | 15        | • Provincially mapped aquifer registered in GWELLS (ENV, 2025a).<br>• 29 wells correlated to Aquifer 221 and 40 registered groundwater wells correlated to Aquifer 1252.<br>• Aquifer stress and groundwater use scenarios completed by Golder (2020) and WSP (2023); however, groundwater level trends are not being monitored, and the groundwater numerical modelling is incomplete.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | • BC Geologic Survey - Surficial geology mapping (1:20,000 Scale).<br>• Geologic Survey of Canada - Surficial geology mapping (1:50,000 Scale).<br>• No registered groundwater wells in GWELLS (ENV, 2025a).                                                                                                                                                                                                                                                                                                                                                                                  |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                           | Data confidence                                                  |           | High                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Low                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                           | Grade                                                            |           | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                 | Groundwater Supply and Environmental Risk | Aquifer characteristics                                          | 35        | <b>Aquifer Type:</b> Unconsolidated (sand and gravel), unconfined.<br><b>Aquifer Thickness:</b> Variable, mapping suggests permeable material (fluvial) could be 10 m thick.<br><b>Vulnerability:</b> High, little to no confining layer above the permeable sediments to provide a barrier to surface contaminants.<br><b>Saltwater Intrusion:</b> High, the aquifer is adjacent the ocean. A gradient reversal from groundwater withdrawal could result in saltwater intrusion.<br><b>Climate Change Resiliency:</b> Moderate, known hydraulic connection to the Englishman River (gaining conditions). Recharge predominantly from surface water.                                                                                                                                                                                                                                                                                                                          | <b>Aquifer Type:</b> Unconsolidated (sand and gravel), unconfined.<br><b>Aquifer Thickness:</b> Variable, mapping suggests permeable material (glacial outwash) could be 2 to 12 m thick.<br><b>Vulnerability:</b> Moderate to High, groundwater level near surface.<br><b>Saltwater Intrusion:</b> Low, surficial sediments are above sea level, not connected with the ocean.<br><b>Climate Change Resiliency:</b> Moderate-Low, possible hydraulic connection to Morison Creek (loosing conditions). Recharge predominantly from precipitation and overland flow. | <b>Aquifer Type:</b> Unconsolidated (sand and gravel), confined or unconfined.<br><b>Aquifer Thickness:</b> Variable, mapping suggests permeable material (glaciofluvial) could be 2 to 50 m thick.<br><b>Vulnerability:</b> Unknown, possible confining layer above the permeable sediments, providing a barrier to surface contaminants.<br><b>Saltwater Intrusion:</b> Low, surficial sediments are above sea level, not connected with the ocean.<br><b>Climate Change Resiliency:</b> Moderate to high, permeable sediments could be confined providing a buffer to low summer recharge. |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                           | Groundwater productivity (water availability and sustainability) |           | • Average well yield is 109 m³/d.<br>• If developed, this groundwater source would have the potential to supplement Parksville's current groundwater supply capacity with several (<10) new WSWs.<br>• Water availability dependant on environmental flow needs and surface water withdrawals by Parksville, suggesting new development could be limited.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | • Average well yield is 54 m³/d.<br>• If developed, this groundwater source would require extensive development (>10 new WSWs) to supplement Parksville's current groundwater supply capacity. Given the small aquifer footprint (5.4 km²), this would be challenging.<br>• Potential impact to existing users from future groundwater development but there is no waterworks or commercial use documented at this time.                                                                                                                                             | • Groundwater sustainability unknown as there are no groundwater wells completed in the immediate area. The closest registered well, Well Tag Number 117630 (~500 m away), has a well yield of 109 m³/day.<br>• If developed, this groundwater source would have the potential to supplement Parksville's current groundwater supply capacity with several (<10) new WSWs.<br>• Low impact to existing users from future groundwater development.                                                                                                                                             |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                           | Grade                                                            | 2         | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |
| 3                                                                                                                                                                                                                                                                                                                                                                                                                                 | Groundwater Quality                       | Meets drinking water standards                                   | 10        | Unknown. There are no environmental monitoring locations registered in EnMoDS (ENV, 2025b); however, groundwater is expected to be fresh based on aquifer recharge characteristics.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                           | Grade                                                            |           | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  |
| 4                                                                                                                                                                                                                                                                                                                                                                                                                                 | Infrastructure Requirements               | Well drilling and testing                                        | 25        | • Well drilling and testing (24- to 48-hour constant rate test) would be required for all three groundwater source options.<br>• As more than one new WSW will be needed to meet future water demands, well interference calculations (radius of influence) should be performed to minimize impacts to existing users and maximize groundwater output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                           | Water system upgrades (distribution piping)                      |           | Parksville's existing water distribution system would be easily accessible for tie-in of new groundwater infrastructure, including access to Parksville's water treatment facility.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Groundwater will need to be conveyed to Parksville, requiring significant water distribution infrastructure upgrades. Assuming the groundwater is not treated, the raw groundwater would need to be conveyed to Parksville's water treatment facility. Specifically, water conveyance from the South Englishman River sub-watershed would pose additional challenges due to potential river crossings.                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                           | Grade                                                            |           | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  |
| 5                                                                                                                                                                                                                                                                                                                                                                                                                                 | Regulatory Requirements                   | Island Health water system permitting                            | 15        | Any new point of diversion added to Parksville's existing water system will require a construction permit and an update to the existing Permit to Operate (Government of BC, 2018). Source approval will be required in accordance with the <i>Guidance Document for Determining Groundwater at Risk of Containing Pathogens</i> (MoH, 2017).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                           | WSA licensing                                                    |           | A new use groundwater licence will be required, including a full technical assessment (Todd et al., 2020). The licence application submission, including a referrals process and potential archaeological study could take 2+ years. Licensing considerations include if an aquifer is hydraulically connected to a surface water body that has a registered water allocation notation, such as the Englishman River and its tributaries (WLRS, 2025).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                           | Land use authorizations                                          |           | • If new infrastructure is located on municipal lands only and ties into existing infrastructure, no land use authorizations are required. Tie-ins to existing municipal infrastructure will not require new land authorization, but existing authorizations may require updates.<br>• If new infrastructure will be located on:<br>1) Federal Crown Land (National Park Reserve), land use and construction authorization may be required.<br>2) First Nations Reserve Land, a federal crown land use authorization may be required. Consultation and terms negotiation with the First Nations council or individuals may be required.<br>3) Provincial Crown Land, a PCL/Crown Land Tenure may be required. Land use applications include a consultation and referrals phase. If new infrastructure will occur within a public road allowance and/or cross public road(s), a MOTT authorization may be required.<br>4) Private Land, the landowner must authorize land use. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                           | Grade                                                            |           | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  |
| Probability Score                                                                                                                                                                                                                                                                                                                                                                                                                 |                                           |                                                                  | 100       | 64                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 71                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 54                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  |
| <b>Notes:</b> EnMoDS denotes Environmental Monitoring Data System; Golder denotes Golder Associates Inc.; GWELLS denotes BC Groundwater Wells and Aquifers database; km² denotes square kilometres; m denotes metres; m³/day denotes cubic metres per day; MOTT denotes Ministry of Transportation and Transit; PCL denotes provincial crown land; WSP denotes WSP Canada Inc.; WSW denotes water supply well; % denotes percent. |                                           |                                                                  |           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |



### 3.4.3 Probability of Groundwater Source Development

From the preliminary evaluation of groundwater source options in the Englishman River watershed, the probability of developing:

1. The unmapped sand and gravel aquifer in the South Englishman River sub-watershed is **“unlikely”**. Although the unconsolidated sediment (fluvial and glaciofluvial) has a high groundwater supply potential, low vulnerability from existing development and groundwater chemistry is considered “fresh”, there are no groundwater wells completed in the immediate area to assess groundwater characteristics or water supply development. The water supply infrastructure requirements needed to connect new WSWs to Parksville’s existing water system would be substantial given the distant to the nearest point of connection. Parksville would also need to invest substantial time and resources towards meeting the necessary regulatory requirements (e.g., multiple different land use authorizations may be required and determination of hydraulic connection with the Englishman River and/or its tributaries would be required).
2. Aquifer 221 or Aquifer 1252 is **“possible”**. Despite some risks related to incomplete modelling, aquifer vulnerability, potential impacts to adjacent groundwater users and probable hydraulic connection with surface water, both aquifers have proven water supply potential. While groundwater source development of either aquifer would require well drilling and testing, a large investment would be needed to connect Aquifer 1252 with Parksville infrastructure. The probability of successfully developing Aquifer 1252 is higher than Aquifer 221, as the perceived regulatory requirements for assessing environmental impacts would be less stringent (e.g., Aquifer 1252 is situated in an area of less land development with less potential for contamination from current land use practices) and the likelihood of obtaining regulatory authorizations could be easier (e.g., WSA licensing for Aquifer 1252 would not involve assessment of potential saltwater intrusion).

### 3.4.4 Data Gaps

The following data gaps have been identified through Waterline’s assessment that should be resolved prior to finalizing the groundwater source evaluation:

- Complete the modelling of Aquifer 221 (Golder, 2020) and Aquifer 1252 (WSP, 2023) to provide a more realistic assessment of groundwater availability. Currently, the models provide an incomplete assessment of groundwater-surface water interaction and do not consider the full aquifer extent.
- Characterization of the groundwater quality for all three groundwater source options. Water quality sampling and discussion with local users could easily be completed to confirm that each groundwater source is fresh.

## 4.0 GROUNDWATER RESILIENCE PLANNING EXECUTION

Execution of the groundwater supply opportunities (i.e., Phase 2) will involve careful planning and support from the RDN. Parksville should also assess if ongoing groundwater supply investigations by the RDN near the Englishman River watershed (e.g., aquifer storage and recovery in Nanoose) can be beneficial to their community water supply.

