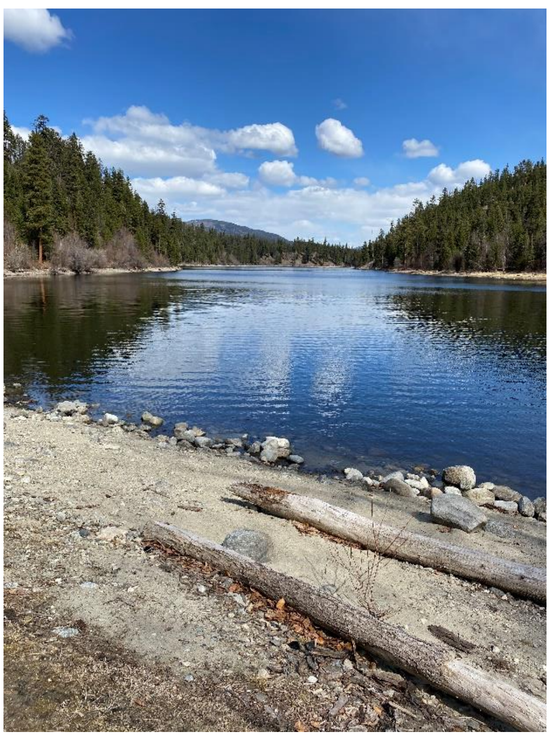
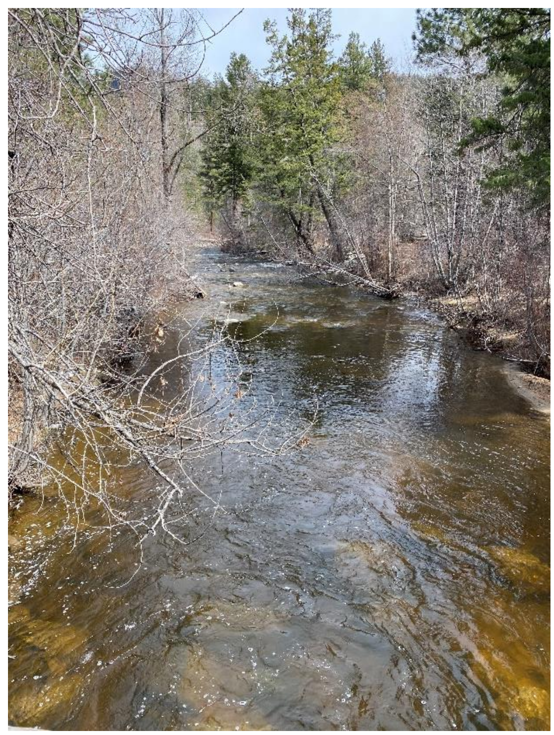
REPORT

Regional District Okanagan Similkameen

Meadow Valley Aquifer Study: Review of Conceptual Model of Groundwater Flow and Groundwater Availability





AUGUST 2022

EXECUTIVE SUMMARY

The RDOS owns and operates the Faulder Community Water System, which includes two wells (FCW1 and FCW2) located on the bank of Trout Creek that supplies domestic water[1] to 81 connections; an estimated population of 215 residents. Several properties within the community of Faulder supplement their RDOS-supplied domestic water use with private wells to meet their needs for landscape watering and providing water for pets and animals kept for household use. These wells are located within Aquifer #299, a sand and gravel aquifer mapped by the Province as extending from Meadow Valley in the North, to the Prairie Valley area of the District of Summerland in the South.

Meadow Valley is a rural area north of Faulder. Meadow Valley residents use a combination of private groundwater wells and surface water intakes, and one community water system, the Meadow Valley Irrigation District, to meet their watering needs for domestic use, forage and fruit tree irrigation, and livestock watering.

There is a history of water availability concerns for the residents who rely on the Faulder Community Water System for domestic use, and within the Faulder and Meadow Valley communities as a whole. During dry years, residents in both areas have reported dry wells, and in 2015, the RDOS drilled a deeper well (FCW2) on the bank of Trout Creek and implemented severe watering restrictions to meet domestic supply. In addition, the RDOS has received several new subdivision applications and is not confident that Aquifer #299 can support additional supply.

RDOS has completed several groundwater availability studies over the years, and each study has resulted in a better understanding of the conceptual model of groundwater flow, and groundwater availability. The last study was completed in 2015, and recommended drilling a second community well (FCW2). Since seven years has passed since drilling FCW2, and with the on-going interest in subdivision development and concerns regarding climate change (e.g., longer and hotter summers, less snowpack in winters), in December 2021, the RDOS identified the need to complete the Meadow Valley Aquifer Study.

As part of the Meadow Valley Aquifer Study (this report), the main objective was to further develop the hydrogeological conceptual model for Aquifer #299 and to assess groundwater availability within the aquifer, with a particular focus on the Faulder Community Water System and Meadow Valley area. This was completed by reviewing all available information, interviewing residents, inspecting select private wells and installing dataloggers in two of these wells, developing hydrogeological cross-sections, comparing upstream and downstream hydrometric flow data available on Darke Creek, analysing precipitation data to help assess aquifer recharge, completing water demand modelling, and incorporating climate change into water supply and water demand concepts.

Based on our study, Associated concludes:

- Aquifer #299 is a long, relatively narrow, valley floor, surficial aquifer of a heterogeneous nature and varies between being an unconfined, semi-confined, or confined aquifer depending on the exact location.
- The dominant recharge mechanism to Aquifer #299 is via creek bed leakage from Darke Creek and Trout Creek, and leakage from other mountainside creeks when they flow over the surficial deposits in the valley floor. To a

[1] Domestic use is defined in the *Water Sustainability Act* as the use of water for household purposes, including drinking water, food preparation and sanitation (indoor use), fire prevention, providing water to animals or poultry kept for household use or as pets, irrigation of a garden not exceeding 1000m^2.

lesser extent, aquifer recharge is also likely provided by direct infiltration of precipitation and from mountain block recharge.

- The amount of preceding winter and spring precipitation and, consequently, aquifer recharge, has the largest impact on Aquifer #299 water levels.
- Extraction from the Faulder Community Wells has a minimal effect on Aquifer #299 water levels; the impact is very localised around the well, as demonstrated by pumping tests undertaken on FCW1 and FCW2.
- Aquifer #299 can be divided into four sub-regions based on geology, hydrogeology, aquifer geometry, and sources of recharge, North Meadow Valley Aquifer sub-region, South Meadow Valley Aquifer sub-region, North Faulder Aquifer sub-region, and Trout Creek Valley Aquifer sub-region. The individual characteristics of these Sub-Regions are important in terms of understanding groundwater availability in each area, and are discussed below.
- Increased water demands are predicted to occur in all Aquifer Sub-Regions due to a changing climate. Average increases from 14% to 39% are estimated to occur for the 2055 climate period, whereas increases from 17% to 44% are estimated to occur for the 2085 climate period.

- North and South Meadow Valley Aquifer Sub-Regions:
  - These two sub-regions cover the Meadow Valley area located north of Faulder. Recharge to the aquifer sub-region is predominantly from creek bed leakage from Darke Creek and other creeks that drain the mountainside and flow into the valley.
  - Streamflow in Darke Creek across North and South Meadow Valley is highly regulated with licensed points of diversion mainly for irrigation purposes (Meadow Valley Irrigation District and private irrigation). Following dry periods, there is often minimal streamflow in Darke Creek at the southern end of South Meadow Valley.
  - Following a series of dry (lower recharge) years, groundwater levels in North and South Meadow Valley Aquifer sub-regions are low with minimal groundwater available. This is a consequence of the generally thin aquifer thickness in this region limiting the amount of available drawdown in wells constructed in the aquifer. In addition, during dryer years, there is a reduction in recharge to the aquifer from creek bed leakage due to less flow, as well as a probable increase in the amount of surface water and groundwater used for irrigation purposes. This impact is exacerbated by a series of low recharge years.
  - Groundwater extraction from the Faulder Community Supply Wells has no impact on groundwater availability in North and South Meadow Valley.

North Faulder Aquifer Sub-Region:

- This narrow aquifer sub-region extends most of the length of the Faulder community, Aquifer #299 here is relatively thin and unconfined, particularly at the northern end of Faulder where bedrock is found at a shallower depth. Recharge to the aquifer sub-region is predominantly from creek bed leakage from Darke Creek and via groundwater flow from the Meadow Valley area.
- Streamflow in Darke Creek often dries before it reaches Trout Creek due to low streamflow from Meadow Valley and creek bed leakage along its length. Following a series of low recharge years, groundwater levels in North Faulder Aquifer sub-region decrease, and on some occasions private wells going dry. Anecdotal evidence suggests that the first wells to go dry are at the northern end of this aquifer sub-region, with wells to the south going dry as aquifer water levels fall. This is unsurprising given the shallower depth to bedrock in the northern part of the aquifer sub region.
- Groundwater extraction from the Faulder Community Supply Wells has negligible impact on groundwater availability in the North Faulder Aquifer sub-region.

Trout Creek Valley Aquifer Sub-Region

- This is the largest aquifer sub-region extending from the southern end of Faulder to Summerland Rodeo Grounds. The aquifer here is typically confined and significantly thicker than other parts of Aquifer #299. The Faulder Community Supply Wells are constructed within this thicker part of the aquifer within the Trout Creek valley.
- Recharge to the aquifer sub-region is predominantly from creek bed leakage from Trout Creek and, to a lesser extent, Darke Creek, and also via groundwater flow from the North Faulder Aquifer sub-region and likely from an unmapped aquifer that exists below Trout Creek to the west of Faulder.
- Trout Creek is a significantly regulated creek with many points of diversion along its length, with the District of Summerland being a large water licence holder on Trout Creek with points of diversion and storage upgradient of Faulder.
- Following a series of low recharge years, groundwater levels in Trout Creek Valley Aquifer sub-region decreased. In 2010 and 2011, this resulted in the groundwater level in FCW1 getting close to the top of the well screen, limiting the amount of drawdown available in the well for pumping. Consequently, FCW2 was constructed in 2015 in a deeper part of the aquifer which provides significantly more available drawdown and, therefore, the well is at significantly less risk of not being able to provide potable water to the Faulder community.
- Pumping test data from FCW2 showed minimal drawdown (<0.5 m) in wells located within 60 m, suggesting that the majority of groundwater extracted is rapidly replaced rather than a depletion of aquifer storage, which would result in a reduction in aquifer water levels.

Recommendations for each of the four aquifer sub-regions are provided in Section 3. Below is a summary of the key recommendations.

- Limit or prevent additional development, land uses or activities that draw water out of surficial Aquifer #299 within the Meadow Valley or North Faulder areas.
- Within the Faulder Community Water System, promote water conservation measures and raise public awareness about the importance of water conservation. The existing water licence for the Faulder Community System is restricted to about 2000 L per person per day for the existing 81 connections. While this is sufficient to meet all indoor watering needs for the system users, best management practices for outdoor watering needs must be followed to stay under this limit as water demand goes up due to more residents per household and due to climate change. Continue to monitor water use and consider working with the Ministry of Forests to determine what technical studies would be needed to apply for a new groundwater use licence application.
- As the Province has jurisdiction with issuing water licences for all surface water diversions and non-domestic groundwater use, notify the Ministry of Forests of the findings of this study with respect to groundwater supply constraints in Meadow Valley and North Faulder areas of Aquifer #299, and no new groundwater licences should be granted in these areas. In addition, share this report with the Ministry of Forests to highlight the importance of Darke Creek in providing recharge to Aquifer #299, with the aim of restricting further surface water licences being granted within these aquifer sub-regions. The Province may wish to measure existing surface water diversions on Darke Creek, Trout Creek and other surface water bodies within the Darke Creek watershed to ensure that the quantity of water diverted does not exceed the licensed quantity, if feasible, as the licensed volumes on the water licence query were unclear.

- Related to continuing to collect data to support primarily on-going management of the Faulder Community Water System (and as a secondary objective management of the North Faulder and South Meadow Valley aquifer sub-regions areas as a whole):
  - Continue groundwater level monitoring in FCW1 and FCW2.
  - Consider additional groundwater monitoring locations in South Meadow Valley and North Faulder aquifer sub-regions (including potentially drilling new monitoring wells). This will allow a greater understanding of aquifer water level fluctuations in the different aquifer sub-regions in response to recharge and groundwater/surface water extractions, as well as providing more information on groundwater flow between the aquifer sub-regions. A partnership with Ministry of Forests, who manages the Provincial Observation Well network, should be pursued.
  - Conduct flow gauging on Darke Creek and Trout Creek to better understand the location, timing, and amount of creek bed leakage. This will help to gain confidence around the groundwater recharge mechanisms to the Trout Creek Valley Aquifer sub-region in the vicinity of FCW1 and FCW2.
  - Conduct a long-term pumping test on FCW2 and monitor water levels in wells within Faulder to clearly demonstrate that extraction from FCW2 has no/negligible impact on water levels in private wells.

ACKNOWLEDGEMENTS

Associated Environmental Consultants Inc thanks those persons and agencies that provided information that was compiled for this report and/or provided insight into observations of climate, surface water and groundwater levels, and water use in the Faulder and Meadow Valley communities. In particular, we thank the water suppliers who took the time to provide their insights, and private groundwater well owners who provided access to their wells for groundwater level measurements and datalogger installation.

The project was directed by Shelley Fiorito, Rob Palmer, and Liisa Bloomfield of Regional District of Okanagan Similkameen. The report was prepared by Marta Green, PGeo, Steve Colebrook, MSc, and Dylan Riley, GIT. Brian De Jong prepared the maps and cross sections. Ron Fretwell (RHF Systems Ltd.) completed the customized runs of the Okanagan Water Demand Model.

The project boundaries are within the territory of the Syilx Okanagan People. We are grateful to be able to live, work, and recreate within these beautiful lands.

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LIST OF ABBREVIATIONS

EFNs – Environmental Flow Needs
FCW1 – Faulder Community Well 1
FCW2 – Faulder Community Well 2
GCM - General Circulation Model
GPM – Gallons Per Minute
GWELLS – Groundwater and Wells Database
MOE – Ministry of Environment
MVID – Meadow Valley Irrigation District
OBWB – Okanagan Basin Water Board
PCIC - Pacific Climate Impacts Consortium
RDOS – Regional District Okanagan Similkameen
SDM - Statutory Decision Maker
WSA – *Water Sustainability Act*
WTN – Well Tag Number

1 INTRODUCTION

The Regional District Okanagan Similkameen (RDOS) retained Associated Environmental Consultants Inc. (Associated) to complete the Meadow Valley Aquifer Study. The Study Area is comprised primarily of the valley bottoms in the Faulder and Meadow Valley areas, within the Darke Creek and Trout Creek watersheds and RDOS Electoral Area F (Figure 1-1). Provincially mapped Aquifer #299, the Meadow Valley Aquifer, underlies the valley bottom.

1.1 Background

The RDOS owns and operates the Faulder Community Water System, which includes two wells (Faulder Community Well 1 [FCW1] and Faulder Community Well 2 [FCW2]) located on the bank of Trout Creek that supplies domestic water to 81 connections; an estimated population of 215 residents. Several properties within the community of Faulder supplement their RDOS-supplied domestic water use[2] with private wells. These wells are located within Aquifer #299.