A summary of the four groundwater supply planning opportunities, details for execution, timelines and costs are summarized in Table 4. Costs to complete the necessary execution plan tasks are preliminary, considered a Class D estimate (+/- 50%), and should only be used as a broad indication of project costs.

**Table 4: Groundwater Supply Planning Execution Plan**

| Opportunity                                         | Execution Plan Tasks                                                                                                                                                                                                                                                                                                                                                             | Timeline  | Cost                  |
|-----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------------------|
| Performance Monitoring for Parksville's Well Fields | Monitoring the Railway Station and Springwood Well Fields would be a continuation of ongoing work by Parksville. Historical data has already been compiled and is available for quick comparison with new groundwater level, use and chemistry data, for assessment of well conditions and operations. Recommended modifications to the monitoring program could be implemented. | Immediate | \$30-50k (Annual)     |
| Parksville Water Supply Optimization                | Performing step rate pumping tests for individual WSWs could be completed using existing well infrastructure with support from Parksville's Utilities Technician. The data would be analyzed to support well rehabilitations, if required, and to confirm potential impact from well interference.                                                                               | Immediate | \$40k (Lump Sum)      |
| Parksville Wellfield Planning                       | Groundwater modelling updates and new scenario for Aquifer 216 could be done using the French Creek water budget (WSP, 2023) calibrated groundwater numerical model to verify groundwater use predictions.                                                                                                                                                                       | Immediate | \$60-80k (Lump Sum)   |
| New Groundwater Source Development                  | To better predict stress for Aquifer 221 (Golder, 2020) and Aquifer 1252 (WSP, 2023), the Leapfrog geology model, which is the basis for the groundwater numerical models, will need to be updated. Model calibration and sensitivity analysis are required.                                                                                                                     | Immediate | \$50-100k (Lump Sum)  |
|                                                     | To assess the groundwater quality of Aquifer 221, Aquifer 1252 and the Unmapped Sand and Gravel Aquifer in the South Englishman River Sub-watershed, three water quality samples should be collected from each groundwater source. If sample collection points (wells) are unavailable, analogue well locations can be selected.                                                 | 1-year    | \$15k (Lump Sum)      |
|                                                     | Drilling and testing a new well will be required for assessment of aquifer characteristics and determination of well capacity.                                                                                                                                                                                                                                                   | 1-year    | \$100-150k (Lump Sum) |
|                                                     | Authorizations for groundwater use may need to be obtained from multiple levels of government (local, provincial, federal) and from private landowners. Technical assessment(s) will be required to support the WSA water licensing process.                                                                                                                                     | 2-years   | \$50-75k (Lump Sum)   |
|                                                     | Designing, permitting and constructing water system infrastructure to connect new WSW(s) to Parksville's current water distribution system would be multi-disciplinary.                                                                                                                                                                                                          | >2-years  | Unknown               |

**Notes:** WSW means water supply well; WSA means Water Sustainability Act.

## 5.0 CERTIFICATION

This document was prepared under the direction of a professional geoscientist registered in the Province of British Columbia.

Waterline Resources Inc. trusts that the information provided in this document is sufficient for your requirements. Should you have any questions or concerns, please do not hesitate to contact the undersigned.

Respectfully submitted,

**Waterline Resources Inc.**  
**EGBC Permit No. 1000669**

**Reviewed By:**



Simon Wing, B.Sc., P. Geo.  
Senior Hydrogeologist

Andrew Hinnell, Ph.D., P. Geo  
Principal Hydrogeologist

Steph Righi, B.NRP, RBTech  
Regulatory Specialist

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## **7.0 LIMITATIONS AND USE**

The information presented in this document was compiled exclusively for Kerr Wood Leidal Consulting Engineers (KWL; the Client) and the City of Parksville by Waterline Resources Inc. (Waterline). This work was completed in accordance with the scope of work for this project that was agreed between Waterline and the Client. Waterline exercised reasonable skill, care and diligence to assess the information acquired during the preparation of this document but makes no guarantees or warranties as to the accuracy or completeness of this information. The information contained in this document is based upon, and limited by, the circumstances and conditions acknowledged herein, and upon information available at the time of the preparation of this document. Any information provided by others is believed to be accurate but cannot be guaranteed. No other warranty, expressed or implied, is made as to the professional services provided to the Client.

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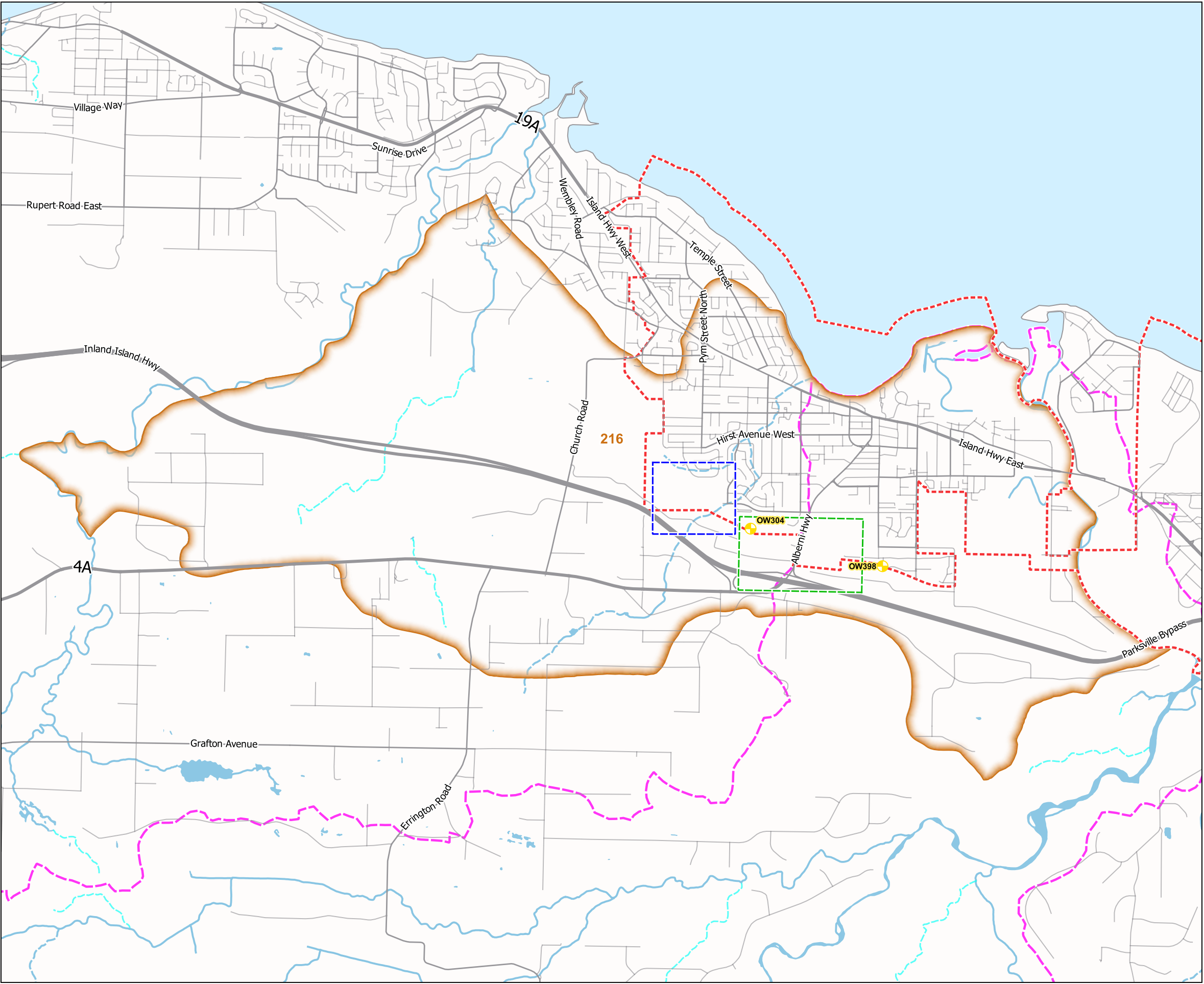
## **Figures**

**Figure 1: Aquifer 216 – Parksville’s Groundwater Source**

**Figure 2: Local Land Use and Registered Wells Within Aquifer 216**

**Figure 3: New Groundwater Source Options in the Englishman River Watershed**

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- Provincial Observation Well
- River/Stream - Definite
- River/Stream - Indefinite
- River/Stream - Intermittent
- Road - Expressway / Highway
- Road - Arterial / Collector
- Road
- Springwood Well Field
- Railway Station Well Field
- Englishman River Watershed
- Parkville Municipal Boundary
- Aquifer 216: Surficial Confined