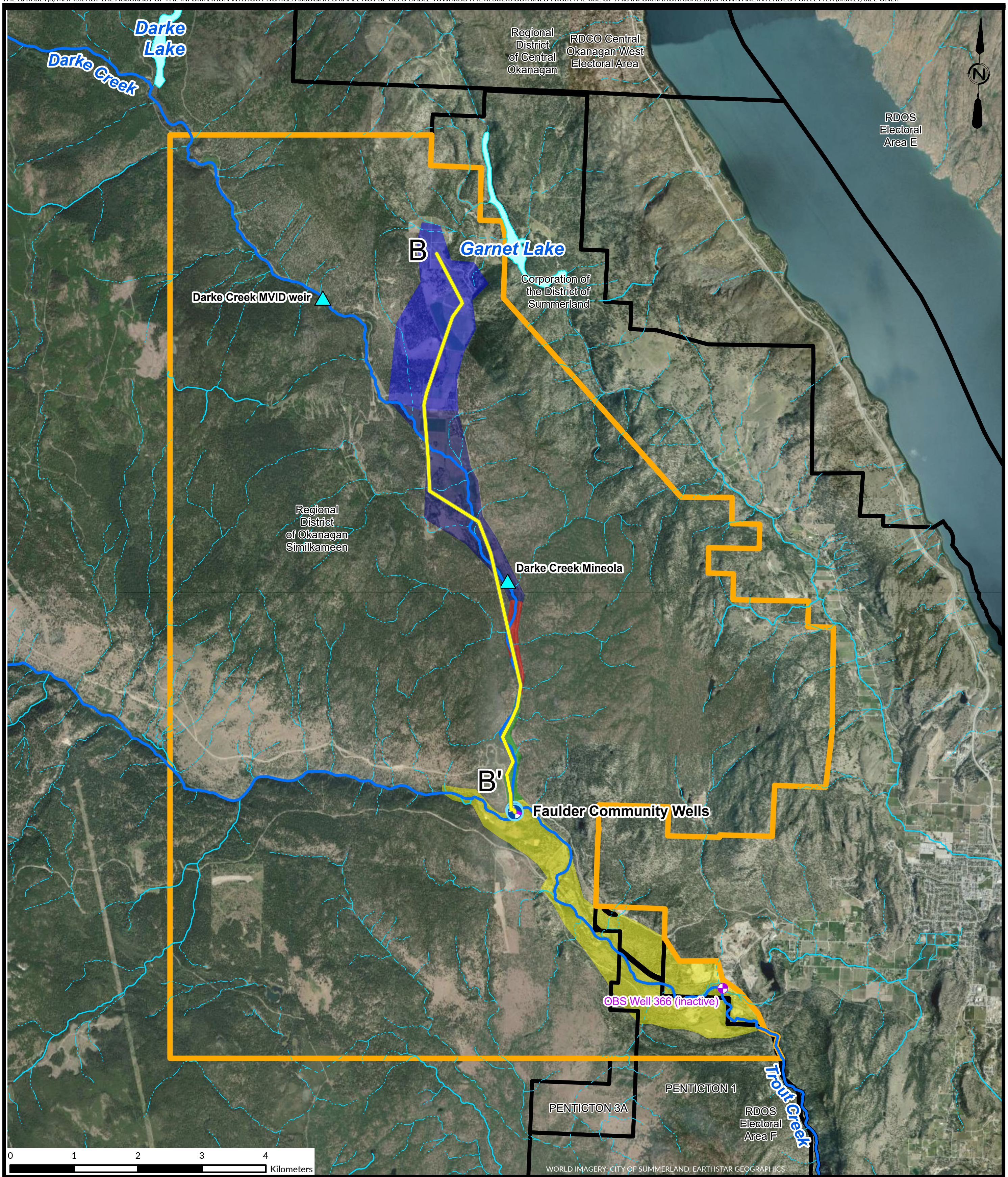
Meadow Valley is a rural area north of Faulder, also overlying Aquifer #299. Meadow Valley residents use a combination of private groundwater wells and surface water intakes, and one community water system, the Meadow Valley Irrigation District, to meet their watering needs for domestic use[2], forage and fruit tree irrigation, and livestock watering.

There is a history of water availability concerns for the residents who rely on the Faulder Community Water System for domestic use, and within the Faulder and Meadow Valley communities as a whole. During dry years, residents in both areas have reported dry wells, and water level in RDOS's FCW1 became close to the minimum water level available. Therefore, in 2015, the RDOS drilled a deeper well (FCW2) near Trout Creek, increasing the amount of groundwater level drawdown available and reducing the risk of not being able to meet the water demand. In addition, RDOS have had to implement severe watering restrictions to meet domestic supply in 2008-2010 before FCW2 was constructed; however, even though FCW2 has relieved the need to implement severe watering restrictions in recent years, the groundwater licence that RDOS was granted for the wells is on the order of water use in 2005-2008 when watering restrictions were not implemented. The RDOS has received several new subdivision applications and, given the water availability concerns, is not confident that Aquifer #299 can support additional supply.

RDOS has completed several groundwater availability studies over the years, and each study has resulted in a better understanding of the conceptual model of groundwater flow, and groundwater availability. The last study was completed in 2015, and recommended drilling a second community well. Since FCW2 was drilled several years ago, and with the on-going interest in subdivision development, and concerns regarding climate change (e.g., longer and hotter summers, less snowpack in winters) and the Faulder Community Water System groundwater licence restrictions, the RDOS identified the need to complete the Meadow Valley Aquifer Study to better assess current and future groundwater availability. In December 2021, RDOS issued a request for proposal and Associated was awarded the contract.

[2] Domestic use is defined in the *Water Sustainability Act* as the use of water for household purposes, including drinking water, food preparation and sanitation (indoor use), fire prevention, providing water to animals or poultry kept for household use or as pets, irrigation of a garden not exceeding 1000 m^2.

ALTHOUGH ASSOCIATED HAS TAKEN THE EFFORT AND DUE CARE TO ENSURE THE ACCURACY OF THE INFORMATION DISPLAYED AT THE DATE OF PRODUCTION, THE USER ACKNOWLEDGES THAT CHANGES OVER TIME AND THE CURRENCY OF THE DATASET(S) MAY IMPACT THE ACCURACY OF THE INFORMATION WITHOUT NOTICE. ASSOCIATED SHALL NOT BE HELD LIABLE TOWARDS THE RESULTS OBTAINED FROM THE USE OF THIS INFORMATION. SCALE(S) SHOWN ARE INTENDED FOR LETTER (8.5X11) SIZE ONLY.



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Faulder Community Wells
Hydrometric Station
Provincial Observation Well
Cross Section B-B'
Jurisdiction Boundary
Study Area

Aquifer 299 Sub Regions

North Meadow Valley Aquifer
South Meadow Valley Aquifer
Meadow Valley Pinch Out
North Faulder Aquifer
Trout Creek Valley Aquifer

Associated Environmental

AE PROJECT NO.	2022-8115
SCALE	1:80,000
COORD. SYSTEM	NAD 1983 UTM ZONE 11N
DATE	2022-08-03
REV	01
DRAWN BY	ES
CHECKED BY	WL

FIGURE 1-1: SITE OVERVIEW

REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

MEADOW VALLEY AQUIFER STUDY

1.2 Objectives and Scope of Work

The project's objective is to answer the following questions:

1. Does the aquifer supplying groundwater to the Faulder Community Water System have the capacity to meet current and future domestic water supply needs, in particular indoor use and minimal outdoor landscaping needs?
2. Does the aquifer supplying groundwater to the private wells in the Faulder area have the capacity to continue to supplement other domestic uses except indoor uses and minimal outdoor landscaping needs?
3. Does the aquifer supplying the private wells in the Meadow Valley area, and the Meadow Valley Irrigation District, have the capacity to meet current and future domestic, livestock watering, and irrigation needs?

Request for Proposal RDOS-21-ENG-15 requested "…a thorough hydrological review of the Meadow Valley Aquifer, providing a technical report focused on the current capacity status and future development potential in terms of water availability". To meet this Associated proposed development of an aquifer budget comprising a detailed quantitative analysis of all inputs to an aquifer (e.g., groundwater recharge, irrigation return), compared with all outputs (e.g., groundwater flow out of the aquifer, groundwater discharge to surface water bodies, and well use). However, it became apparent early in the project that the data quality was insufficient to complete a quantitative approach[3]. As an alternative, Associated proposed focusing on a detailed analysis of the conceptual model of groundwater flow and demonstrating the relationship between the portion of the aquifer recharging the Faulder Community System and the portion of the aquifer recharging private wells in the north portion of Faulder and Meadow Valley aquifer, where the bulk of the concerns of dry wells has originated. Using this agreed upon alternative approach, Associated completed the following tasks to meet the project objectives:

1. ***Completed site visits, interviewed those familiar with the area, installed dataloggers and collected manual water levels***. On April 10, 2022, Marta Green, P.Geo., visited the Study Area, accompanied by Shelley Fiorito, and interviewed Allen Wiens, Owner and Water Bailiff with the Meadow Valley Water System. Dylan Riley, GIT, visited the site several times, installed water level dataloggers in two wells constructed in Aquifer #299, installed one barologger to allow for atmospheric pressure correction, collected three manual groundwater levels, and interviewed local residents.
2. ***Completed a desktop review of available information***. We reviewed the following reports provided by RDOS, and publicly available information:
   - Wilson (1990), Golder Associates (2005), Golder Associates (2008), Golder Associates (2013), and (Golder 2015).
   - Province of BC's provincial well and aquifer data base (GWELLS)
   - Environment Canada climate data (Summerland station ID: 1127800)
   - Environment Canada hydrological data (Camp Creek station ID: 08NM134)
3. ***Interpreted the data with an emphasis on graphical displays***. We synthesised data into four aquifer sub-regions defined by different (but linked) hydrogeological regimes, and developed detailed cross sections for effective communication of complex topics to a wide audience. We also compared upstream and downstream hydrometric flow data available on Darke Creek, and analysed precipitation data to help assess aquifer recharge,

[3] Darke Creek, one of the main sources of recharge to Aquifer #299, has only been gauged (has only had a means to record flow), since July 10, 2020. In addition, there is no gauging of Trout Creek in the vicinity of Faulder (the closest gauge is at the mouth of the Creek before entering Okanagan Lake, within the District of Summerland).

4. ***Assessed climate change impacts on future water supply***. We retained Ron Fretwell, of RHF Systems, a contractor that commonly partners with Ministry of Agriculture, to complete analysis of current and future water demand of the Study Area, so RDOS and the community understand how changing climate might impact the water demand into the future. Associated also completed additional climate modelling to assess changes in supply due to a changing climate.
5. ***Prepared this Technical Memorandum***.

1.3 Regulatory Context

Several organisations, from the Provincial level, to the local municipal level, as well as individual citizens and community groups all play a role in managing development, land uses or activities that can draw water from both Aquifer #299, and surface water bodies that recharge Aquifer #299.

Local governments have a series of tools available to them to protect the function of watersheds through protecting aquifers, headwaters and aquifer recharge areas" and to control growth (OBWB 2009), as follows:

- Regional Growth Strategies,
- Official Community Plans (including Local Area and Watershed Plans)
- Zoning
- Density Bonus/Amenity Zoning
- Development Permit Areas
- Watercourse Protection Bylaw
- Subdivision Servicing Bylaw
- Water Service
- Well Closure Bylaw

Ministry of Transportation and Infrastructure approves subdivisions of land outside a municipality. A Provincial approving officer, appointed by the B.C. government, approves subdivision plans in regional district electoral areas.

While RDOS has a Subdivision Servicing Bylaw, it does not preclude or prevent an individual from drilling their own well and using the well for outdoor domestic use. The *Water Sustainability Act* (WSA) was enacted in 2016. Under the WSA, domestic groundwater users are deemed to have rights to the water they use for domestic purposes[4]. All non-domestic[5] groundwater use requires a licence to be issued from the BC Ministry of Forests. Before granting a licence, the Statutory Decision Maker (SDM) must consider other water users, and, if the aquifer is considered hydraulically connected to a surface water body, the SDM must also consider environmental flow needs (EFNs). Completing the technical studies to assess whether the application will negatively affect other water users or EFNs are often quite involved. The Province

[4] Domestic use is defined in the *Water Sustainability Act* as the use of water for household purposes, including drinking water, food preparation and sanitation (indoor use), fire prevention, providing water to animals or poultry kept for household use or as pets, irrigation of a garden not exceeding 1000 m^2.

[5] Non-domestic groundwater use includes all groundwater use except domestic use. Examples of non-domestic use include industrial (e.g.: camp and public facility, commercial enterprise, crop harvesting and processing, fresh water bottling, greenhouse and nursery, lawn, fairway and garden, livestock and animal watering, swimming pool), irrigation (the use of water on cultivated land or hay meadows to nourish crops or pasture to nourish forage), and waterwork. (Ministry of Environment 2016).

then completes First Nation consultation. The process of obtaining a new water licence can take years to be completed and is not guaranteed.

1.3.1 Zoning and Accessory Dwelling Allowance

Under the Okanagan Valley Zoning Bylaw No. 2800, 2022, a variety of zoning designations apply to properties overlying Aquifer #299 including agricultural and rural holdings (i.e., small and large holdings) zones, including:

- Agriculture Three (AG3), which are mostly within the Agricultural Land Reserve (ALR)
- Large Holdings One (LH1)
- Small Holdings Two (SH2), Small Holdings Three (SH3), Small Holdings Four (SH4)
- Resource Area (RA)
- Parks and Recreation (PR)

While the various zones allow for a variety of accessory dwelling allowance, most parcels (with the exception of the PR zone which just allows one accessory dwelling), allow for a single detached dwelling (or mobile home, within the AG3, LH1, and RA zones), as well as accessory dwellings and secondary suits, and agriculture. The number of accessory dwellings is dependent on parcel size, with the maximum number of secondary suites/accessory dwellings on a property being four for parcels greater than 16.0 ha. Accessory dwellings are not permitted on parcels under 1.0 ha in size unless connected to a community sewer system, which do not exist within Aquifer #299 boundaries. AG3 and RA parcels are generally larger parcels that are 20/0 ha or more in area, through this can vary/ LH1, SH2, SH3, and SH4 parcels are all typically under 8.9 Ha in size. SH2 parcels have a minimum parcel size of 0.5 ha; however there is only one SH2 parcel with the aquifer boundary. PR parcels vary considerably in size.

SH2, SH3, and SH4 parcels are only permitted one principal dwelling unit (i.e.: a single detached dwelling) and one secondary suite or one accessory dwelling.

1.3.2 Subdivision Potential

Each zone requires a minimum parcel size:

- Agriculture Three (AG3): 20.0 ha
- Large Holdings One (LH1): 8.0 ha
- Small Holdings Two (SH2): 0.5 ha
- Small Holdings Three (SH3): 1.0 ha
- Small Holdings Four (SH4): 2.0 ha
- Small Holdings Three (SH3), Small Holdings Two (SH2), Small Holdings Four (SH4)

At this time, there are 16 parcels within the Faulder Water System which are capable (in terms of meeting parcel size, and not taking into consideration other factors that can impact subdivision approval) of being subdivided under the SH3 zone (i.e.: they are greater than 2.0 ha in area).

1.3.3 Existing OCP Policies in the Faulder and Meadow Valley Areas

Section 7.3 of the Electoral Area "F" Official Community Plan Bylaw No. 2790, 2018 lays out the local area policies which relate to the Faulder/Meadow Valley area. As it relates to the Meadow Valley Aquifer Study:

- Section 7.3.1.1 indicates that the Regional Board "supports continuing work with Interior Health Authority to ensure high quality drinking water in the Faulder area";
- Section 7.3.1.2 indicates that the Regional Board "supports the protection of source water in the Faulder/Meadow Valley and will consider the establishment of a development permit area to achieve this goal";
- Section 7.3.1.3 indicates that the Regional Board "discourages subdivision of properties in order to maintain the rural character of the area"

It is noted that Section 7.3.1.3 does not speak specifically to water supply concerns, but rather is focused on maintaining the "rural character" of the area, which is not well-defined, making application of this policy challenging.

1.3.4 Proposed Zoning in the Faulder and Meadow Valley Area

In response to the water supply and quality concerns within the Faulder/Meadow Valley area, the RDOS Planning Services Department is currently undertaking the Faulder Zoning Review to strengthen the policies and regulations which govern subdivision and use of properties in the Faulder Water System Service Area and Meadow Valley Aquifer in general (Amendment Bylaw No. 2461.19).

Under the Faulder Zoning Review, RDOS Planning Services Department is proposing that a new zone, the Faulder Small Holdings Zone (SH7) Zone, be created and apply to the properties specifically within the Faulder Water System Service Area. The SH7 zone would restrict permitted uses to single detached dwelling, bed and breakfast operation, home occupation, and accessory building and structures (e.g., detached garages, shops, swimming pools, etc.). It would effectively remove the ability for a property owner to construct a secondary suite or accessory dwelling and undertake agricultural uses on SH7 properties if the zoning amendment bylaw is adopted as proposed.

The SH7 zone would also increase the minimum parcel size for subdivision to 5.0 ha, which would effectively prevent subdivision of SH7 parcels if the zoning amendment bylaw is adopted as proposed. Property owners would maintain the ability to apply for a rezoning to carry out uses no longer permitted in the SH7 zone.

1.3.5 Proposed OCP Policies in the Faulder and Meadow Valley Area

Under the Faulder Zoning Review (Amendment Bylaw No. 2790.03), it is being proposed that Section 7.3.1.3 be replaced in its entirety, and be replaced such that it indicates that the Regional Board "does not support subdivision of parcels within the Faulder Community Water System Local Service Area".

It is also being proposed that the following additional local area policies be adopted to indicate that the Regional Board:

- "does not support the expansion of the Faulder Community Water System Local Service Area";
- "supports the professional decommissioning of all private water wells within the Faulder Community Water System Local Service Area in order to protect the local aquifer and prevent contamination"
- "discourages the rezoning of parcels in order to facilitate subdivision, particularly within the Meadow Valley Aquifer in order to maintain the rural character of the area and preserve existing water resources."
- "supports an Aquifer Vulnerability Assessment being completed for the Meadow Valley and Enesas Creek Aquifers to develop aquifer vulnerability mapping and to inform future land use policy and decision making"

Further, it is being proposed that a new figure be added under the Faulder/Meadow Valley Local Area Policies section to delineate the boundaries of the Meadow Valley Aquifer.

The OCP amendment bylaw also contemplates the following amendments to Section 19 (Infrastructure and Servicing) of the Electoral Area "F" OCP Bylaw:

- The replacement of the first three sentences of the second paragraph in Section 19.4 (Water Supply and Distribution) with: "The Faulder system, which is currently is at capacity, was upgraded with a new well and uranium treatment and made operational in early 2017, bringing one of the two uranium removal canisters online."
- Deleting Section 19.4.2.1.

2 CONCEPTUAL MODEL OF GROUNDWATER FLOW

2.1 Aquifer Sub-Regions and Summary of Conceptual Model of Groundwater Flow

For the purpose of this project, we have split Aquifer #299 into four aquifer sub-regions:

- North Meadow Valley Aquifer (Figure 2-1),
- South Meadow Valley Aquifer (Figure 2-2),
- North Faulder Aquifer (Figure 2-3) and
- Trout Creek Valley Aquifer (Figure 2-4).

These sub-regions are important to distinguish amongst each other because there are fundamental differences in recharge, and aquifer size and shape. Each aquifer sub-region is detailed in Section 3, and Figure 2-5 presents a schematic representation of how each sub-region interacts with other sub-regions. The below provides a summary of each sub-region. One groundwater recharge mechanism that is discussed throughout Section 2 is infiltration of surface water via "losing streams". A losing stream, disappearing stream, influent stream or sinking river is a stream or river that loses water as it flows downstream. The water infiltrates into the ground recharging the local groundwater, because the water table is below the bottom of the stream channel (Wikipedia 2022).

North Meadow Valley Aquifer Sub-region

The North Meadow Valley Aquifer sub-region is at the northern most extent of Aquifer #299 (Figures 1-1 and 2-1). It extends south from the northern boundary of Aquifer #299 to the east-west groundwater divide that splits North Meadow Valley Aquifer and South Meadow Valley Aquifer, near where Fish Lake Road turns west toward Darke Lake. This part of the aquifer is thinner than the other sub-regions and groundwater flows north to Acland Spring, rather than south toward Summerland. Recharge is predominantly from losing stream reaches of Darke Creek.

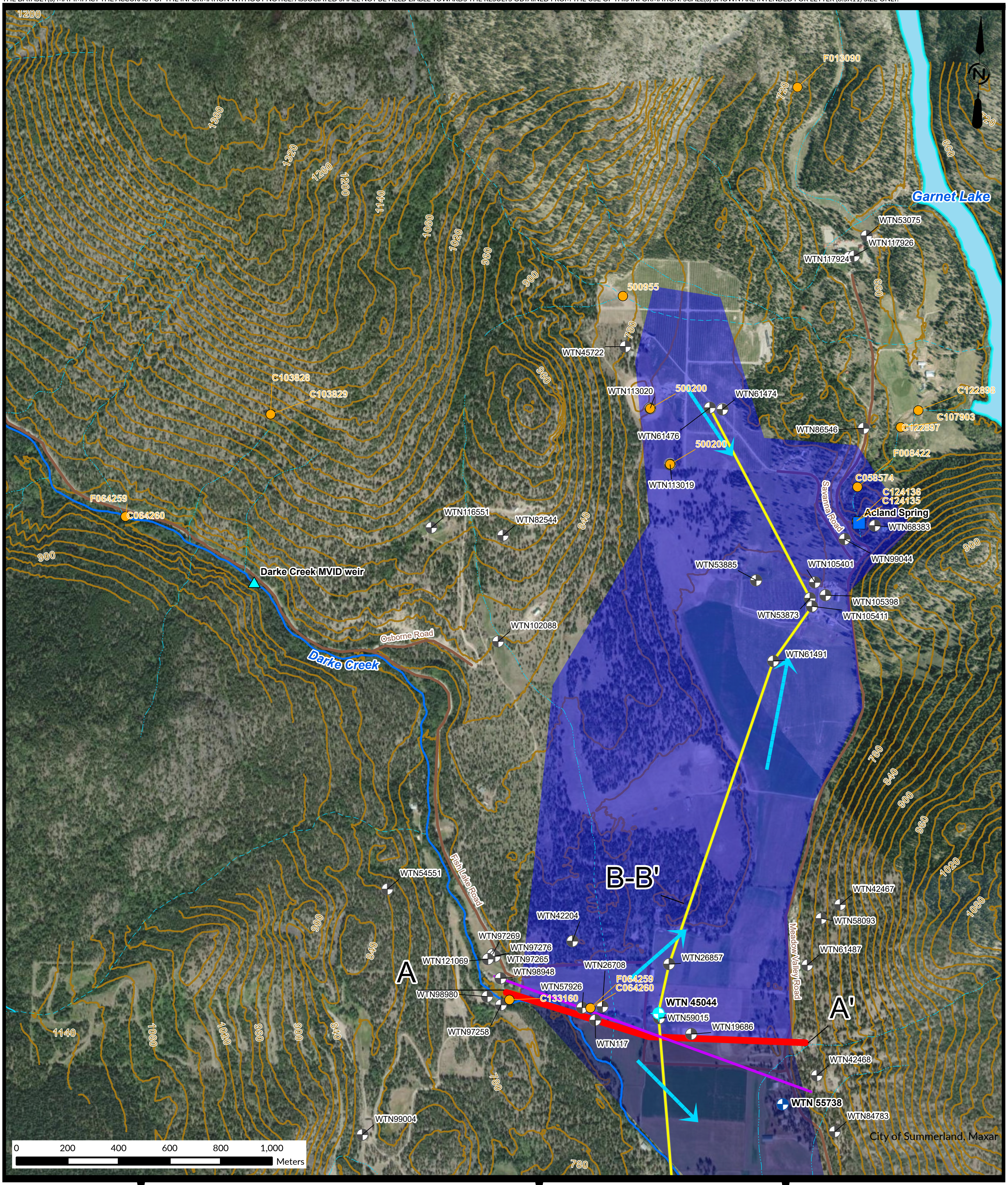
South Meadow Valley Aquifer Sub-region

Immediately south of the groundwater divide is the South Meadow Valley Aquifer sub-region which extends south to the southern edge of Meadow Valley where it 'pinches out' by the constricting bedrock valley (see "Meadow Valley Pinch Out" on Figure 1-1 and Figure 2-2). Groundwater flow to the south would be limited to years of high groundwater levels and recharge is from losing stream reaches of Darke Creek, which is ephemeral[6] at this location. The limited groundwater flow that leaves this sub-region is to the south toward Faulder.

[6] Ephemeral stream is a stream that does not flow year-round (Wikipedia 2022)

North Faulder Aquifer
South of the pinch out is the North Faulder Aquifer, which runs down the narrow valley from the north end of Faulder to just north of where the aquifer joins the deeper part of the aquifer underlying Trout Creek, where the Faulder Community Wells (FCW1 and FCW2) are located (Figure 2-3). The aquifer is narrow, shallow, and the main source of recharge is likely from losing stream reaches of Darke Creek, which is ephemeral at this location. Groundwater flow is south toward the Faulder Community Wells. The North Faulder Aquifer sub-region area consists of lands within the Faulder Water System Service Area.

Trout Creek Valley Aquifer
Immediately south of North Faulder Aquifer and in the vicinity if FCW1 and 2 is the Trout Creek Valley Aquifer. The Trout Creek Valley Aquifer runs from the western most extent of Aquifer #299, west of Faulder, to the aquifer's eastern most extent near the Summerland Rodeo Grounds (Figure 2-4). Groundwater flow is southeast toward Summerland. Different from the previous three sub-regions, this aquifer is predominantly recharged by Trout Creek (as opposed to Darke Creek). Trout Creek Valley Aquifer area consists primarily of lands zoned SH4, with some lands zoned AG3 which are not within the ALR, Parks and Recreation (PR), SH3, and RA.



Hydrometric Station
Spring
Wells – Revised Locations
Wells With Data Logger
Wells - GWELLS
Points of Diversion
Contour (20m Interval)
Cross-Section A-A'
Cross Section B-B'
Groundwater Flow Direction
Meadow Valley Groundwater Divide
North Meadow Valley Aquifer
South Meadow Valley Aquifer
Road

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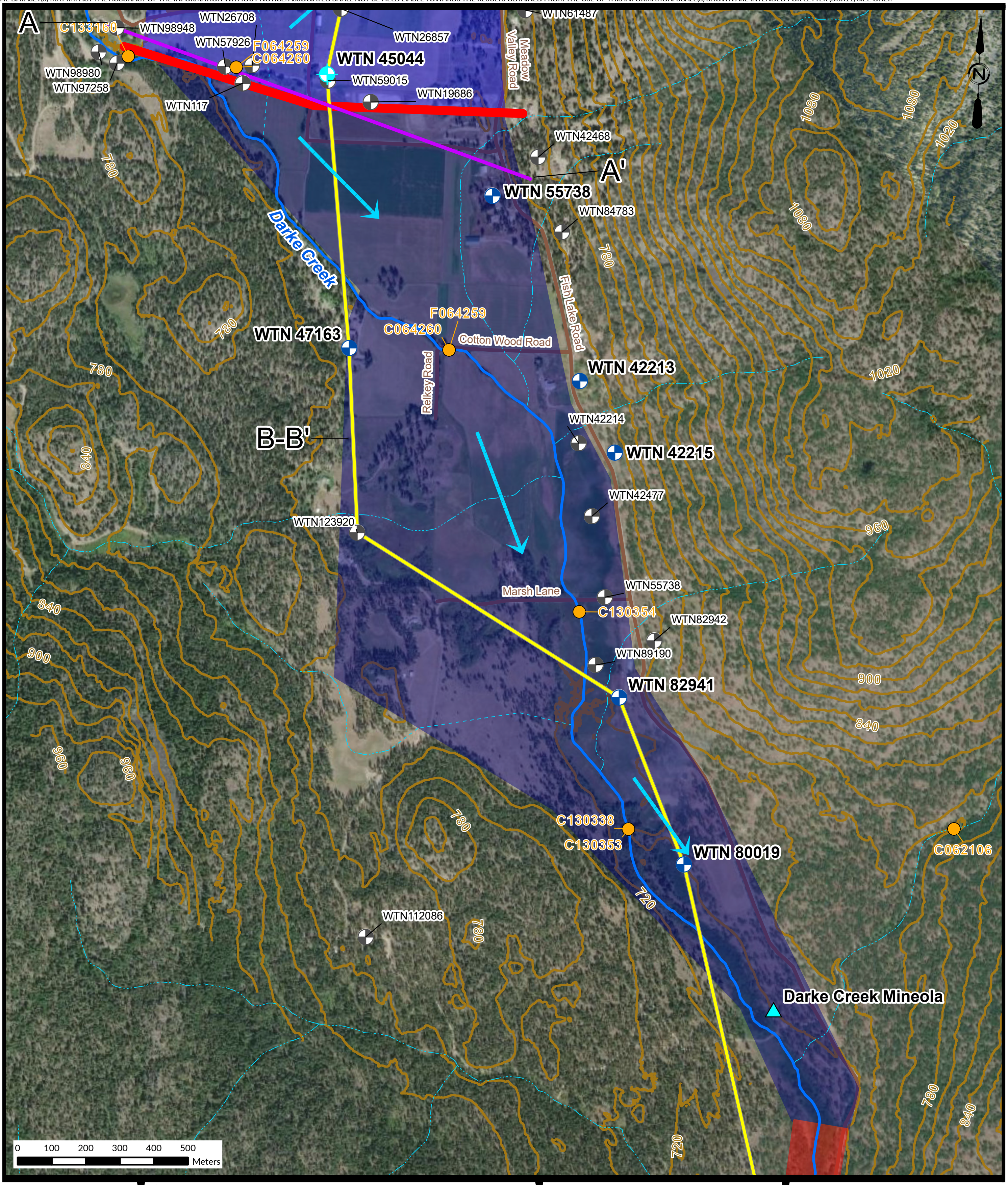
FIGURE 2-1: NORTH MEADOW VALLEY AQUIFER

REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

MEADOW VALLEY AQUIFER STUDY



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Hydrometric station
Wells – Revised Locations
Wells With Data Logger
Wells – GWELLS
Points of Diversion
Contour (20m Interval)
Cross-Section A-A'
Cross Section B-B'
Groundwater Flow Direction
Meadow Valley Groundwater Divide
North Meadow Valley Aquifer
South Meadow Valley Aquifer
Meadow Valley Pinch Out
Road