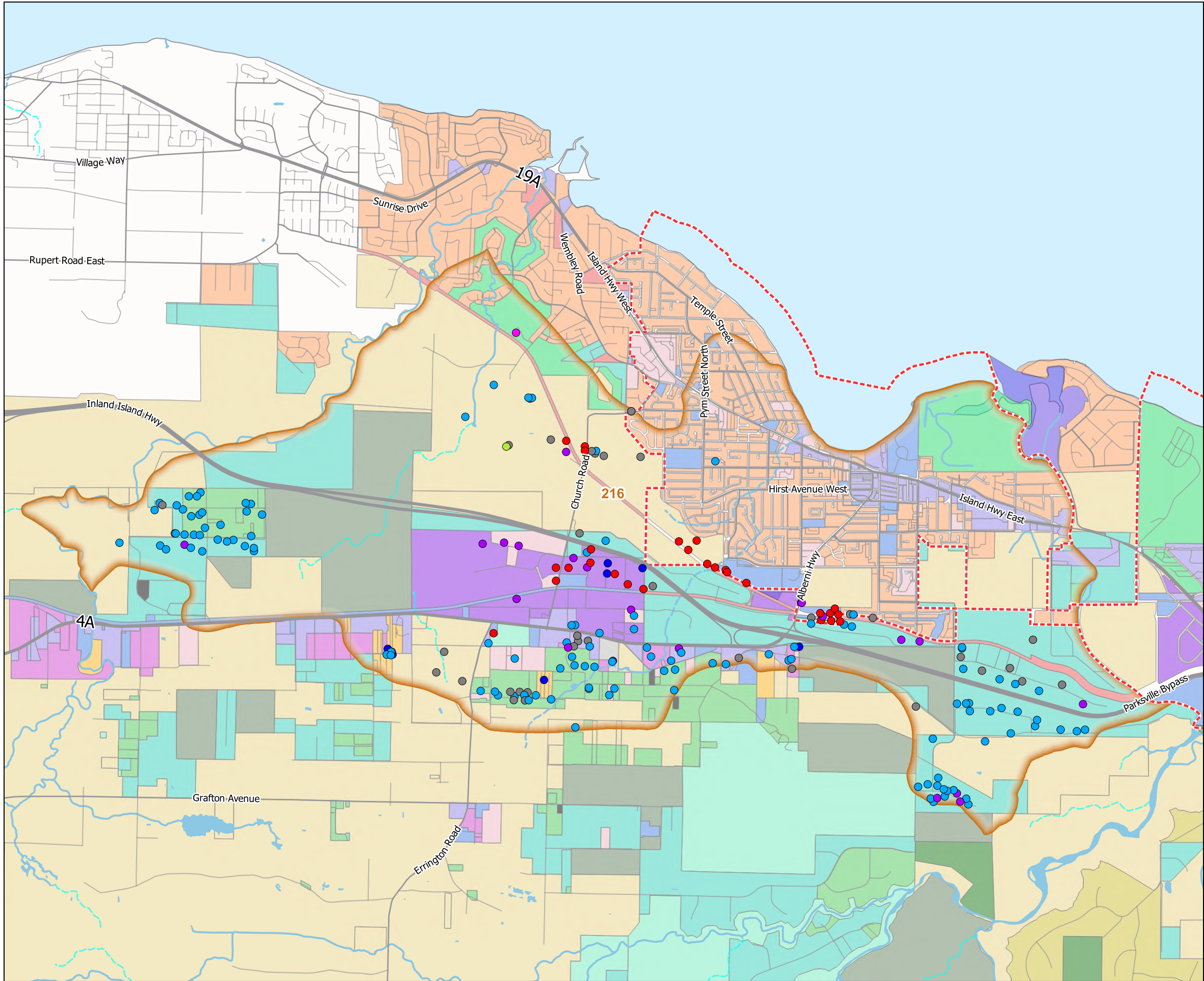
References:  
Fresh Water Atlas (2017), National Road Network (2016),  
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|                                                                                                                                              |                                       |          |
|----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|----------|
| Task 3 – Groundwater Supply Resilience Planning<br>City of Parkville, British Columbia<br>Submitted to Kerr Wood Leidal Consulting Engineers |                                       |          |
| AQUIFER 216 – PARKVILLE’S<br>GROUNDWATER SOURCE                                                                                              |                                       |          |
|                                                                                                                                              | Prepared By: Waterline Resources Inc. | FIGURE 1 |
|                                                                                                                                              | Project Number: 3917-24-001           |          |
|                                                                                                                                              | Compiled By: mwine                    |          |
|                                                                                                                                              | Date Issued: 2025-Sep-16              |          |
| Date Revised: --                                                                                                                             |                                       |          |

Coordinate System: NAD83(CSRS) / UTM zone 10N



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Registered Well - Use Type

- Domestic
- Water Works
- Water Supply System
- Golf Course
- Commercial & Industrial
- Irrigation
- Unknown

River/Stream - Definite

River/Stream - Indefinite

River/Stream - Intermittent

Road - Expressway / Highway

Road - Arterial / Collector

Road

Parkville Municipal Boundary

Aquifer 216: Surficial Confined

Land Use Zoning

- Agriculture
- Commercial
- Comprehensive Development
- Industrial
- Institutional/Community Facility
- Manufactured Home Park
- Parks and Open Space
- Recreation
- Public
- Residential
- Resort Commercial Zone
- Forestry/Resource 1
- Resource Management
- Rural
- Rural Residential
- Salvage and Wrecking
- Village Residential
- CD-18 Alberni Highway Mini Storage
- Conservation 1 Zone
- Englishman River (Block 564)

References:

Fresh Water Atlas (2017), National Road Network (2016),  
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the Open Government Licence - Canada

Task 3 – Groundwater Supply Resilience Planning  
City of Parkville, British Columbia  
Submitted to Kerr Wood Leidal Consulting Engineers

**LOCAL LAND USE AND REGISTERED  
WELLS WITHIN AQUIFER 216**

Prepared By: Waterline Resources Inc.

Project Number: 3917-24-001

Compiled By: mwine

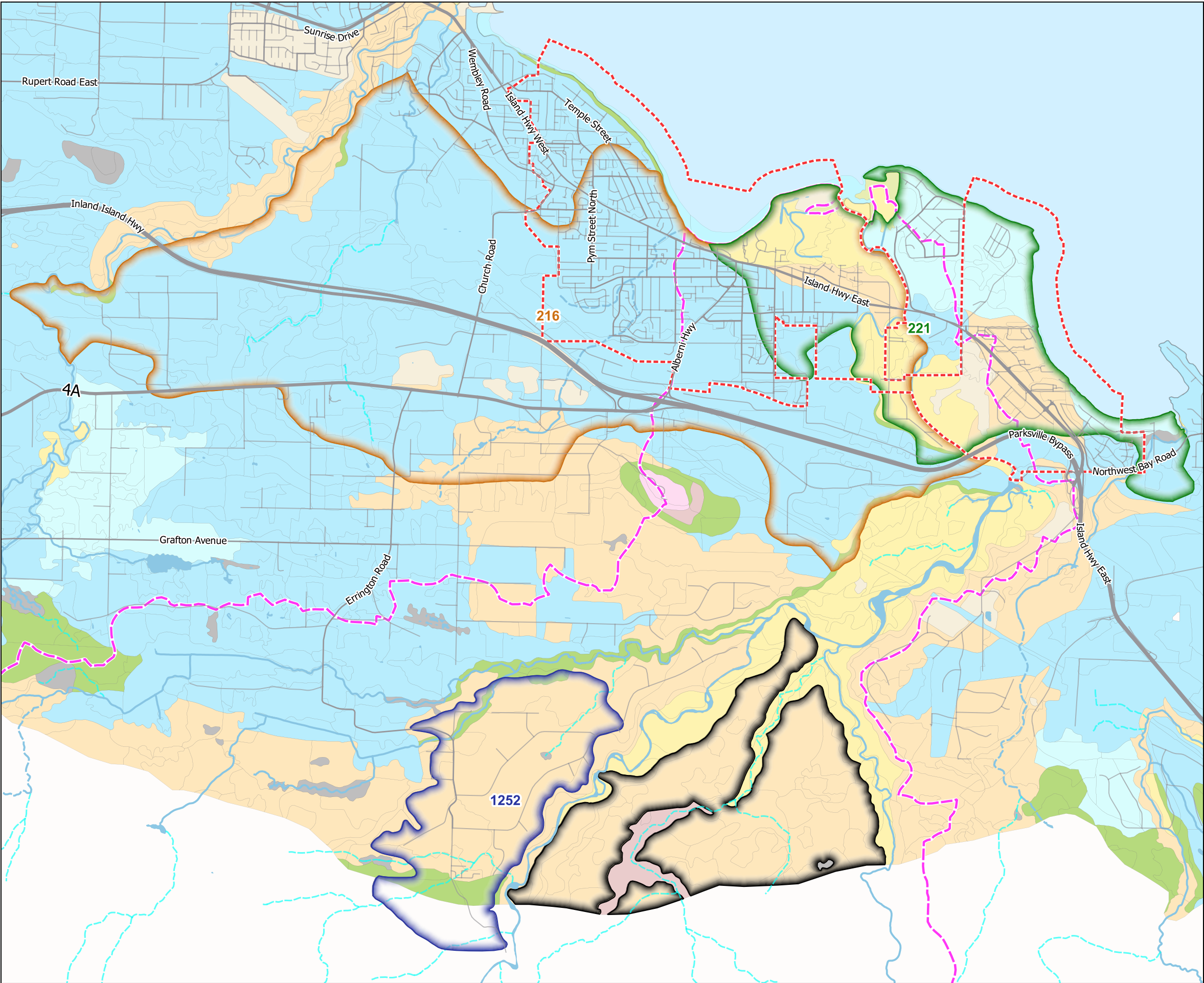
Date Issued: 2025-Sep-24

Date Revised: --

**FIGURE 2**



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- River/Stream - Definite
- River/Stream - Indefinite
- River/Stream - Intermittent
- Road - Expressway / Highway
- Road - Arterial / Collector
- Road
- Englishman River Watershed
- Parksville Municipal Boundary
- Aquifer 216: Surficial Confined
- Aquifer 221: Surficial Unconfined
- Aquifer 1252: Surficial Unconfined
- Possible Unmapped Sand and Gravel Aquifer

- Surficial Geology
- Anthropogenic Material
  - Bedrock
  - Colluvium
  - Fluvial Material
  - Glaciofluvial Material
  - Glaciomarine Material
  - Marine Material
  - Morainal Material (till)
  - Not Classified
  - Organic Material

References:

Fresh Water Atlas (2017), National Road Network (2016),  
Contains information licensed under the Open Government Licence - British Columbia and  
the Open Government Licence - Canada

**Task 3 – Groundwater Supply Resilience Planning**  
**City of Parksville, British Columbia**  
**Submitted to Kerr Wood Leidal Consulting Engineers**

**NEW GROUNDWATER SOURCE OPTIONS**  
**IN THE ENGLISHMAN RIVER WATERSHED**

Prepared By: Waterline Resources Inc.  
Project Number: 3917-24-001  
Compiled By: mwine  
Date Issued: 2026-Jan-19  
Date Revised: --

**FIGURE 3**

Coordinate System: NAD83(CSRS) / UTM zone 10N

## Appendix E

# Climate Change and Hydrology Assessment

## Appendix E: Climate Change and Hydrology Assessment

### Climate Change and Hydrology Assessment

The International Panel on Climate Change (IPCC) has stated that global climate records and modelling indicate warming of the global climate system is unequivocal (IPCC, 2013). Evidence of the warming can be found in increased observed temperatures, widespread melting of snow and ice, and increased sea levels. In order to better understand how to adapt to these changes in the study area, a review of past trends and future projections for the region is required.