Associated Environmental

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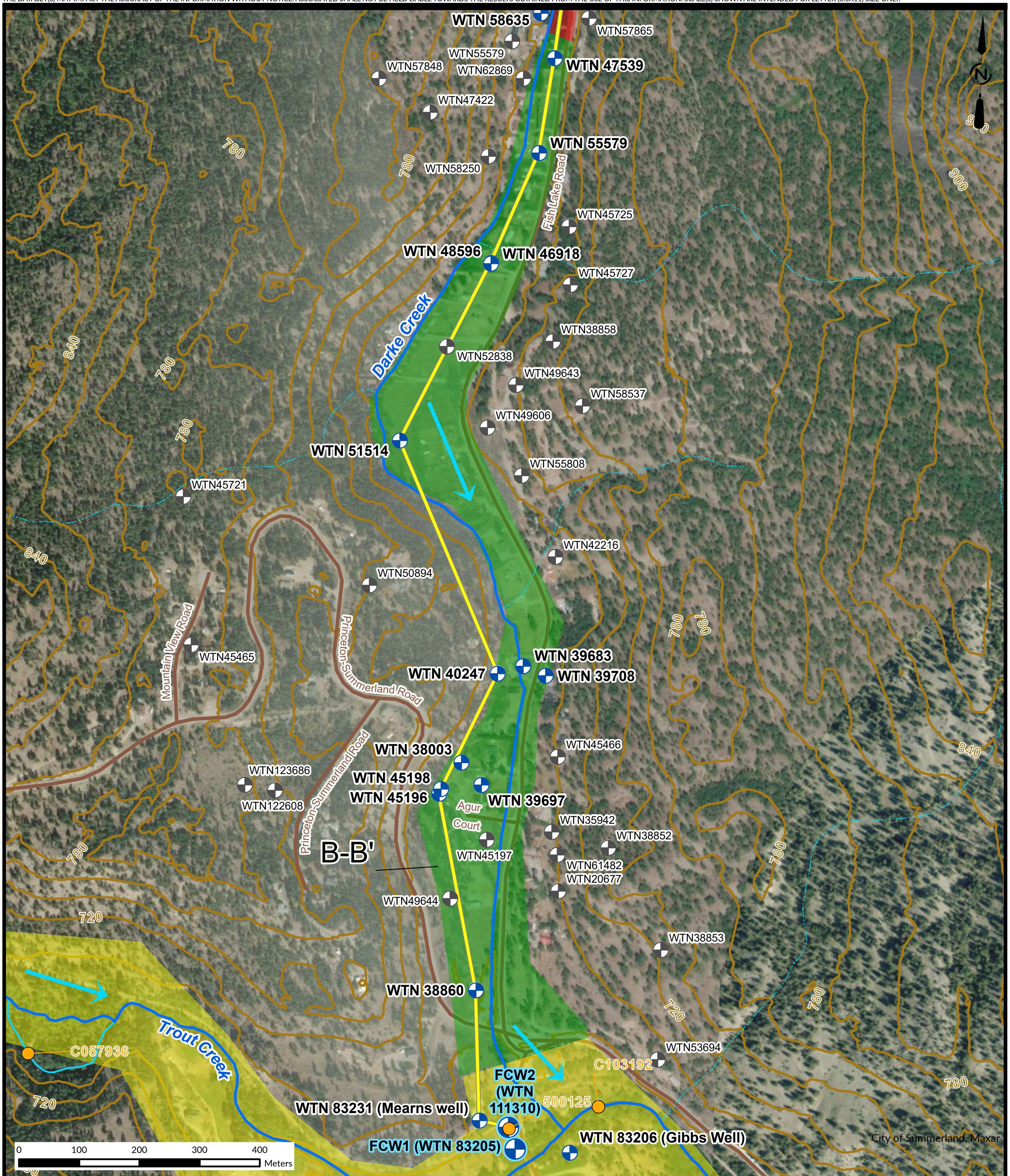
FIGURE 2-2: SOUTH MEADOW VALLEY AQUIFER

REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

MEADOW VALLEY AQUIFER STUDY



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Associated Environmental

- Faulder Community Water System Wells
- Wells - Revised Locations
- Wells – GWELLS
- Points of Diversion
- Contour (20m Interval)
- Cross Section B-B'
- Groundwater Flow Direction
- Meadow Valley Pinch Out
- North Faulder Aquifer
- Trout Creek Valley Aquifer
- Road

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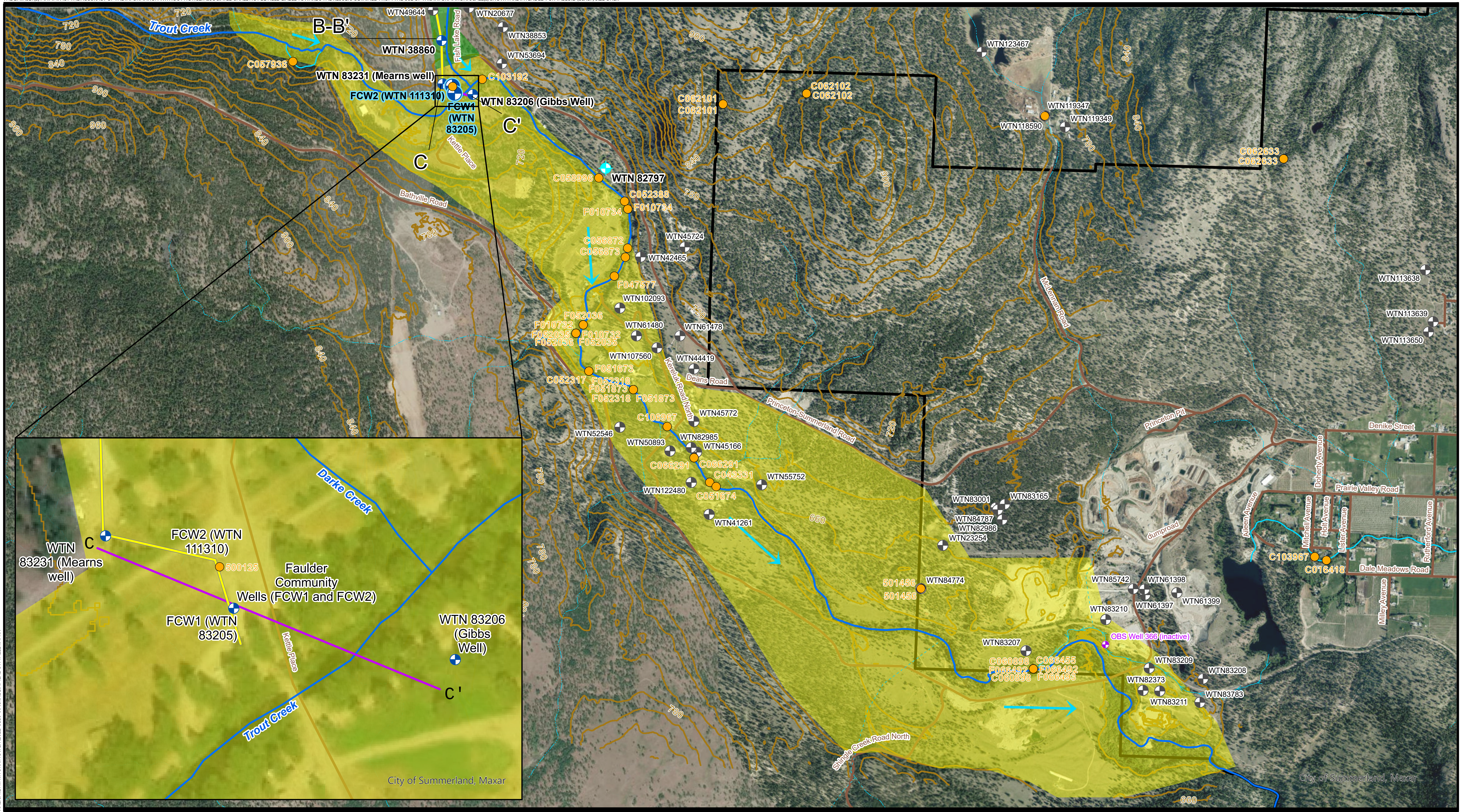
FIGURE 2-3: NORTH FAULDER AQUIFER

REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

MEADOW VALLEY AQUIFER STUDY



Faulder Community Water System Wells
Wells - Revised Locations
Wells With Data Logger
Wells – GWELLS
Provincial Observation Well
Points of Diversion
Contour (20m Interval)
Cross Section B-B'
Cross-Section C-C'
Groundwater Flow Direction
North Faulder Aquifer
Trout Creek Valley Aquifer
Road
Jurisdiction Boundary

Associated Environmental

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FIGURE 2-4: TROUT CREEK VALLEY AQUIFER OVERVIEW

REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

MEADOW VALLEY AQUIFER STUDY

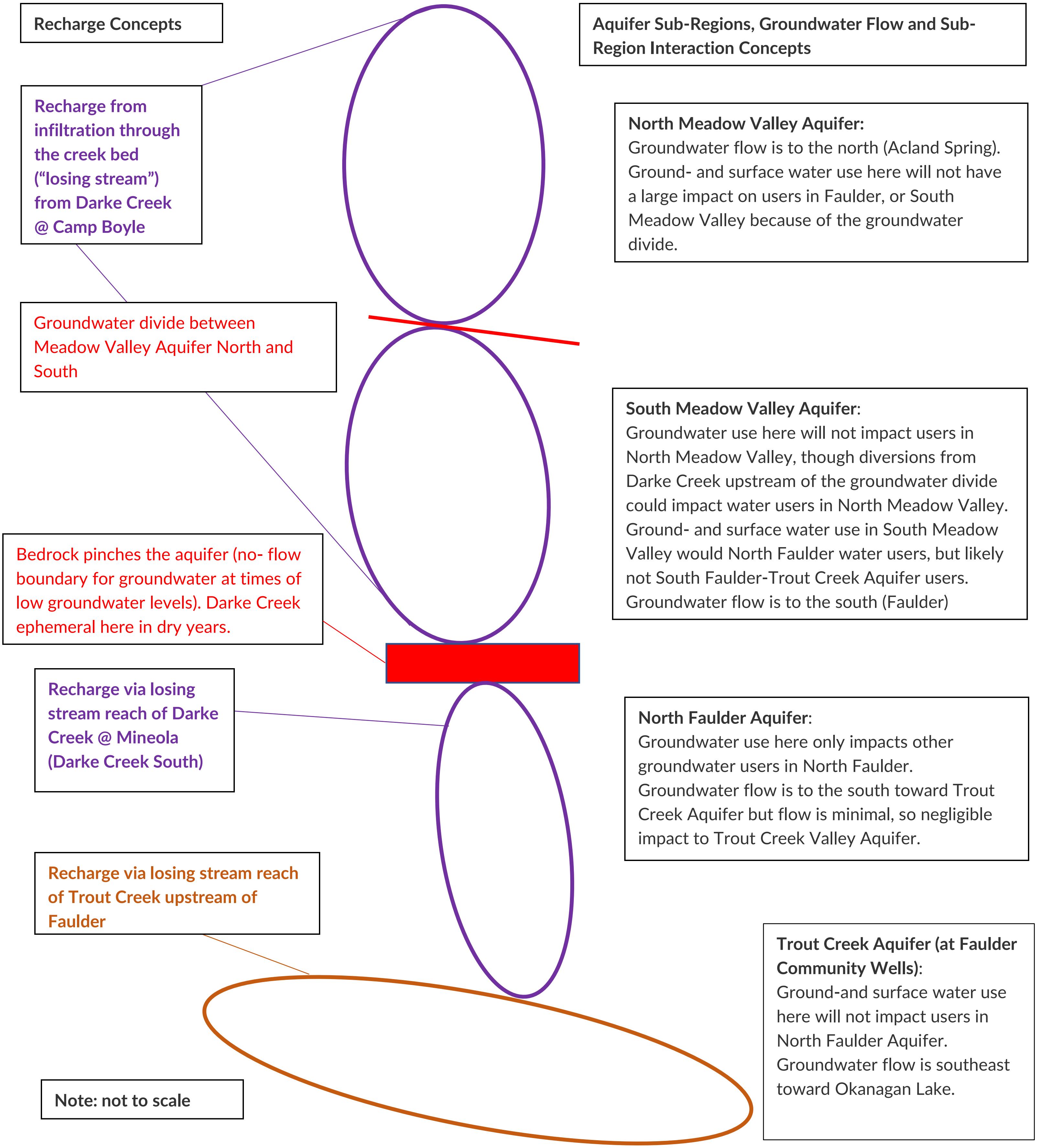


Figure 2-5
Schematic of the Aquifer Sub-Regions

2.2 Historic Climate Conditions

Historic climate conditions for the study area were obtained from ClimateBC[7] (Wang et al. 2016). ClimateBC provides monthly estimates of various climatic variables (e.g., air temperature, precipitation) for a 4 km x 4 km grid across BC for historical periods as well as future climate change scenarios.

Mean monthly temperatures for the 1981 to 2010 climate normal period, hereafter referred to as the 1995 climate period, range from -5.3°C in December to 15.7°C in July/August. Annual precipitation is 563 mm, with total monthly precipitation being relatively consistent between months, with a monthly low of 34 mm in April and August, and a high of 68 mm in November, with 34 mm of that falling as snow (Table 2-1). Climate change considerations are presented in Section 4.

Table 2-1
Historic (1981 – 2010) Mean Monthly Temperature and Precipitation Estimates for the Study Area

Month	Mean Temperature (°C)	Total Precipitation (mm)	Total Precipitation as Snow (mm)
Jan	-5.1	58	41
Feb	-3.4	40	29
Mar	0.1	39	23
Apr	4	34	8
May	8.5	42	2
Jun	12.4	60	0
Jul	15.7	44	0
Aug	15.7	34	0
Sep	10.8	37	1
Oct	4.8	44	4
Nov	-1.6	68	34
Dec	-5.3	63	49
Yearly[1]	4.7	563	191

Notes:

1. Yearly values are the yearly average for mean monthly temperature (°C) and total yearly precipitation for precipitation (mm) and precipitation as snow (mm).