In addition to climate change, defined as the long-term trends in climate, climate variability is defined as shorter-term annual or decadal cycles in climate and can also play an important role in the hydrological regime of a region. Climate variability is impacted by phenomena such as the El Niño Southern Oscillation (ENSO), and the Pacific Decadal Oscillation (PDO) which are driven by changes in sea surface temperatures and ocean currents (Miles, Mantua, & Mote, 1999). The ENSO can oscillate from cool phase to warm phase on an annual basis but often varies in two to three-year cycles. The PDO cycles between warm and cool phases about once in every 20 to 30 years. We may have recently shifted from a warm to cool PDO phase, which may have the effect of slowing warming trends in Southwestern BC for the next 20 to 30 years.

### Regional Projected Climate Change

To better understand the uncertainty of projected climate on water supply reliability an ensemble of climate models was used in the analysis. Weekly precipitation and temperature data (1950 - 2100) from six global circulation models (GCM), with two Shared Socioeconomic Pathway (SSP) scenarios each, from the 6<sup>th</sup> Coupled Model Intercomparison Project (CMIP6) were used in the analysis. The projected daily temperature and precipitation data for the grid cells covering the region were downloaded from the Pacific Climate Impacts Consortium (PCIC) (PCIC, 2021). The SSPs selected for analysis come from the IPCC 6<sup>th</sup> Assessment Report (AR6) and are SSP2, which represents a “middle of the road” future greenhouse gas (GHG) emission scenario that sees development continue as is, and SSP5, which represents a high fossil fuel development GHG scenario (IPCC, 2021). The six GCM models selected are considered to be representative of projected future climate change conditions in British Columbia and are included as part of PCICs regional climate data subsets of the CMIP6 ensemble (PCIC, 2023).

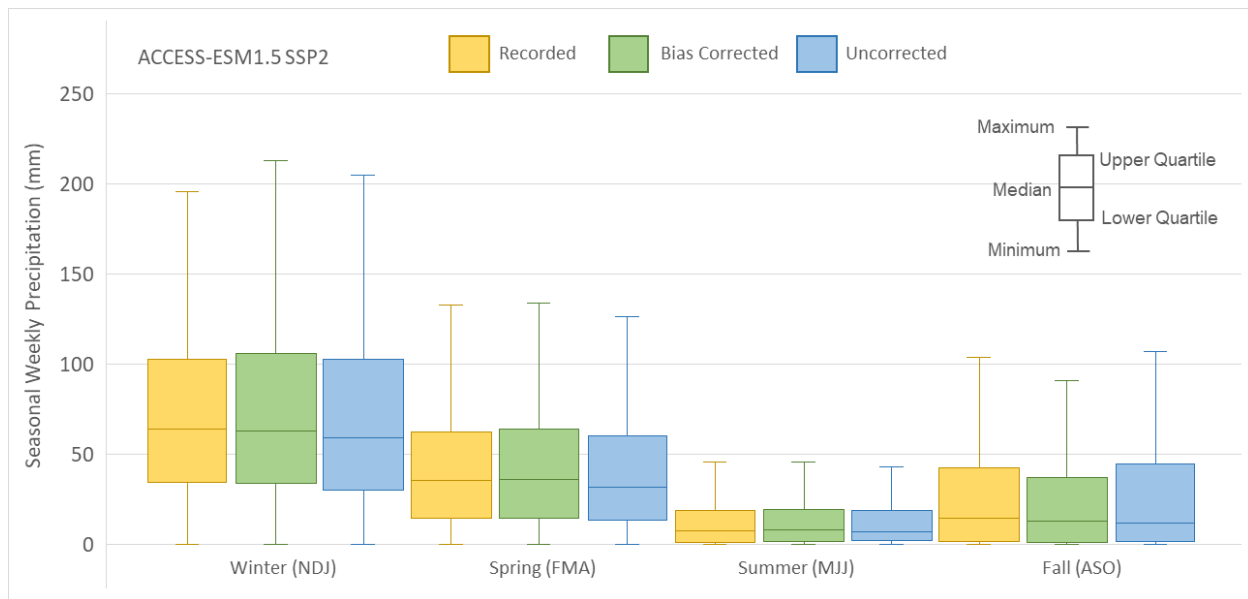
For the purpose of this analysis, the daily projected datasets from each of the twelve GCM/SSP pairings were converted to monthly time series for the period from 1977 - 2100.

### Bias Correction

A comparison of the precipitation GCM model output to the historical recorded dataset indicated that the climate projections appear to be overestimating precipitation for the region. Therefore, the climate model data was bias corrected using quantile mapping, with the historical climate data. The quantile mapping was completed for the 1981-2010 climate normal period.

The precipitation across the Englishman river basin exhibits strong seasonal pattern. As such, annual precipitation records are divided into four seasons: winter (November to January), spring (February to April), summer (May to July) and fall (August to October). Winter and spring are grouped as the non-operation period, and summer and fall are grouped together as the operation period. Precipitation percentiles were calculated for each weekly data point in the recorded and climate model datasets for the operation and non-operation period separately. Temperature percentiles were calculated on the annual basis.

Comparing the weekly data points of the same percentiles, a correction factor was calculated; for the precipitation, the correction factor was a percentage, and for temperature, the correction factor was an additive term. The future period of 2041 - 2100 was then corrected by calculating the percentiles of each monthly data point and applying the correction factor that corresponds to that percentile. It was assumed that the correction factors remain constant throughout the entire future period. Figure E-1 provides a comparison of the seasonal recorded, uncorrected, and corrected precipitation for the period 1981 - 2010, for one sample model (ACCESS-ESM1.5 SSP2).



**Figure E-1: Bias Correction of Seasonal Precipitation**

Like other regions in South-Western British Columbia, the climate forecasts for the study area indicate that:

- summers are likely to become warmer and drier; and
- winters are likely to become warmer and slightly wetter.

Climate projections for the 2050s and 2080s for the Englishman River across all climate models are shown in Figure E-2 and Figure E-3.

The regional forecasts based on the GCM output provide a reasonable estimate of future climate average conditions. However, extreme conditions, such as high-intensity rainfall events and prolonged dry periods, are not easily modelled using GCMs and are therefore not as well understood. Nevertheless, the general consensus is that both the intensity and frequency of large rainfall events and the length of dry periods are likely to increase (PCIC, 2013).