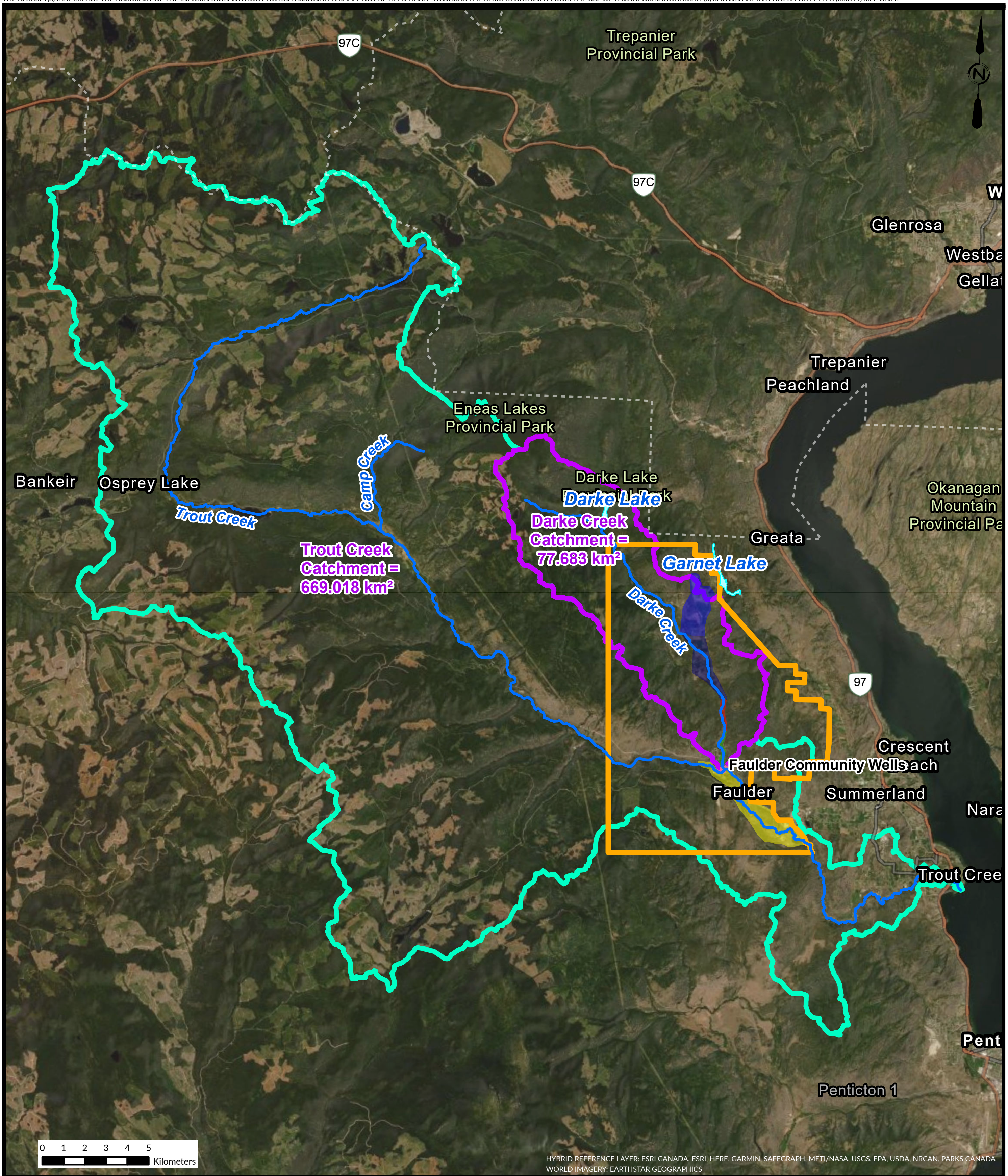
[7] https://www.climatewna.com/ClimateBC_Map.aspx

2.3 Hydrology

Two main creeks run through Aquifer #299; Trout Creek and Darke Creek (Figures 1-1, 2-1. 2-2, 2-3, and 2-4). Trout Creek has a drainage area of 746 km^2 and Darke Creek, a sub-catchment within the Trout Creek catchment, has a significantly smaller drainage area of 77.7 km^2 (Figure 2-6) Both creek catchment areas are major contributors of recharge to Aquifer #299. Based on their respective catchment size, Trout Creek is estimated to contribute 88% and Darke Creek 12% to aquifer recharge (Golder 2013) via creek bed leakage, direct infiltration of precipitation, and mountain block recharge. Both creeks have regulated flows with many regulated (and likely unregulated) points of surface water diversion located along their length, used for public water supply, private domestic water supply, and for irrigation and livestock watering. Flow in each creek is highly variable, typically peaking in late May and early June (Golder 2013). A comparison of available Aquifer #299 water level elevation data compared to the elevation of Darke Creek indicates that Darke Creek is perched through Meadow Valley and Faulder to its confluence with Trout Creek, except during times of high aquifer water levels when groundwater may intersect and provide baseflow to the creek in Meadow Valley. As a perched creek, creek bed leakage occurs along Darke Creek where it flows over permeable deposits. This results in intermittent flow south of Marsh Lane in south Meadow Valley and the creek is typically dry at its confluence with Trout Creek.

There is no recent flow data available for Trout Creek and only limited data available for Darke Creek which consists of two hydrometric stations set up in 2020. One hydrometric station (MVID Weir) is located upstream of where Darke Creek flows into Meadow Valley and the second station (Mineola) is located near Mineola at the southern end of Meadow Valley (Figures 1-1, 2-1, and 2-2). The unapproved flow data[8] is presented in Figure 2-7. The data shows the regulated nature of Darke Creek, with an increase in flow recorded at MVID Weir from June to September in both 2020 and 2021, when it is assumed water was released from Darke Lake. The hydrograph for Mineola does not show the increase in flow, suggesting that the majority of additional streamflow from water released from Darke Lake is either used for irrigation purposes or is evidence of a “losing stream” reach recharging groundwater. The hydrograph also shows that flow recorded at Mineola during summer 2021 was virtually zero. The higher flows recorded at Mineola compared to MVID Weir over the winter and spring months likely reflects additional flows from other creeks draining into Darke Creek between the two hydrometric stations.

[8] Unapproved flow data has not been checked and verified and the data may be subject to change if rating curve shifts are identified during review.



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Associated Environmental

- Study Area
- Darke Creek Catchment
- Trout Creek Catchment
- North Meadow Valley Aquifer
- South Meadow Valley Aquifer
- Meadow Valley Pinch Out
- North Faulder Aquifer
- South Faulder-Trout Creek Valley Aquifer

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FIGURE 2-6: CREEK CATCHMENT AREAS

REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

MEADOW VALLEY AQUIFER STUDY

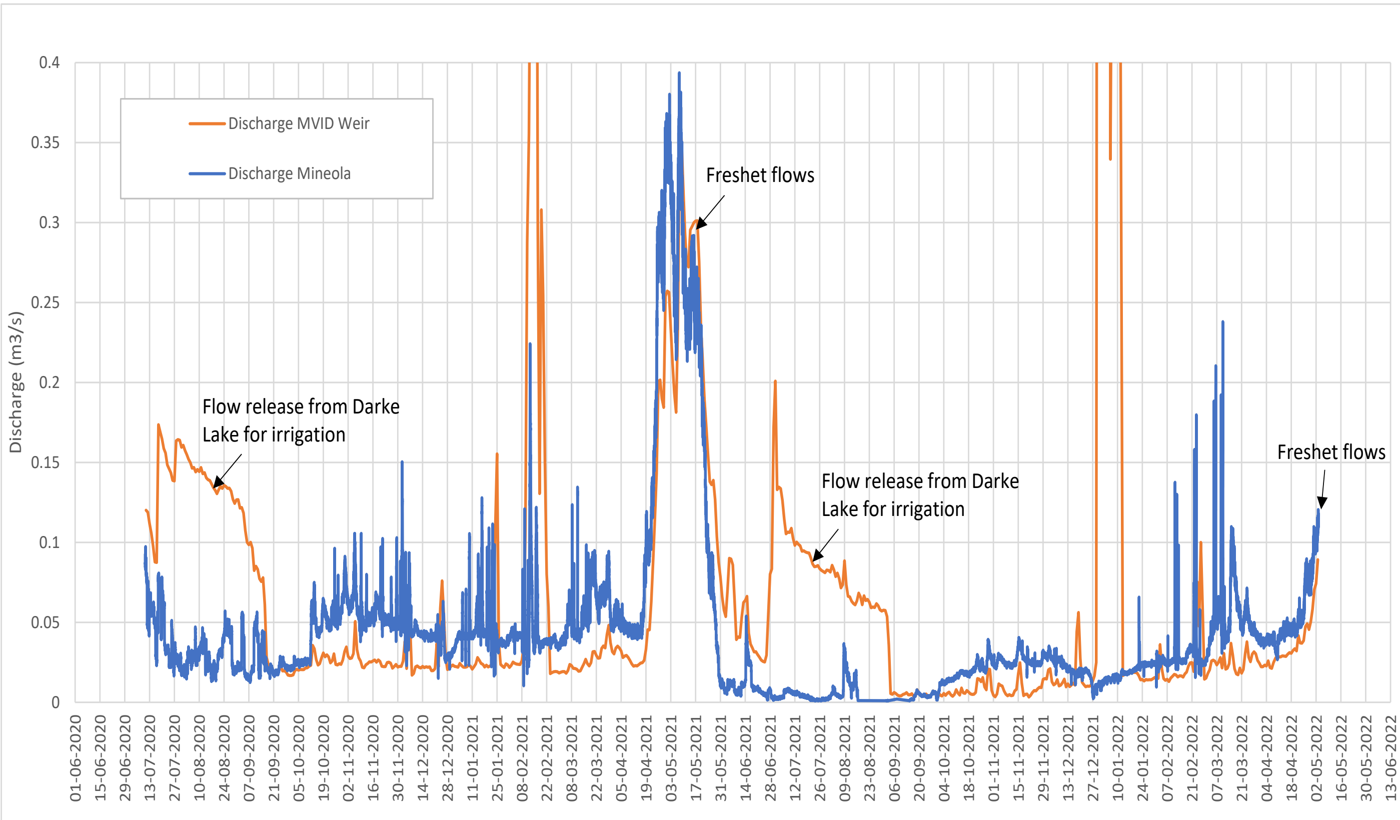

Figure 2-7
Flow Measurements from Hydrometric Stations on Darke Creek

Golder Associates collected field flow measurements on both Trout Creek and Darke Creek on October 3, 2013 (typically a period of low flow) to assess creek bed leakage (Golder 2013). On Trout Creek, two measurements were taken 330 m apart at locations just upstream of where Darke Creek flows into Trout Creek. The results showed flow in Trout Creek of 2.1 m^3/s at the upstream monitoring location and 1.46 m^3/s at the downstream location, a 0.64 m^3/s (640 L/s) reduction in flow between the two measurement points, which is a significant quantity of water. It is likely this water was lost to hyporheic flow[9] with an unknown proportion potentially providing recharge to Aquifer #299 where it infiltrates through areas of more permeable deposits (known to exist in this area based on well logs). Additional flow gauging would be required to verify this quantity of streamflow loss through this area and if it varies at different time of the year, as this leakage likely provides important recharge to Aquifer #299.

Field flow measurements were carried out on Darke Creek in the Meadow Valley area, with a loss of 0.012 m^3/s (12 L/s) measured where Darke Creek flows over alluvial deposits as it enters Meadow Valley. Within Meadow Valley, various

[9] Flow through sand and gravel substrate of the stream

points of surface water diversion complicated the calculation of flow changes in the creek, making it difficult to calculate flow losses. Flow gauging was also conducted on the lower portion of Darke Creek with a measurement at the north end of Faulder and a second location closer to the confluence with Trout Creek. These field measurements indicated a 0.017 m^3/s (17 L/s) reduction in flow, from 0.02 m^3/s (20 L/s) to 0.003 m^3/s (3 L/s) along this reach. The flow losses recorded along Darke Creek illustrate the important role creek bed leakage from Darke Creek has on recharge to Aquifer #299 in Meadow Valley and the north Faulder areas. Additional flow gauging would be required to verify the quantity of streamflow loss through these areas and how leakage varies over the year.

2.4 Geology and Hydrogeology

Two mapped aquifers underly the study area: Aquifer #300 and Aquifer #299, as follows:

- Aquifer #300 (Faulder/Eneas Creek) is mapped as a fractured crystalline (igneous intrusive, or metamorphic, meta-sedimentary, volcanic) bedrock aquifer, with moderate productivity, moderate density, and low vulnerability to contamination. Only seven wells are mapped as correlated to this aquifer, with the median well yield of 0.22 L/s (3 USgpm). Sometimes wells that are considered “bedrock” are installed in the uppermost portion of a bedrock aquifer, and these wells can influence water levels in the sand and gravel aquifer above it.

- Aquifer #299 is an unconsolidated unconfined and semi-confined aquifer running from the north end of Meadow Valley near Garnet Lake, south down Meadow Valley to Faulder, and then southeast down the Trout Creek valley to the Summerland Rodeo Grounds (Figure 1-1). Well logs and previous reporting indicate Aquifer #299 consists of predominantly uncemented, loose sand and gravel, deposited as glacial outwash during glacial retreat during the last ice age (Golder 2013). In the Meadow Valley part of the aquifer, the aquifer is formed from alluvial fan deposits where the tightly-bedrock constrained Darke Creek enters the wider Meadow Valley. The remainder of the section describes Aquifer #299 in more detail.

Three cross-sections have been drawn using well log data to show the aquifer’s geology:

- **A-A’** runs west (WTN 98980) to east (WTN 42468) along the groundwater divide in Meadow Valley (Figure 2-8).
- **B-B’** runs nearly the entire north to south extent of Aquifer #299, from well WTN 61476 at the north end of North Meadow Valley Aquifer to FCW1 at the north end of Trout Creek Valley Aquifer (Figure 2-9). Insufficient well logs are available to extend the section further southeast along Trout Creek Valley.
- **C-C’** shows the runs from west (Mearns Well [WTN 83231]) to east (Gibbs Well [83206]) to show the hydrogeology in the Faulder Community Water System area (Figure 2-10).

Note: during review of well logs in the aquifer, it was recognised that many wells were shown in the wrong locations with incorrect coordinates. Therefore, the positions of these wells were manually adjusted based on location sketches provided with the well logs. The cross sections are based on the adjusted well locations.

In Meadow Valley, well logs indicate that aquifer thickness is consistently thin relative to the Faulder and Trout Creek Valley areas, ranging from about 1 m to 8 m, although the overburden can be far thicker, > 79 m at WTN 47163 (Figure 2-8 and 2-9). In the Faulder and southeast parts of the aquifer, the aquifer is constrained within a narrow valley by steep bedrock valley edges. Where present, the aquifer’s thickness is highly variable, ranging from 2m to 43 m, again the overburden is substantially thicker; at least 94 m at FCW2 (WTN 111310) (Figure 2-9 and 2-10). In Faulder the aquifer generally thins to the north and steadily thickens moving south, and appears thickest in the area around the old and current Faulder Community Wells, FCW1 (WTN 83205) and FCW2 (WTN 111310), respectively. As expected, thinner parts of the aquifer are generally found along the valley edges and thicker parts along the valley axis. In the Meadow Valley area and north Faulder, well logs indicate that the aquifer is shallow and largely unconfined (Figures 2-8 and 2-9). Moving southeast down the valley toward Summerland, the aquifer remains relatively thick, about 20 m in the central valley (WTN 82797), and thins at the valley edges. In south Faulder and to the southeast towards Summerland, the aquifer is semi-confined (Figure 2-9 and 2-10) in that groundwater levels occasionally fall below the upper confining layer of the overlying aquitard (Golder 2005). Overall, through Meadow Valley and into Faulder and southeast, Aquifer #299 is heterogeneous and its water production is highly variable. Well yields range from 1 GPM (WTN 57926 in North Meadow Valley Aquifer) to 650 GPM (WTN 83211 in Trout Creek Valley Aquifer), likely due to the heterogeneous nature of aquifer material deposition (glacial outwash). We noted that there are likely areas within Aquifer #299's extent that are not productive enough for viable groundwater wells.

Although the aquifer is largely unconfined in the Meadow Valley area, where it is confined, the confining layer is generally composed of clay and silt rich material, and tight and/or cemented sands and gravels. The confining aquitard in both Meadow Valley and the Faulder area is interpreted as kettle deposits left during glacial retreat (Golder 2013). In the Faulder and southeast areas of the aquifer, the aquitard is a mix of clay and silt rich tills and tight and/or cemented sands and gravels. In the Faulder area, the confining aquitard is absent in north Faulder but becomes present and is thick at 104 Fish Lake Road. It then thins, moving south before thickening again substantially in south Faulder where the Faulder Community Wells are located. Well logs indicate the aquitard remains present in most places moving southeast of Faulder toward Summerland.

The basal confining units for the aquifer in the Meadow Valley area appear to be a mix of igneous bedrock, and in some places, glacial lacustrine deposits of clays and silts. These surficial deposits are discontinuous, potentially eroded during outwash sands and gravel deposition. In the Faulder and southeast area, wells logs show Aquifer #299 directly overlying bedrock.