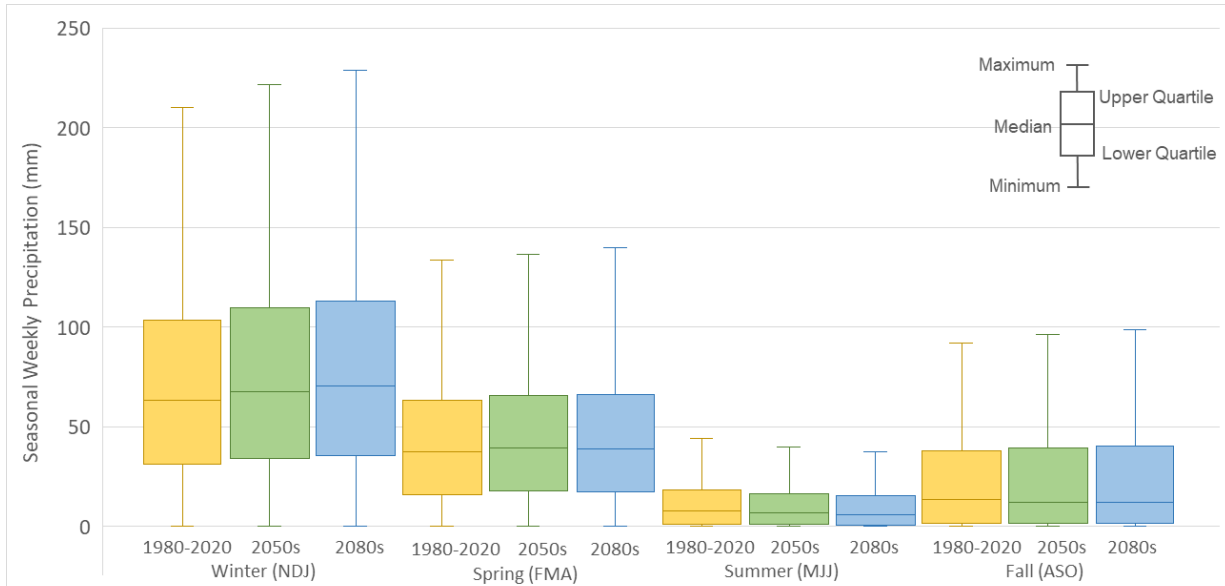


Figure E-2: Change in Seasonal Weekly Precipitation Across all Climate Models

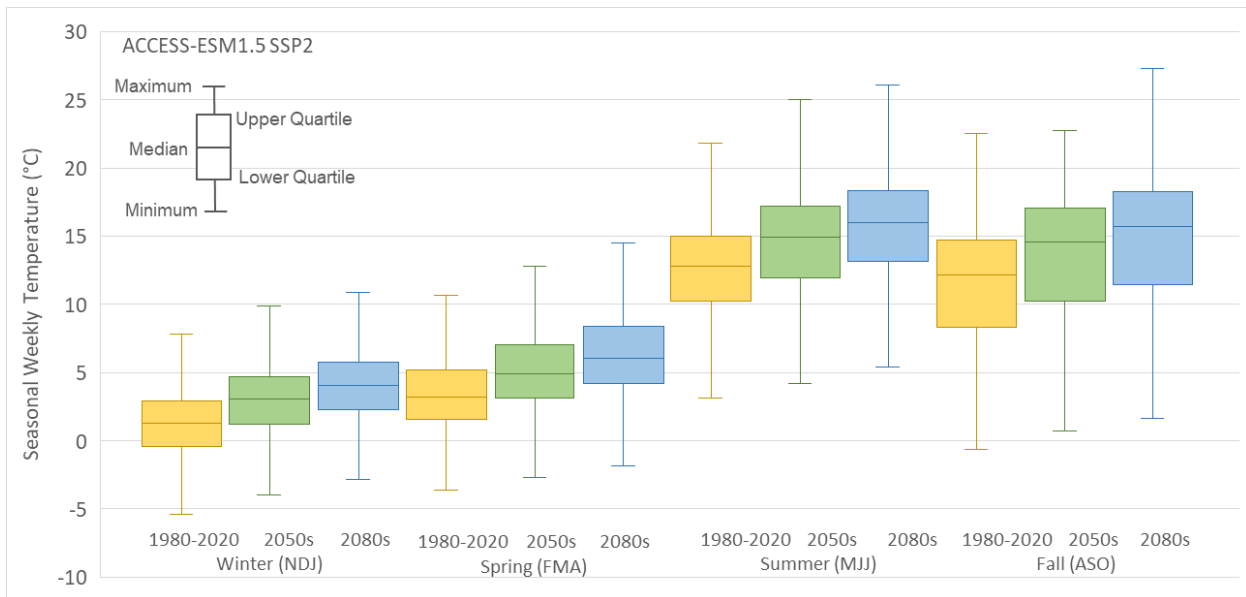


Figure E-3: Change in Seasonal Weekly Average Temperature Across all Climate Models

## Projected Changes in Englishman River Watershed Flow Regime

The average weekly lake net inflows for the Arrowsmith Lake and the English River baseflow were simulated using the calibrated hydrologic model for the projected 2050s and 2080s climate period using bias corrected PCIC projections. The projected continuous weekly record was used for the potential yield and storage analysis. The projected and historical flows (Lake inflow and Englishman River baseflow) using simulations from all GCM models are shown in Figure E-4 and Figure E-5.

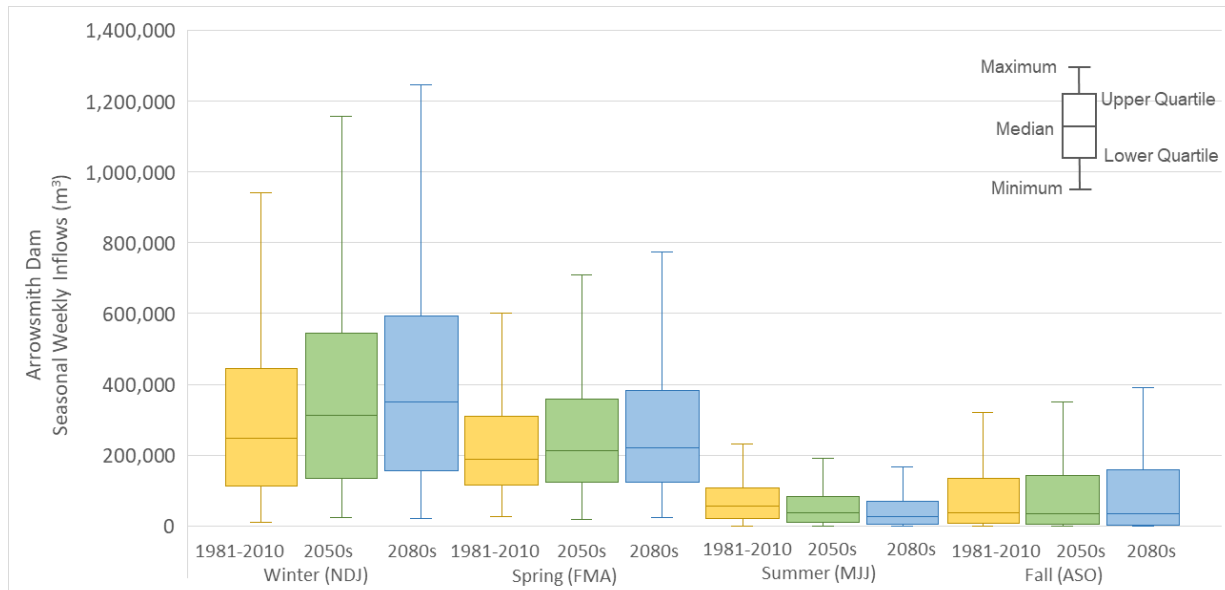


Figure E-4: Historical and Future Seasonal Weekly Inflows to the Arrowsmith Lake Dam

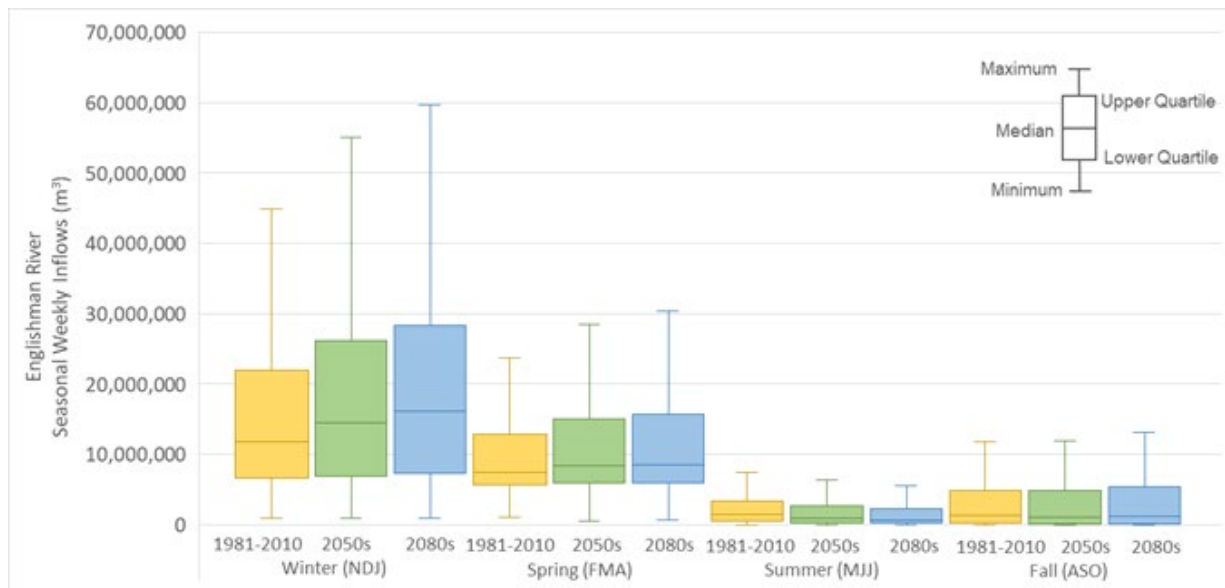


Figure E-5: Historical and Future Seasonal Weekly Baseflow of the English River Basin

## Appendix F

# Current Water Conservation Initiatives

## Appendix F: Current Demand Management Initiatives

### Outdoor Programs

The average water consumption for the cooler, wetter months of October-April more than doubles during the warmer, drier months of May-September and increases to over 3 times at its peak (Table F-1). The increase in summer water consumption is largely associated with lawn and garden irrigation.

MDD is typically the driver of the sizing and design of the systems' major infrastructure, the higher the peak, the larger the infrastructure required to support it. Therefore, shaving peak demand is a critical goal of the region's conservation programs. From June 1 to October 31, the City through AWS operates through an order from the Province, which regulates the flow release from the Arrowsmith Lake Reservoir. The provincial enabling order determines when water conservation levels will be implemented to ensure an adequate water supply for the Englishman River to support the EFN and residents of the City.

The focus of the region's outdoor programs is increased efficiency of water application to lawns and gardens, as opposed to reducing lawn area or planting climate appropriate landscaping. The following programs are currently supported.

### Watering Restrictions

Watering restrictions are the most common strategy employed by BC communities to reduce peak demands. In response to changing climatic conditions, the City developed a new outdoor water conservation framework, approved by Council in February 2025 through Water Service System Bylaw 1320. This framework aims to ensure a high-quality water supply for residents, firefighting, and fisheries while also aligning with the RDN's restrictions, providing a coordinated approach with regional water providers as well as clarity to customers.

The region's water conservation framework includes four levels of restrictions, effective from April 1 to October 31. These levels are designed to manage water demand during the hotter, dryer summer months:

- **Level 1:** Allows sprinkler and lawn watering between 7 pm and 7 am, any day of the week.
- **Level 2:** Limits sprinkler and lawn watering to even and odd days between 7 - 10 am or 7 - 10 pm for a maximum of 2 hours.
- **Level 3:** Restricts sprinkler and lawn watering to one day per week; odd-numbered houses on Monday and even-numbered houses on Thursday.
- **Level 4:** No sprinkler or lawn watering is permitted (effective during severe drought conditions).

Vegetable gardens and fruit trees are exempt from watering restrictions at all levels. Ornamental trees, shrubs and flowers may be watered using a container or hose fitted with a shutoff nozzle at any time under Stages 1-3, and between 7 and 10 am or between 7 and 10 pm under Stage 4.

Awareness is promoted on the RDN and City's websites and on social media. Residents can track the current status online through the watering restriction map. The City and RDN have ticketing bylaws that could be utilized if there are infractions.

Compliance with watering restrictions is monitored through complaints to the City and operator observation. The 2020 WCP suggested that enforcement effort may need to escalate with a small number of customers due to staff reporting of isolated but persistent problems with non-compliance.



## Irrigation Upgrades and Soil Improvements

The Irrigation Upgrades and Soil Improvements program, offered through the RDN, was created to help residents conserve water outdoors by enhancing the water efficiency of automated irrigation systems and/or by improving the water-holding capacity of soil through soil amendments. Up to \$875 per residential property is available to help offset the cost of landscape upgrades to improve water efficiency (Table F-1). Up. As of 2025, program eligibility has been extended to Stratas.

**Table F-1: Irrigation Upgrades and Soil Improvement Rebates**

| Category                    |                                                  | Maximum Rebate        |
|-----------------------------|--------------------------------------------------|-----------------------|
| Add a:                      | Smart Controller                                 | \$100                 |
|                             | Rain Sensor                                      | \$75                  |
| Convert to:                 | Drip Irrigation                                  | \$400                 |
|                             | Matched Precipitation (MP) Rotors                | \$100                 |
| Add:                        | Quality Topsoil, Compost, or Other Organic Mulch | 50% off (up to \$100) |
| Combine                     | Irrigation System Upgrades & Soil Amendment      | \$100                 |
| <b>Maximum Total Rebate</b> |                                                  | <b>\$875</b>          |

The 2020 WCP found that WSAs averaged 3.3 rebates per year, with the majority (about 70%) taken up in Nanoose Bay and that staff believe that greater uptake could occur with more resources and advertising.

## Rainwater Harvesting

Rainwater harvesting is the practice of collecting and storing rainwater for reuse, rather than allowing it to run off and be absorbed into the ground or channeled into drains. This method can contribute to water conservation by providing an alternative source of water for uses such as irrigation, toilet flushing, and laundry. Rainwater harvesting systems can range from simple rain barrels to more complex systems involving tanks, pumps, and filtration.

Residents of Parksville and Nanoose Bay are eligible to participate in the RDN's rainwater harvesting program which focuses only on larger systems (4,500 litres), which are more effective at buffering against drought and reducing reliance on potable supply. The program provides up to \$1,000 per household for the purchase and installation of a rainwater cistern. The program provides rebates up to \$700 for the cistern and up to \$300 is available for other eligible collection system expenses such as transport piping, debris traps, filters, and installation costs. The City also offers its own rain barrel rebate program in addition to that of the RDN, providing up to \$50 to residential customers.

The direct water savings from rainwater harvesting can be modest. A 4,500 L cistern can easily fill during the wet winter months but may be depleted within just 2 to 3 weeks of summer irrigation. Given the typically dry summer conditions in the region, the tank is unlikely to refill until after the irrigation season ends. Setting the minimum volume at 4,500 L ensures that at least that amount will be diverted, the smaller rain barrels offered by the City however have very limited water savings value.

The cost of installing a rainwater harvesting system can be significant. Expenses may include pouring a concrete pad, obtaining engineering approvals, and connecting electrical components for pumps or controls. For this reason, the greatest value may come from integrating rainwater systems with indoor non-potable uses (e.g., toilet flushing or laundry), though this approach introduces additional permitting requirements and potentially high costs

to install indoor non-potable water supply lines in an existing building. The cost of installing non-potable supply plumbing at the time of construction or major renovation is typically a negligible fraction of the total project cost.

The success of a rainwater harvesting program depends on implementation and the size of the cistern, and while the water savings may be limited, the program provides important co-benefits (Polis, 2013):

- Encourages behavioral change and conservation awareness
- Reduces stormwater runoff<sup>1</sup>
- Builds community resilience to drought

Between 2011 and 2020, 15 rebates were issued in the WSAs, averaging 1.7 per year, peaking in 2016 at five. About half of these were issued in Nanoose.

The RDN's Team WaterSmart invests significant resources in its education programs around rainwater harvesting; they've developed a comprehensive rainwater harvesting guidebook, offer workshops and promote the rebate with local vendors and businesses.

## Residential Irrigation System Check-Ups (discontinued)

RDN's Team WaterSmart had offered free irrigation system check-ups in the past targeting the top 100 users across the region. Between 2010 and 2020, Team WaterSmart had performed hundreds of residential irrigation system check-ups to encourage residents to get familiar with their own systems and operate them more efficiently. The 2020 WCP showed a spike in participation in early years, likely due to promotion of a pilot project in Nanoose at the outset of the program. Participation then leveled off to about five check ups per year, with staff availability as a primary limiting factor. Staff believed that there could be more uptake if additional resources were allocated and greater promotion were to occur. Most check ups (about 80%) took place in Nanoose.

The 2020 WCP called for increasing the number of checkups, setting expanded targets, and focusing on high seasonal users. However, the checkups were discontinued during COVID-19.

## Indoor Programs

The replacement of inefficient fixtures, particularly toilets and washing machines, has had the single largest impact of reducing indoor demands and decoupling urban demands and population growth. Toilet fixture replacement has long been a staple of the water industry's initiatives to reduce potable water consumption and probably the single biggest contributor to keeping demands steady as populations have increased. Thanks to the gradual natural replacement of older fixtures over time and any incentive programs, many homes now have high-efficiency models. With the BC Building Code mandating high-efficiency 4.8 Lpf toilets since 2012 for residential construction, all new installations must meet this standard, making most rebate programs susceptible to "free-rider" effects.

However, a study completed by Alliance for Water Efficiency in 2017 found that surprisingly high levels of inefficient toilet stock remain. While difficult to know exactly portion of the toilet stocks are using 13L or higher, we know that almost half of housing units were built before 1990<sup>2</sup> and we also know that 156 L/c/d base demand is relatively efficient. Given that, we can assume that between 10-20% of the remaining toilet stock are high use models, reflecting a significant enough number to target with fixture replacement measures.

The RDN does not currently offer any indoor fixture rebates.

<sup>1</sup> The system must be designed and operated to attenuate peak roof runoff flows to yield significant benefit for stormwater management.

<sup>2</sup> Regional Housing Needs Report, RDN 2020.

While non-residential water use is limited in the RDN, the WCP identified the need to expand the Team Watersmart campaign to new sectors. The plan specifically identified the potential for a Commercial, Institutional and Multi-Family Residential Pilot Project in Nanoose Bay and set a target date of 2023 to design and launch the pilot. The programs have not yet expanded to these sectors.

## Water Metering and Rates

### Water Metering

Each property connected to the City water system is equipped with a water meter (some City uses such as irrigation and fire flows are unmetered). These meters are read twice a year, in March and September, to monitor water usage and ensure accurate billing. Periodic meter tests are conducted to check for accuracy, and meters are replaced if they are found to be less than 98% accurate.

All properties in Nanoose Bay serviced by the ERWS are also metered. Single-family residential meters are read bi-annually while ICI and multi-family meters are read quarterly.

While universal metering is a significant strength, the absence of timely information limits the potential of the system. Bi-annual reads provide a very basic level of consumption data but limited ability to detect leaks, monitor peak demand, and engage customers to change behavior.

### Water and Sewer Rates

In 2013, the City revised the tiered billing rates for water use, and this includes both a fixed charge and a 4-tier increasing block rate volumetric charge and a 5<sup>th</sup> tier at a lower rate than the 3<sup>rd</sup>. Commercial users pay the same fixed fees as the residential users plus volumetric charge. Both residential and commercial customers also pay a base sewer fee as well as an “overconsumption” volumetric charge. Customers are billed twice a year.

The sanitary sewer rate structure is different than the water rate structure but is based on the metered water consumption. The residential and commercial sectors both pay the same fixed charge for 100 m<sup>3</sup> of sewage system use every six months. Any use of the system above 100 m<sup>3</sup> is charged a per cubic metre rate (0.9615/m<sup>3</sup> in 2025). The sewer volume amount is calculated on the user’s metered water consumption as meters are not installed on the sewerage system; residential users’ sewer bills are based on the lesser of their winter and summer water consumption.

RDN, which also bills bi-annually, amended its system of tiered rates for water usage, starting with the 2023 water bills. It now has a three-tiered, volumetric water user fee rate structure for all its WSAs. Sewer rates are a fixed annual fee. The water conservation plan indicates that the RDN will conduct a review of water rates to, among other reasons, explore whether rates and the rate structure can be further optimized to encourage conservation and reduce peak demand.

Conservation rates are an important and effective demand management measure. Customer-side leakage and outdoor water use are more influenced by price signals than are less discretionary indoor uses. While metering and volumetric billing certainly has value in promoting efficiency, bi-annual billing poses several challenges to water efficiency:

**Delayed Detection of Leaks:** With bi-annual billing, leaks may go undetected for months, leading to significant water loss before corrective actions are taken.

**Limited Usage Feedback:** Residents receive feedback on their water usage infrequently, making it harder for them to adjust their consumption habits promptly.

**Lagging Resource Management:** The long intervals between meter readings can hinder the City's ability to manage water resources effectively and respond to changing conditions.

To improve water efficiency, more frequent meter readings and billing cycles are typically recommended. Monthly or quarterly billing provides timely feedback to residents, enabling quicker detection of leaks and more responsive adjustments to water usage.

## Water Loss

The difference between water production and metered use (non-revenue water) averaged 15% of total production in both the City and Nanoose Bay between 2020 and 2024. Non-revenue water includes water used by the City and RDN but not metered (e.g. parks/boulevards watering, fire flows, etc.) Based on the City's annual reports, it seems that most efforts on water loss in Parksville are focused on reactive response to main breaks and leaks that surface above ground, often reported by residents.

At a regional level, the 2020 WCP notes that there is increasing awareness within RDN of opportunities to improve NRW management. The WCP made some preliminary recommendations on water use accounting and NRW management procedures that included examining unexpected variations in production as well as challenges in data accounting, and noted high averages in a number of WSAs, including Nanoose Bay.