The uncemented, loose sand and gravel nature of the aquifer makes it highly prolific in the south Faulder area where the aquifer is thickest and deepest; flows are up to 18.3 L/s (290 GPM [WTN 83205]). Transmissivity for WTN 82305 (FCW1) was 715 m^2/day (GWELLS, MOE 2022) and nearby WTN 111310 (FCW2) was in the order of 500 m^2/day (Golder 2015). In the Meadow Valley area where the aquifer is thinner or has some fines present, water production is highly variable, ranging from below 0.2 L/s (3 GPM [ex. WTN 117]) to 5.8 L/s (92 GPM [ex. WTN 26708]). In the north and central Faulder area flows have a narrower range from 0.5 L/s (8 GPM [ex. WTN 51514]) to 2.5 L/s (40 GPM [ex. WTN 40247]). Overall for Aquifer #299, GWELLS lists the median well yield as 1.77 L/s (28 GPM), with a median well depth of 41.3 m bgs and a median depth to water level of 18.9 m bgs.

Although provincial mapping shows the boundary of Aquifer #299 in Trout Creek Valley ending just west of Faulder and the southeastern (downgradient) extent of the aquifer ending just west of Summerland Rodeo Grounds, likely this is not the case, and in reality, the boundary is mapped this way due to the lack of groundwater wells in those areas. The more likely scenario is that the aquifer extends further west within the Trout Creek valley, upgradient and to the west of Faulder. Likewise, it is unlikely Aquifer #299 ends sharply at the Summerland Rodeo Grounds but potentially discharges into Aquifer #297, an unconfined-confined deltaic aquifer, underlying Trout Creek shown mapped to the south of Summerland, and ultimately discharges either as springs or below water level into Okanagan Lake. Alternatively, there may be a geological no/low flow boundary at the southeastern extent of the mapped aquifer resulting in groundwater rising to the surface and discharging to Trout Creek via springs (a spring called Summerland Spring is present near the eastern extent of the mapped aquifer).

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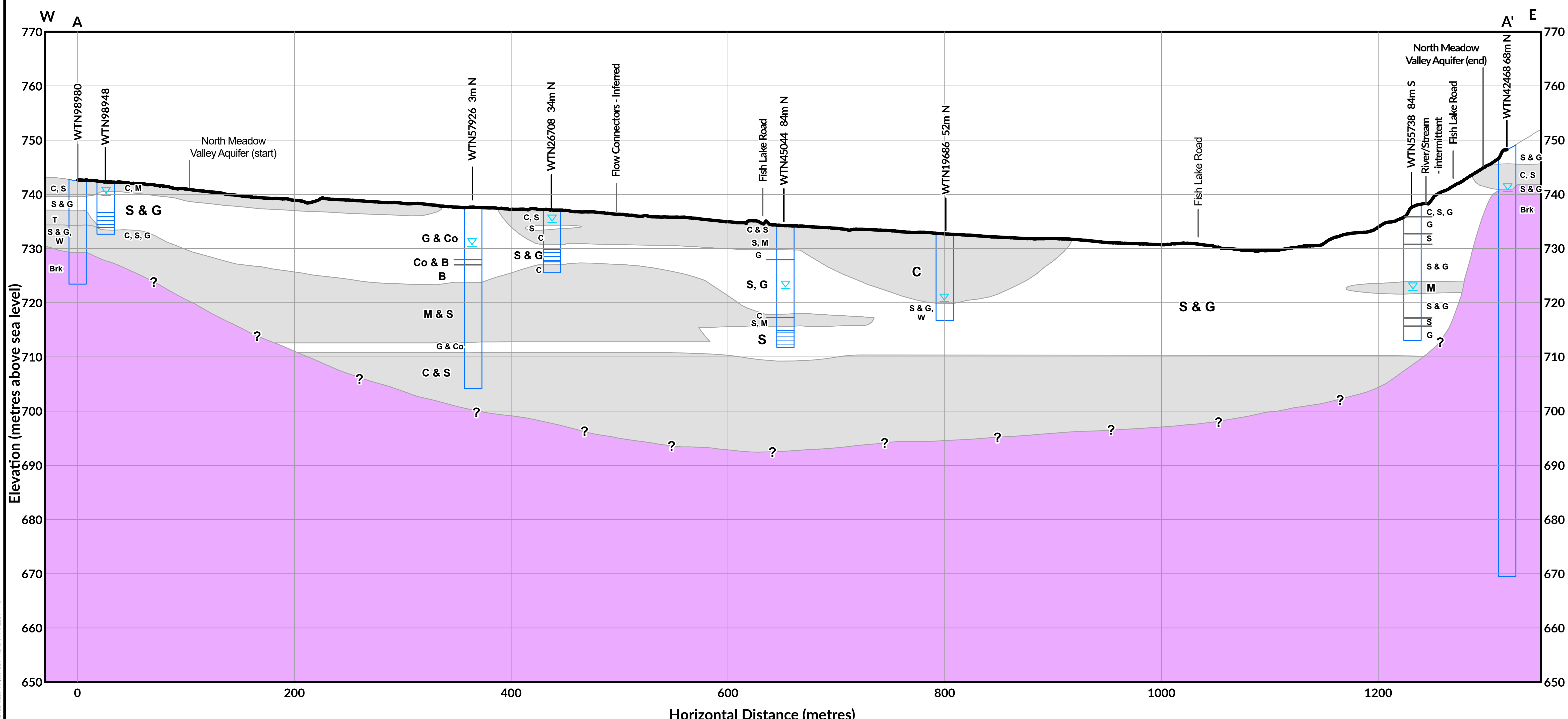

Water Table

Aquifer like sediment

Aquitard

Bedrock

Screen

C = clay
M = silt
S = sand
G = gravel
B = boulders
T = Till

Co = cobbles
Brk = bedrock
W = wet
? = Lithology contact unknown

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FIGURE 2-8: CROSS - SECTION A-A'

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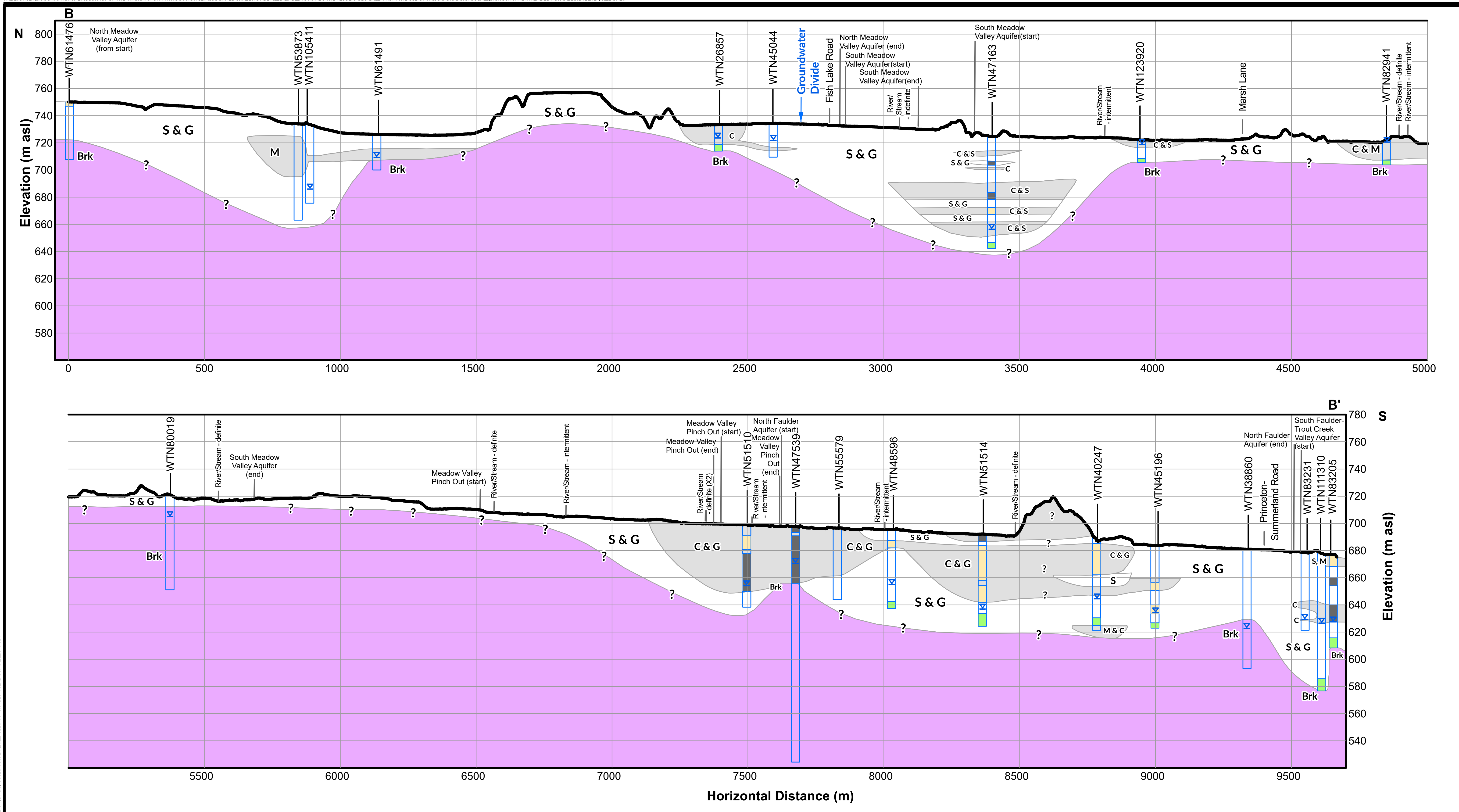
MEADOW VALLEY AQUIFER STUDY



Water Table
Aquifer like sediment
Aquitard
Bedrock

Screen
Cemented
Tight

C = clay
M = silt
S = sand
G = gravel
B = boulders
T = Till

Co = cobbles
Brk = bedrock
? = Lithology contact unknown

Associated Environmental

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FIGURE 2-9: CROSS - SECTION B-B'

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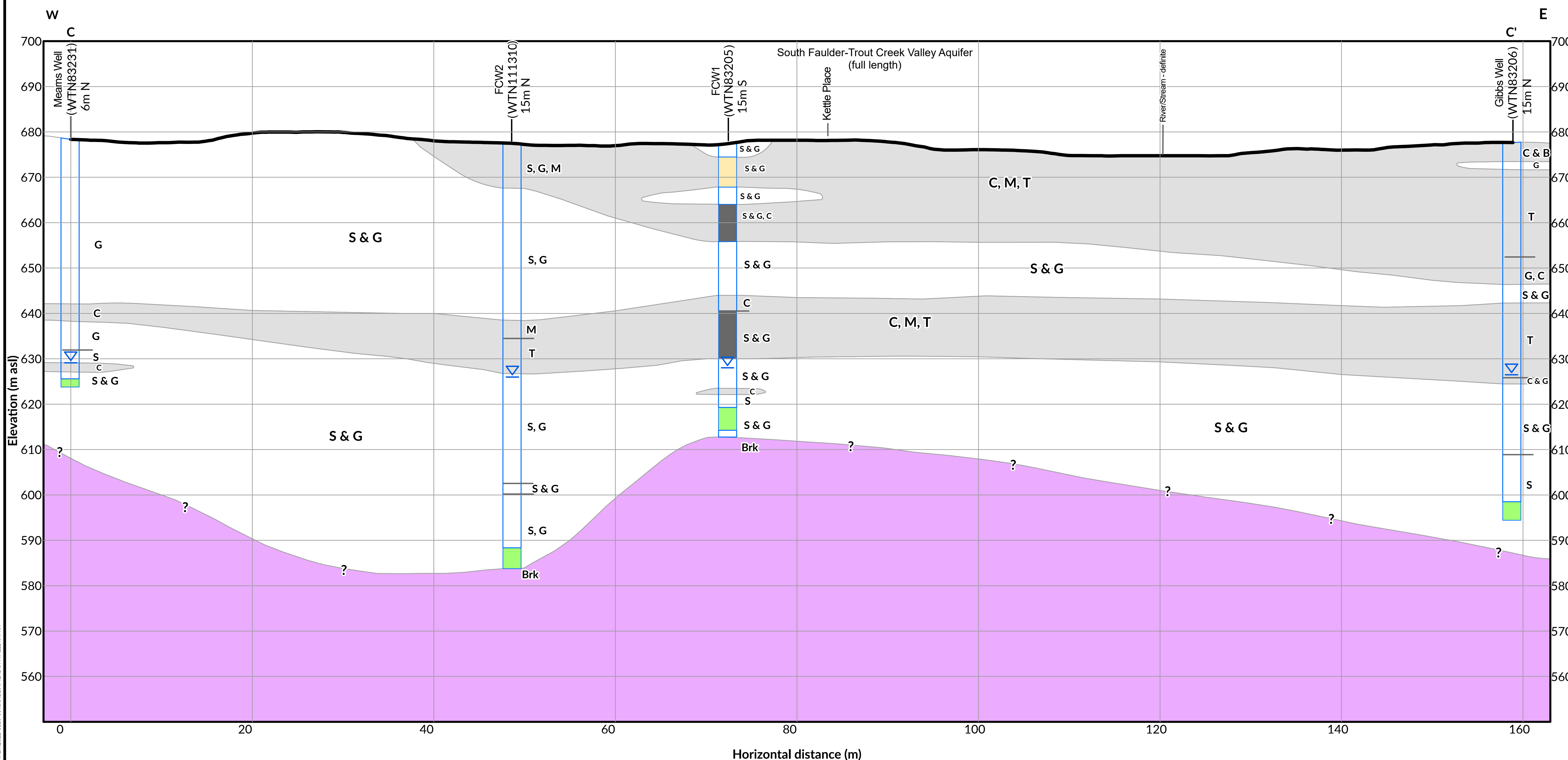
MEADOW VALLEY AQUIFER STUDY



Water Table
Aquifer like sediment
Aquitard
Bedrock

Screen
Cemented
Tight

C = clay
M = silt
S = sand
G = gravel
B = boulders
T = Till

Co = cobbles
Brk = bedrock
? = Lithology contact unknown

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FIGURE 2-10: CROSS SECTION C-C'

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MEADOW VALLEY AQUIFER STUDY

2.4.1 Groundwater Flow

Flow Aquifer #299 is divided into two flow regimes, the flow direction diverging at approximately the east-west running part of Fish Lake Rd (Figure 2-1) in Meadow Valley. To the north of Fish Lake Rd, groundwater flows in a north to northeast direction discharging at Acland Spring. To the south of Fish Lake Rd, groundwater flows south towards Faulder and Trout Creek and then flows in a southeast direction beneath Trout Creek valley toward Summerland. In the Meadow Valley area, the aquifer/bedrock interface potentially has a basin shape, with bedrock rising at the south end of Meadow Valley, just north of Mineola. This may require groundwater levels to be above this bedrock 'lip' before groundwater is able to 'spill over' and flow south toward Faulder. This would cause discontinuous flow from the north/Meadow Valley end of Aquifer #299 into the Faulder part of the Aquifer #299 and may be responsible for the occasionally low groundwater levels experienced in north Faulder. Groundwater levels in south Faulder are likely not affected as that portion of the aquifer receives recharge via creek bed leakage from Trout Creek (discussed in Sections 2.2 and 3.4).

2.4.2 Aquifer Recharge and Aquifer Water Levels

Recharge to the aquifer is likely driven mostly by stream bed leakage, direct infiltration from precipitation, adjacent groundwater inflows (e.g., mountain block recharge), and returns from irrigation and septic water (Golder 2013). Groundwater inflows from upgradient aquifers is multifaceted: North Faulder Aquifer receives groundwater inflows from the upgradient South Meadow Valley Aquifer when groundwater levels in South Meadow Valley Aquifer are sufficiently high; Trout Creek Valley Aquifer receives groundwater inflows from two upgradient aquifers, North Faulder Aquifer and the unmapped unconsolidated valley aquifer underlying Trout Creek west of Faulder. Note, North Meadow Valley Aquifer and South Meadow Valley Aquifer will not receive flow from upgradient aquifers, as there are no upgradient aquifers to these aquifers, only recharge from stream bed leakage from Darke Creek and mountain block recharge.