## Education and Support

Education and support programs are vital components of effective water conservation initiatives. These programs play a crucial role in raising awareness, fostering community engagement, and promoting sustainable water use practices. By educating residents about the importance of water conservation and providing them with the tools and knowledge to implement water-saving measures, these programs help to create a culture of conservation within the community. While it is difficult to quantify the water savings or cost-effectiveness associated these types of programs, they can be critical to the success of the overall efforts by supporting and facilitating participation in all other program initiatives. Key benefits include:

**Increased Awareness:** Educational programs inform residents about the impact of water scarcity and the importance of conserving water. This heightened awareness encourages individuals to adopt water-saving behaviors in their daily lives.

**Empowerment:** Support programs provide residents with practical tips, resources, and incentives to reduce water usage. This empowerment leads to more proactive and informed decisions regarding water consumption.

**Community Engagement:** By involving the community in conservation efforts through workshops, school programs, and events, these initiatives foster a sense of collective responsibility and cooperation.

**Long-Term Sustainability:** Education and support programs help to instill sustainable water use practices that can be maintained over the long term, ensuring the resilience of the water supply for future generations.

The City relies primarily on the RDN to administer its education and support programs, which include a robust menu of activities. Since 2009, RDN's Drinking Water and Watershed Protection program has offered educational initiatives and programs through Team WaterSmart. Most water conservation communication and outreach are branded under the RDN and Team WaterSmart logos, which is seen in print material, web resources, community events, rebates, workshops, school education and more. The RDN has initiated several outreach programs to educate and engage the community in water conservation efforts. These programs include:

**Public Workshops:** Workshops are held to inform residents about water-saving techniques and the importance of conservation. The 2025 series largely focus on general watershed stewardship, with the exception of the raingarden self-guided tour.



**School Programs:** Educational programs in local schools teach students about the water cycle, conservation methods, and the impact of drought. RDN delivers curriculum resources for teachers in the region that aim to engage students in ongoing learning about water sustainability, complimented by Team WaterSmart classroom visits. Field trips are also offered to students in grades 4 and 5 to the Englishman and Nanaimo River watersheds. Additional youth resources are available online.

**Community Events:** Team WaterSmart hosts a variety of staffed booths across the region at fairs, festivals, and environmental stewardship events. Events such as Water Conservation Week feature activities, demonstrations, and information booths to promote water-saving practices. These events provide an opportunity for staff to reach many people and to promote RDN programs. Opportunities to host events at the WSAs are limited but all residents are encouraged to participate in events in nearby communities.

**Demonstration Garden:** There are five raingardens located in the City of Nanaimo and Team WaterSmart offer information for self-guided tour as well as a related contest.

**Publications and Online Resources:** The City promotes water conservation in its social media and utility billing and provides limited information on its website. Currently the Parksville.ca website rebate page provides information about its rain barrel and toilet rebates and a link to the RDN rebate page. The water conservation content is largely focused on watering restrictions, on both the main City site (Parksville.ca) as well as a separately branded site called “Let’s Talk Parksville” which provides more detail on watering restrictions. It’s not clear why there are two Parksville sites with very similar content.

The RDN website hosts the conservation-related information for the region with brief conservation tips, links, restrictions, and rebate information. Team WaterSmart also publishes a series of brochures on topics such as lawn and garden best practice including irrigation system management for residents who are interested in applying water conservation techniques and strategies both outdoors and indoors. All are available online.

RDN includes messages in its semi-annual water bills as well as on social media, newspapers, and radio and hosts conservation level signs in all water systems. The RDN conservation messaging is consistently branded across all water systems, and regionally as well through Team WaterSmart.

The WCP noted that, while Team WaterSmart design was generally clean and contemporary, there were opportunities for improvement, notably around making communication less information intensive and more focused on simple key messages. The following enhancements to education and outreach efforts were identified:

- Ensure that Team WaterSmart events occur regularly either within WSAs or within a short drive.
- Continue to push Team WaterSmart best practice guidance into the WSA communities through events, direct mail, social media, and other online channels.
- Ensure that Nanoose Bay Elementary School students receive their share of water conservation youth outreach proportional to the rest of the region.
- Continue to offer and promote rainwater harvesting rebates to WSA residents.
- Continue to build a water stewardship ethic in the WSA communities.
- Promote awareness of the DWWP Program and its vision, mission, and goals.

## Appendix G

# Hydroelectric Power Potential for Englishman River Watershed

## Appendix G: Power Generating Potential

### Introduction

KWL assessed the potential for power generation in the area to identify opportunities to offset project costs and capitalize on hydropower generation on the system at locations such as Arrowsmith Dam and the surrounding watershed. Scope for power generation potential includes:

- Arrowsmith Dam Hydropower.
- RHAM model assessment of the Englishmen River watershed.
- Solar Potential on the Englishmen River Pump Station.

### Current BC Hydro Policy

The BC Hydro Customer Load Displacement Program (CLDP) allows for large commercial or industrial customers to generate clean (clean energy is defined in the BC Clean Energy Act) electricity to offset load.

BC Hydro defines load displacement as “*customer-based electricity generation, behind the electricity meter, whose main purpose is to displace the electrical load normally supplied from the grid, and results in no net increase in GHG emissions*”.

If the power generation is more than the customer load BC Hydro has stated that they would consider negotiating an electricity purchase agreement for the additional energy. In the fall of 2024 BC Hydro offered electricity purchase agreements to 10 proponents at an average cost of \$74/MWh. BC Hydro offers adjustments to the pricing based on location, month, and peak vs non-peak hours.

BC Hydro offers incentives on solar generation, to a maximum rebate of \$25,000. This is calculated as \$1,000 per kilowatt (kW) of installed generator capacity, capped at 50% of total installed product cost (including labour and materials).

### Arrowsmith Dam Hydroelectric Opportunity

Arrowsmith Dam was identified as a location for potential hydroelectric development. The priority of flows through Arrowsmith Dam is to service drinking water for the City, sustain environmental flows, and then generate power. This development would involve the use of the existing drinking water storage dam with the following additions:

- Extend the existing shallow intake to the same depth as the deep intake.
- Add twin submersible electric pumps to ensure the siphons on the intake pipes remain charged.
- Extend the pipe works approximately 1,350 m to a powerhouse located by the creek.
- Add a powerhouse with a 4.2 MW Pelton turbine based on a 1.6 m<sup>3</sup>/s flow at 300 m of head. The powerhouse would consist of:
  - Turbine
  - Generator
  - Controls
  - Switchgear
  - Transformer to step up to 25 kV
  - Access road

- 25 kV 3-phase powerline to connect to BC Hydro's system at the intersection of Englishmen River Road and Errington Road.

A siphon is required to provide flows through the upper and lower conduits throughout the year considering resilience to water level and temperature fluctuations, including ice formation. Twin submersible electric pumps are proposed for priming the siphon. Due to the altitude of the project location, air and hydrostatic pressure calculations need to be performed to ensure pressure is sufficient to carry water through the siphon. Care must be taken to ensure no air or water leaks in the siphon section of the intake to ensure the siphon remains charged.

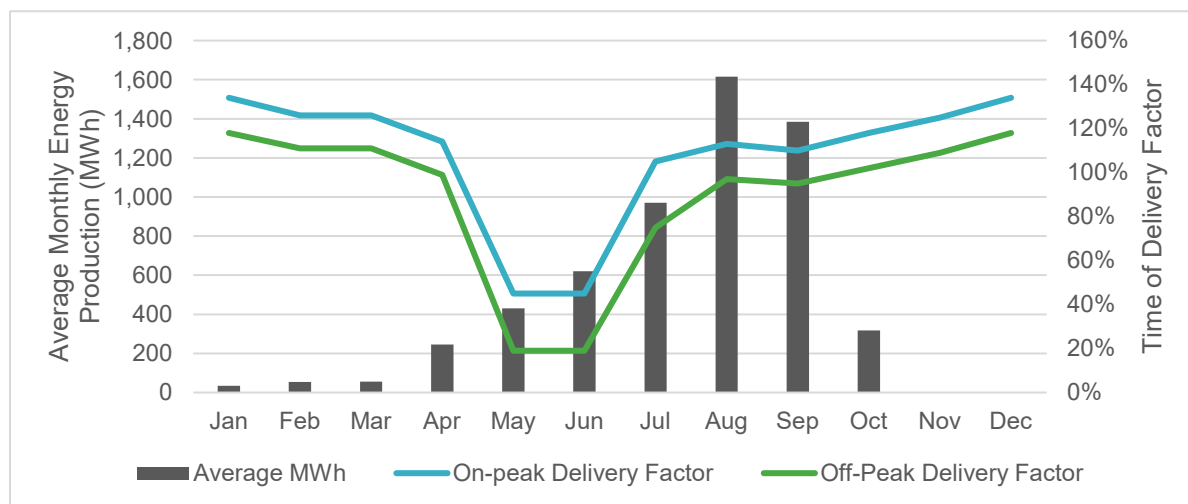
Hydropower potential was estimated using daily flow data collected at the dam from 2007 - 2023. Power calculations assume that both the upper and lower conduit flows as well as flows over the spillway would be utilized for generation. Because historical flows between approximately November to April are minimal or zero, the project has been sized based on flows from May to October. A design flow of 1.6 m<sup>3</sup>/s was selected based on historical averages during this period. A 4.2 MW project was selected based on this flow at 300 m of head. The average annual energy generation based on the historic stream flow from 2007 - 2023 is 5.7 GWh/yr.

The estimated capital cost is \$30 million. With a 2% real discount rate (4% nominal) and an economic life of 40 years, the project would have a unit energy cost of approximately \$230/MWh. This is higher than the estimated price BC Hydro is likely willing to pay which is approximately \$100/MWh.