Recharge is difficult to quantify across Aquifer #299, as there is no current and consistent groundwater level monitoring in Aquifer #299 other than at FCW1 and FCW2 located in Trout Creek Valley Aquifer. Hence, exact recharge and groundwater level trends over time in North Meadow Valley Aquifer, South Meadow Valley Aquifer and North Faulder Aquifer, are unknown. Note the Provincial Observation Well Network has an inactive monitoring well, OBS Well 366 at the southeast end of the Trout Creek Valley Aquifer near the Summerland Rodeo Grounds, the only such well in Aquifer #299 (Figure 1-1). The period of record is from 2005-2021 (16 years), when the Province took it out of service to install a packer because the well experienced flowing artesian conditions (i.e. the aquifer pressure raises the water column in the well casing to above the ground surface).

Groundwater level data is available from 2007 to 2021 for FCW1 and 2017 to 2021 for FCW2. Recharge to the aquifer is measured by observing a rise in groundwater levels at FCW1 or FCW2. These groundwater level changes are highly variable, some years experience annual water level rises exceeding 9 m (2018), while other years see very little or no annual water level rise (2007, 2009, 2019, and 2021) (Table 2-2 and Figure 2-11). These observation trends were also noted in the hydrograph for OBS Well 366, though ranges were more muted, with a rise of about 6 m over the 16 year period of record, including a decline of about 2 m from 2006 to 2012, a rise of about 8 m from 2012 to 2021, and smaller seasonal fluctuations of about 1-2m each given year[10].

[10] Observation well graphs are available at: https://aqrt.nrs.gov.bc.ca/Report/Show/Groundwater.OW366.GWGraphAllData/

Table 2-2
Aquifer Recharge Recorded at FCW1 or FCW2

Year	Water level rise (m)	Year	Water level rise (m)	Year	Water level rise (m)
2007	Negative	2012	0.6*	2017	Insufficient data
2008	0.8	2013	8.6	2018	9.4
2009	Negative	2014	2.4	2019	Negative
2010	1.2	2015	0.9	2020	5.3
2011	8.9*	2016	Insufficient data	2021	negative

*Incomplete data

In general, recharge appears to be freshet and precipitation driven, where accumulated snow melts and infiltrates into the ground or flows as runoff into creeks. Leakage through the stream bed then infiltrates into the aquifer (Golder 2005, Golder 2013, Wilson 1990). Groundwater levels are generally at their minimum in late spring and typically experience recovery (recharge) between April and August, peaking in July or August. Conversely, recharge is at a minimum through winter where frozen precipitation and ground reduce any infiltration to the groundwater system. Figure 2-11 shows that the range in aquifer water level over the period 2007 to 2021 is in in excess of 20 m[11]. Again, these observation trends were also noted in OBS Well 366's hydrograph, though ranges were more muted, as described previously.

[11] Note that the hydrographs in Figure 2-11 show the depth to water below top of casing for the two wells, the water levels have not been converted to an m asl elevation due to a possible shift in the water level readings obtained in one of the wells which may over emphasise the water level difference observed between FCW1 and FCW2 by +/- 3-4 m. However, the hydrographs do show the trend in water level and the changes in water level shown in the individual wells are correct.

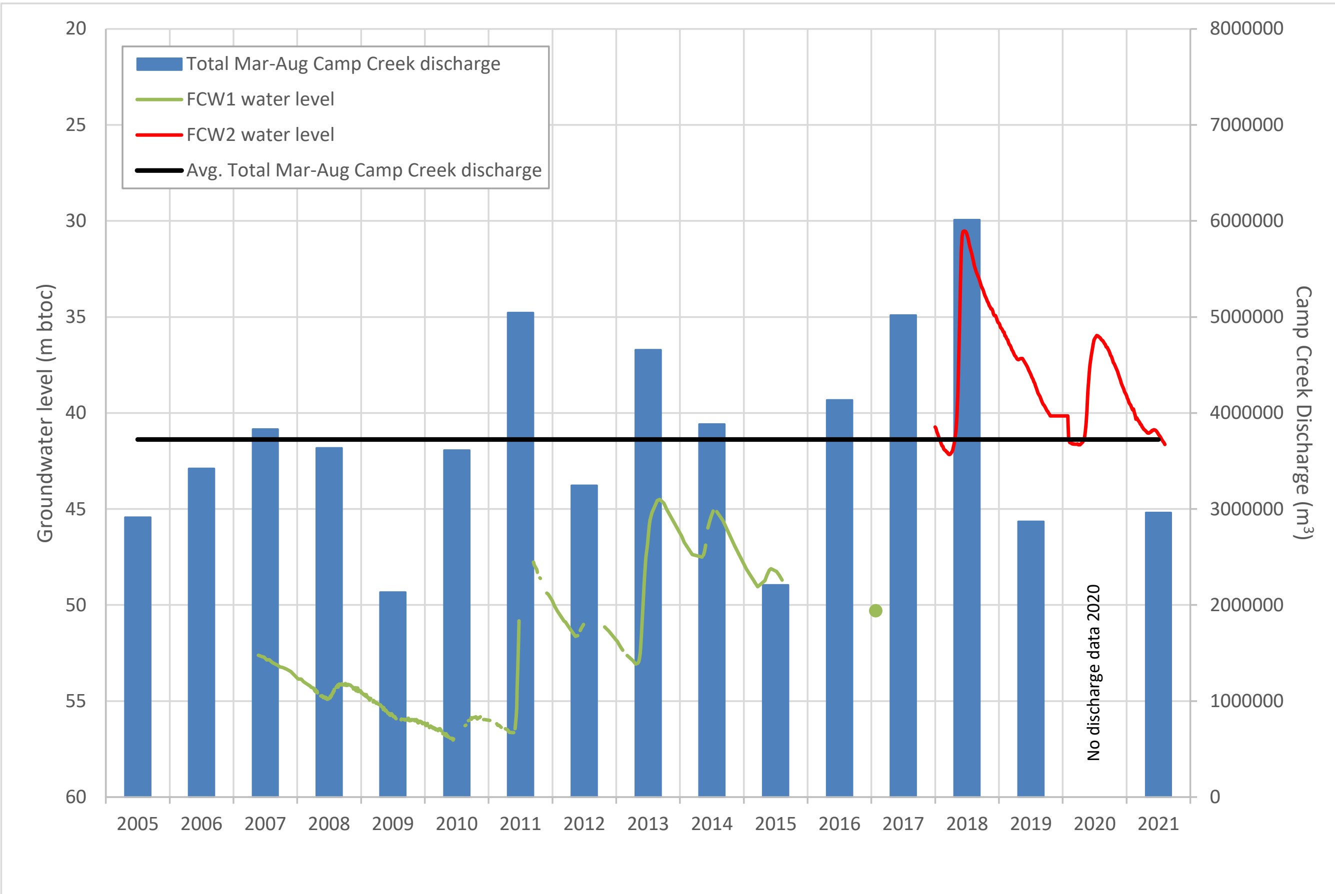

Figure 2-11
Groundwater Level in FCW1 and FCW2 and Camp Creek March to August Total Discharge

Total March to August streamflow discharge from Environment Canada's hydrometric station on Camp Creek near Thirsk Reservoir (Station ID: 08NM134) have also been plotted on Figure 2-11. This data is used as a crude proxy for precipitation and stream flow discharge for Meadow Valley/Faulder and Trout Creek/Darke Creek. The Camp Creek data set is used because it is located in a neighbouring catchment, flow in Camp Creek is unregulated (i.e., not influenced by diversions), and it has a data record which covers the same period that groundwater level data is available for the Faulder Community Wells. Higher levels of precipitation in winter (released in Freshet) and spring lead to increased discharge in streams in the Okanagan. Comparison of the Camp Creek discharge to groundwater levels in FCW1 and FCW2, clearly indicates a positive correlation between discharge quantity and aquifer groundwater levels (Figure 2-11). Years with above average creek discharge in March to August (e.g., 2011, 2013 and 2018), show greater levels of recharge (larger rise in groundwater level) in FCW1 and FCW2. Whereas, in years with below average creek discharge in March to August (e.g., 2009, 2015, and 2019), there is little or no recharge observed in FCW1 and FCW2. The only year in which the correlation does not fit is 2007 where a higher than average March to August creek discharge is not reflected by a rise in aquifer water level. This may be due to the relatively simple nature of this assessment which may not capture local differences between the catchments or timing in precipitation. However, with the exception of 2007, there is a strong correlation between the Camp Creek discharge and recharge to the aquifer, indicating that changes in aquifer water levels strongly reflect preceding winter and spring precipitation. Likewise, these observation trends were also noted in OBS Well 366's hydrograph, though ranges were more muted, as described previously.

A comparison of Faulder Community Water System annual withdrawals was also made to determine the impact the groundwater extraction from this water system has on aquifer water levels (Figure 2-12). A review of the data indicates that higher annual groundwater extraction does not correspond to decreased levels in the aquifer, nor do decreased groundwater extraction rates correspond to increased groundwater levels. This suggests that the current Faulder Community Water System extraction rates do not have a meaningful affect on aquifer groundwater levels. As a note of caution, groundwater and surface water use for irrigating in Meadow Valley are likely to vastly exceed the community system's domestic use withdraws and may indeed correlate negatively to groundwater levels. This potential correlation would also likely be exacerbated during times of low precipitation and stream flow (e.g., 2009-2010 and 2015) when withdrawals for irrigating would be at their greatest.

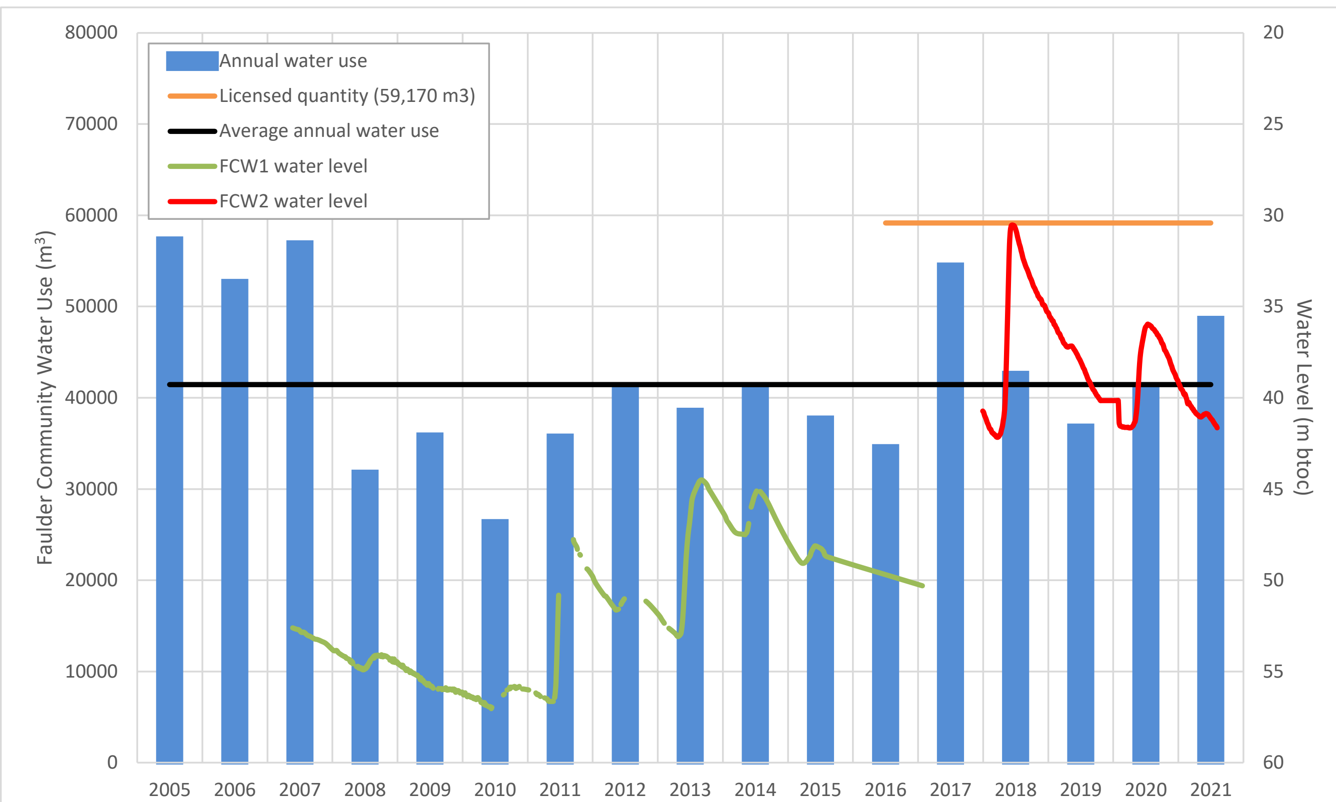

Figure 2-12
Groundwater Level in FCW1 and FCW2 and Annual Water Extraction from Faulder Community Water System

3 GROUNDWATER AVAILABILITY BY AQUIFER SUB-REGIONS

As introduced in Section 1.3 Aquifer #299 has been split into four aquifer sub-regions because of the important differences in recharge, and aquifer properties, which are important in the context of groundwater availability. The following sections describe the aquifer setting, recharge mechanism, water use and groundwater availability for each aquifer sub-region. It also provides recommendations for future data acquisition and groundwater and surface water use.

3.1 North Meadow Valley Aquifer Sub-Region

3.1.1 Aquifer Setting

North Meadow Valley Aquifer sub-region is located at the northern extent of Aquifer #299 (Figure 2-1). Its southern boundary is defined by a groundwater divide where Darke Creek enters the Meadow Valley area. Groundwater generally flows north to northeast, and likely discharges from the aquifer at Acland Spring which in turn flows into Garnet Lake (Golder 2005, Golder 2013, Wilson 1990). It is generally unconfined and composed of a thin layer (up to 10m (Figure 2-8) of unconsolidated material including sands, gravels, and cobbles. The aquifer typically directly overlies bedrock near the valley's edge but also occasionally towards the valley's middle. More typical of wells in the valley's middle is for the aquifer to directly overlie clay-silt rich sediment and not intersect bedrock.

Well depths are between 8.7-60.0 m (28.5-197 ft), with a median of 33.5 m (110 ft). Well yields are between 0.1-12.6 L/s), or 1-200 USgpm, with a median of 1.6 L.s (25 USgpm).

3.1.2 Aquifer Recharge

Recharge to this aquifer is predominantly by leakage from Darke Creek as the creek flows over an alluvial fan, and direct infiltration from precipitation. There are no groundwater inflows from upgradient surficial aquifers, as there are no upgradient aquifers to this sub-region. However, there is likely to be some mountain block recharge from the bedrock hillsides, although due to the thin nature of the overburden in the valley, these flow inputs may be modest. There is also likely an additional minor component of aquifer recharge to North Meadow Valley Aquifer from irrigation and septic returns. Irrigation returns are generally in the order of 7.5 % to 42.5 % depending on soil and irrigation methods used for the Okanagan Basin (Associated 2016). Septic returns are expected to be minor contributors to recharge relative to the other forms discussed above.