Average monthly energy production was estimated from the historical flow data at Arrowsmith Dam. Monthly average energy sales were calculated based on this production and a regionally adjusted energy purchase price. This price was varied as per the BC Hydro Time of Delivery Factor over the year, as can be seen in and compared to monthly energy production in Figure G-1, below. The energy sales for this project is estimated at \$500 k/yr.

**Table G-1: BC Hydro Time of Delivery Factor**

| BC Hydro Time of Delivery Factor |      |      |      |     |     |      |      |      |      |      |      |
|----------------------------------|------|------|------|-----|-----|------|------|------|------|------|------|
| Jan                              | Feb  | Mar  | Apr  | May | Jun | Jul  | Aug  | Sep  | Oct  | Nov  | Dec  |
| 134%                             | 126% | 126% | 114% | 45% | 45% | 105% | 113% | 110% | 118% | 125% | 134% |
| 118%                             | 111% | 111% | 99%  | 19% | 19% | 75%  | 97%  | 95%  | 102% | 109% | 118% |



**Figure G-1: Arrowsmith Dam Potential Generation and Delivery Factor Over the Year**



<https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/independent-power-producers-calls-for-power/independent-power-producers/2024-call-for-power-rfp-info-meetings-2024may.pdf>

The hydroelectric project at Arrowsmith Dam improves the resilience of the drinking water system by:

- Improving access to 2,000 m<sup>3</sup> of live storage.
- Improving the reliability of the siphon intake.
- Improving automation, control, and monitoring of the discharges from Arrowsmith Dam through the proposed hydroelectric project.

The hydroelectric project also improves the reliability of meeting the environmental flow requirements as described above.

## Englishman River Watershed Hydroelectric Opportunities

The KWL Rapid Hydroelectric Assessment Model (RHAM) assessed the Englishmen River watershed to estimate hydroelectric potential (Figure G-2). The largest potential projects would range from approximately 6 - 10 MW, located downstream of the confluence of the Moriarty River with the Englishmen River. This area is classified as a Fisheries Information Summary System (FISS) historical observation reach, as it is a known habitat for Steelhead. Development of hydroelectric projects on a reach of stream used by Steelhead is very challenging for the following reasons:

1. Intake screening would be required.
2. Large instream flows would be required, limiting hydroelectric potential.
3. Moderate flow ramping would be required, limiting power generation flexibility.

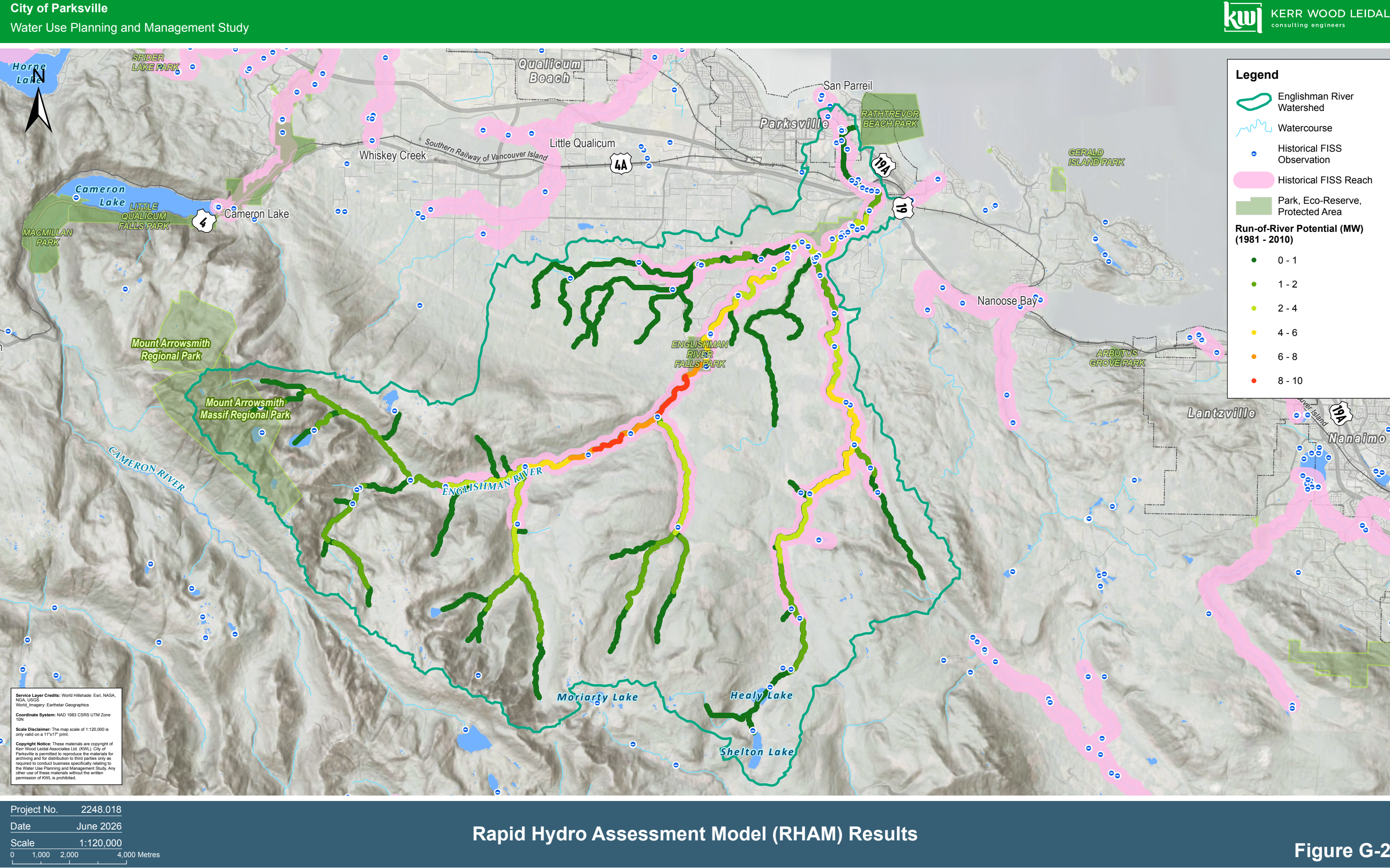
Therefore, hydroelectric projects would not be feasible in this reach of the stream and a cost estimation was not performed.

## Solar Power Potential at Water System Facilities

KWL's sub-consultant Charge Solar performed a solar potential assessment for the rooftop of the Englishmen River Pumpstation. Charge Solar sized this system at 25 kW, based on a project with 76 panels across 297 m<sup>2</sup> of rooftop with minor obstructions. This project would provide approximately 26,000 kWh of annual energy production to offset consumption at the pumpstation.

This project would have an initial cost of \$75 k. The system would produce a total lifetime benefit of \$5 k over a 25-year operating life. Financial analysis includes \$25 k of BC Hydro solar incentives. Although it was determined that such a project would be viable, the monetary benefit is small and the project is still subject to confirmation of interconnection requirements and BC Hydro's solar program. Further analysis could be performed in the next phase of the project to consider other sites such as the WTP or Springwood water compound as well as other municipal buildings in the community as well as assess the battery energy storage and the potential for a local microgrid. Up to an additional \$25 k of BC Hydro incentives could be added if the project were to include a battery energy storage system.







## Appendix H

# Surface Water Storage Options Comparative Cost Estimates (Class 5)



Table H-1: Surface Water Storage Options Comparative Capital Cost Estimates (Class 5)

| Project                    | Dam Length | Dam Height | Crest Width | Slope | Dam Embankment Fill Volume | Assumed Dam Type | Dam and Appurtenant Structures | Free Overflow Spillway | Dam Material, Dam Construction, and Works Cost | Contingency (40%) (Class 5) | Construction (with Contingency) | Engineering/ Environmental (10%) | Environmental/ Social Mitigation (3% to 6%) | Insurance/ Bonding (2%) | Total Project Cost (\$2025) | Operations and Maintenance Cost |
|----------------------------|------------|------------|-------------|-------|----------------------------|------------------|--------------------------------|------------------------|------------------------------------------------|-----------------------------|---------------------------------|----------------------------------|---------------------------------------------|-------------------------|-----------------------------|---------------------------------|
|                            | m          | m          | m           | x:1   | m³                         |                  | \$                             | \$                     | \$ Million                                     | \$ Million                  | \$ Million                      | \$ Million                       | \$ Million                                  | \$ Million              | \$ Million                  | \$/yr                           |
| Fishtail                   | 130        | 20         | 2           | 0.5   | 15,500                     | Concrete         | 14,300,000                     | 500,000                | 14.8                                           | 5.9                         | 20.7                            | 2.1                              | 0.6                                         | 0.4                     | 23.8                        | 250,000                         |
| Healey                     | 235        | 12         | 5           | 2     | 41,000                     | Earthfill        | 8,100,000                      | 500,000                | 8.6                                            | 3.4                         | 12.0                            | 1.2                              | 0.7                                         | 0.2                     | 14.2                        | 250,000                         |
| Shelton                    | 370        | 15         | 5           | 2     | 97,000                     | Earthfill        | 16,100,000                     | 500,000                | 16.6                                           | 6.6                         | 23.2                            | 2.3                              | 1.4                                         | 0.5                     | 27.4                        | 250,000                         |
| South Englishman Tributary | 440        | 14         | 5           | 2     | 101,500                    | Earthfill        | 16,700,000                     | 500,000                | 17.2                                           | 6.9                         | 24.1                            | 2.4                              | 1.4                                         | 0.5                     | 28.4                        | 250,000                         |
| Moriarty Creek             | 340        | 48         | 2           | 0.5   | 212,000                    | Concrete         | 195,200,000                    | 2,000,000              | 197.2                                          | 78.9                        | 276.1                           | 27.6                             | 8.3                                         | 5.5                     | 317.5                       | 500,000                         |