3.1.3 Water Use

The North Meadow Valley Aquifer sub-region consists primarily of lands zoned Agriculture Three (AG3) which are mostly within the Agricultural Land Reserve (ALR) but also includes some lands zoned Large Holdings One (LH1). This area is outside of the Faulder Community Water System; therefore, all properties require their own source of water for domestic and commercial use. Water is predominantly used for irrigating crops (mainly for forage), watering livestock (predominantly cattle and horses – up to 200 to 300 head in a given fall/winter), and domestic use (Wiens, A, pers. comm. 2022).

There are 27 wells registered with the Province. Well uses include private domestic, irrigation, other, and unknown. Of the four documented as used for irrigation, two are licensed. Under the WSA, irrigation use requires a water licence. A summary of the registered wells by sub-region is located in Appendix A.

Water licences (surface and groundwater for the Study Area are listed in Appendix B. There are 38 water licences issued by the Province within the North Meadow Valley and upstream areas of the Darke Creek watershed. Licences extracting groundwater from Aquifer 299 total 98,726 m^3/year, and licences extracting groundwater from Aquifer 300 total 179,715 m^3/year. Licences with surface water intakes on Darke Creek total 2,88,070 m^3/year, and licences with intakes for all surface water bodies total 3,04,172 m^3/year. The total sum of water licences in this area is 3,342,163 m^3/year. Total water use may exceed these values as some commercial enterprises may be using unlicensed groundwater and there is no requirement for domestic users to licence their wells for domestic groundwater use. However, some licenced users may use far less than their licenced amount. For example, the RDOS' licence for the Faulder Community Water System is typically well under their licenced volume.

Of particular interest is that a surface water licence has been issued as recently as Dec 27, 2016. This suggests that the Province continues to issue surface water licences in this area. This is quite surprising considering that mountainside creeks along the valley walls are an important source of recharge to the valley bottom aquifer, and there have been groundwater availability concerns for many years in this area (see recommendations in Section 5.2). We understand that Aquifer #299 has a "possible water shortage notation"; however, the link between mountainside creeks and their contribution to groundwater recharge may need to be reinforced to the people responsible for issuing surface water authorizations.

For domestic use, groundwater and surface water is used, and only domestic use sourced by surface water requires a water licence under the WSA. The RDOS Sub-Division Servicing Bylaw No. 2000, 2002 Schedule A states "maximum daily domestic flow" as 8,000 L/day per parcel; however, a more likely value for domestic water use is the Okanagan annual average water of 675 L/day per person (OBWB 2010). Domestic use of water includes indoor (drinking water, food preparation, sanitary) and outdoor (landscaping, recreation).

Personal communications with Al Wiens, Owner and Water Bailiff of the Meadow Valley Irrigation District (MVID) stated that numerous wells in the district have reported negative water pressures (in other words, the water level reaches the pump level in the wells) in dry years (Wiens, A, personal communication, 2022).

3.1.4 Groundwater Availability

Based on the geology of the aquifer (i.e., the aquifer is generally thin with many wells already located just on top of bedrock or confining layers), and reports from water well owners that wells "go dry", it is reasonable to conclude that groundwater availability is fully allocated in dry year. Additionally, Associated strongly recommends against increasing any further surface water diversions/licences along Darke Creek or any springs and streams that feed into Darke Creek because Darke Creek is the predominant source of recharge for the North Meadow Valley Aquifer, and further reductions in flow would reduce the amount of water available for recharging the aquifer (discussed further in Section 4.2).

3.1.5 Interaction with Other Sub-Regions

Groundwater and surface water use in North Meadow Valley Aquifer will likely only affect users in North Meadow Valley Aquifer because of the groundwater divide that would prevent flow from North Meadow Valley Aquifer and Trout Creek Valley Aquifer.

3.1.6 Future Data Acquisition and Water Use Recommendations

Critical Data Acquisition

- There is no critical data acquisition required for this aquifer. There is sufficient data to indicate that North Meadow Valley Aquifer is fully allocated in dry years based on the geology and water level observations from local well logs and from interviews with residents.

Non-Critical but Easy to Obtain Data Acquisition

- Continue groundwater monitoring at well WTN 45044 where a water level data logger was installed in April 2022 until at least Fall 2023 (this will require the continued approval from the landowner). This dataset will allow a full season of groundwater levels to be observed to gain a better understanding of groundwater fluctuations in response to recharge and extractions. It will also aid in the determination of if/when groundwater use restrictions should be implemented.

Non-Critical Data Acquisition

- Conduct flow accretion profiling/streamflow gauging of Darke Creek and other creeks flowing across this area. This would involve measuring streamflow at various locations along Darke Creek, repeated multiple times during the year to monitor streamflow changes. This will provide more robust aquifer recharge data via creek bed leakage from Darke Creek and other creeks.
- Collect long-term groundwater level monitoring data from one or more wells (potentially drill a monitoring well) constructed within Aquifer #299 in this sub-region. This long-term dataset will allow a better understanding of yearly groundwater fluctuations and response to recharge. The data could be used to provide an early warning to groundwater users when aquifer water levels are getting low and will also aid determination of if/when groundwater use restrictions should be implemented.
- Measure the quantity of surface water diverted and used for irrigation purposes, and ensure they are kept within the licenced quantity, if feasible.

Recommendations

- Restrict additional surface water diversions from Darke Creek or other mountainside creeks for commercial and private/domestic irrigation use, as this water provides important recharge to the aquifer.
- Promote water conservation measures and encourage reduced groundwater and surface water extractions for private and domestic irrigation use in dry years.

3.2 South Meadow Valley Aquifer Sub-Region

3.2.1 Aquifer Setting

The South Meadow Valley Aquifer sub-region is located in the southern half of Meadow Valley in Aquifer #299 (Figure 2-2). The northern boundary has been defined by a groundwater divide at the area where Darke Creek enters the Meadow Valley area. Groundwater generally flows in a south direction toward Faulder (Golder 2005, Golder 2013, Wilson 1990).

Well depths are between 12-80m (39-260 ft), with a median of 14.3 m (47 ft). Well yields are between 0.4 and 5 L/s (6-80 USgpm), with a median of 1.3 L/s (20 USgpm) (Appendix A). The geometry and material is similar North Meadow Valley Aquifer.

As described in Section 2.3, the data suggests that there is a groundwater basin formed by the bedrock's geomorphology that prevents groundwater from flowing down gradient toward North Faulder Aquifer until the groundwater level has gone above this bedrock basin 'lip' and 'spills' down into the North Faulder Aquifer. In successive dry years it is likely groundwater levels do not climb above this lip and in turn cause reduced groundwater levels in the North Faulder Aquifer.

3.2.2 Aquifer Recharge

Recharge to this aquifer is predominantly provided by leakage from Darke Creek as the creek flows over an alluvial fan, and direct infiltration from precipitation. There are likely no groundwater inflows from upgradient aquifers, as there are no upgradient aquifers to this sub-region. The flow from North Meadow Valley Aquifer is to the north and so will not recharge South Meadow Valley Aquifer.

3.2.3 Water Use

The South Meadow Valley Aquifer sub-region consists primarily of lands zoned AG3 within the ALR but also includes some lands zoned Resource Area (RA). Like North Meadow Valley Aquifer, the South Meadow Valley Aquifer area is outside of the Faulder Community Water System; therefore, all properties require their own source of water for domestic and commercial use. Water use is similar to North Meadow Valley Aquifer.

There are 11 well registered with the Province (Appendix A). Well uses include private domestic, other, and unknown. No wells are licenced (and domestic use does not require licensing under the WSA).

There are 18 water licences issued by the Province within the South Meadow Valley Aquifer and upstream areas within the Darke Creek watershed (Appendix B). Licences extracting groundwater from Aquifer 299 total 1,440 m^3/year, licences with intakes on Darke Creek total 1,107,912 m^3/year, and for all surface water totals 1,142,537 m^3/year. The oldest priority date is 1892, and the most recent dates are 2008 for a groundwater licence (on the "Summerland Unconsolidated" aquifer) and 1993 for a surface water licence (on Darke Creek).

3.2.4 Groundwater Availability

Similar to North Meadow Valley Aquifer, based on results of our study, groundwater and surface water is fully allocated and use should not be expanded in the South Meadow Valley Aquifer sub-region. Additionally, Associated strongly recommends against increasing any further surface water diversions/licences along Darke Creek or any springs and streams that feed in to Darke Creek. This is because Darke Creek is the predominant source of recharge for the North Meadow Valley Aquifer and further reductions in flow would reduce the amount of water available for recharging the aquifer.

3.2.5 Interaction with Other Sub-Regions

Groundwater and surface water use in South Meadow Valley Aquifer will likely affect groundwater users in South Meadow Valley Aquifer and North Faulder Aquifer, though not North Meadow Valley Aquifer nor Faulder Community Water System users. This is due to the North Faulder Aquifer groundwater users being downgradient of users in South Meadow Valley Aquifer. Recall, the groundwater basin at the southern extent of the South Meadow Valley Aquifer likely prevents groundwater from flowing down gradient toward North Faulder Aquifer in successive dry years and could cause reduced groundwater levels in the North Faulder Aquifer. Heavy groundwater use in the South Meadow Valley Aquifer would likely exacerbate the problem. Water use in South Meadow Valley Aquifer is not likely to impact users in North Meadow Valley Aquifer due to the groundwater divide precluding flow from South Meadow Valley Aquifer from flowing toward North Meadow Valley Aquifer. Additionally water use in South Meadow Valley Aquifer is not likely to impact groundwater used by the Faulder Community Water System because that aquifer sub-region is predominantly sourced by Trout Creek derived recharge.

3.2.6 Future Data Acquisition and Water Use Recommendations

Critical Data Acquisition

- There is no critical data acquisition required for this aquifer. There is sufficient information to conclude that South Meadow Valley Aquifer is fully allocated in dry years based on the geology and water level observations from local well logs and from interviews with residents.

Non-Critical but Easy to Obtain Data Acquisition

- Continue groundwater monitoring at well WTN 45044 where a water level data logger was installed in April 2022 until at least Fall 2023 (this will require the continued approval from the landowner). This dataset will allow a full season of groundwater levels to be observed in order to gain a better understanding of groundwater fluctuations in response to recharge and extractions. It will also aid in the determination of if/when groundwater use restrictions should be implemented.

Non-Critical Data Acquisition

- Conduct flow accretion profiling/streamflow gauging of Darke Creek and other creeks flowing across this area. This would involve measuring streamflow at various locations along Darke Creek, repeated multiple times during the year to monitor streamflow changes. This will provide more robust aquifer recharge data via creek bed leakage from Darke Creek and other creeks.
- Collect long-term groundwater level monitoring data from one or more wells (potentially drill a monitoring well in the southern part of South Meadow Valley Aquifer) constructed within Aquifer #299 in this sub-region. It will help better understand the hydrogeological characteristics of the potential no-flow boundary at the South Meadow Valley Aquifer southern end (i.e., does the aquifer pinch out at the southern end of Meadow Valley). A long-term dataset will also allow a better understanding of yearly groundwater fluctuations and response to recharge. The data could be used to provide an early warning to groundwater users when Aquifer #299 water levels are getting low, and will also aid determination of if/when groundwater use restrictions should be implemented.
- Measure the quantity of surface water diverted and used for irrigation purposes, and ensure they are kept within the licenced quantity, if feasible.

Recommendations

- Limit additional surface water diversions from Darke Creek or other mountainside creeks for commercial and private/domestic irrigation use, as this water provides important recharge to the aquifer.
- Promote water conservation measures and encourage reduced groundwater and surface water extractions for private and domestic irrigation use in dry years.

3.3 North Faulder Aquifer Sub-Region

3.3.1 Aquifer Setting

North Faulder Aquifer sub-region is located at the northern extent of Aquifer #299 (Figure 2-3). It's northern boundary is the Meadow valley pinch out that separates the South Meadow Valley Aquifer from the North Faulder Aquifer. It's southern boundary is just north of the Faulder Community Water System where Aquifer #299 becomes more influenced by Trout Creek and less by the Darke Creek. Groundwater generally flows in a southern direction into Trout Creek Aquifer (Golder 2005, Golder 2013, Wilson 1990). It is generally unconfined and composed of unconsolidated material including sands, gravels, and cobbles. The aquifer typically directly overlies bedrock though occasionally clay-silt rich layers separate the aquifer from bedrock.

Well depths are between 43.9-62.2 m (144-204 ft), with a median of 58.5 m (192 ft). Well yields are between 0.1-3.2 L/s (2-50 USgpm), with a median well yield of 0.6 L/s (9 USgpm) (Appendix A).

3.3.2 Aquifer Recharge

Recharge to this aquifer is predominantly provided by leakage from Darke Creek as the creek flows over coarse sediment in North Faulder Aquifer, and direct infiltration from precipitation. Additionally, there is likely groundwater inflows from the upgradient South Meadow Valley Aquifer, though as previously mentioned, it likely only flows into the North Faulder Aquifer when it has sufficient groundwater levels to spill over its basin lip.

3.3.3 Water Use

The North Faulder Aquifer sub-region consists primarily of lands zoned Small Holdings Three (SH3), with some lands zoned Small Holdings Two (SH2) and Small Holdings Four (SH4). The entire area is served by the Faulder Community Water System for domestic use; however, based on interviews with local residents, some parcels within the North Faulder Aquifer have chosen to supplement their water use with supply from private groundwater wells.

There are 24 wells registered with the Province. The intended well uses are all private domestic, or unknown (Appendix A). No large acreages exist in this area, indicating that the well use is likely predominantly domestic, and based on interviews and air photos the supplemental domestic use is primarily for watering lawns, gardens, other landscaping, and household poultry and pets. It is Associated's understanding all of these domestic scale farms abide within the domestic use (<8,000 L/day) constraints as stated in the RDOS Sub-Division Servicing Bylaw 2000, 2002 Schedule A (RDOS 2000).

Domestic use is predominantly sourced from the Faulder Community Water System though some residents continue to partially or wholly use their own groundwater wells to meet all their domestic needs. Associated assumes the domestic use is largely in line with the Okanagan annual average water of 675 L/day per person [12].

3.3.4 Groundwater Availability

Groundwater availability is likely to be fully allocated in dry years. This is based on the geology of the aquifer, i.e., the aquifer is generally thin with many wells already located just on top of bedrock or confining layers. Additionally, previous studies have noted residents stating their wells had gone dry in previous dry years (Golder 2005, Golder 2008, Golder 2013). Furthermore, North Faulder Aquifer groundwater users with shallower wells or further north are potentially more likely to experience dry well conditions than deeper wells or wells further south. This is due to the wells being shallower as bedrock is intercepted at a higher elevation thus reducing the aquifer thickness. Therefore, as groundwater levels decline, they reach the bottom of the well sooner. These wells are also more affected by reduced groundwater inflows from the upgradient South Meadow Valley Aquifer. When groundwater levels decline in the South Meadow Valley Aquifer, there is a reduction in groundwater flow over the bedrock basin lip into North Faulder Aquifer. Additionally, wells further south/downgradient have more opportunity to collect surface runoff from the valley lining hills and mountain block recharge. However, if groundwater users in North Faulder Aquifer overuse the groundwater, there would likely be reduced groundwater leading to potential scarcity for users further south in North Faulder Aquifer.

3.3.5 Interaction with Other Sub-Regions

Groundwater and surface water use in North Faulder Aquifer will only affect other users within North Faulder Aquifer because the North Faulder Aquifer groundwater users are downgradient of South Meadow Valley Aquifer users. It is likely that North Faulder Aquifer groundwater users further north/upgradient will affect North Faulder Aquifer groundwater users further south/downgradient as their pumping would reduce availability downgradient. There is also potential for shallow depth users and users in the north to experience dry conditions during low groundwater inflows from the South Meadow Valley Aquifer. These north and shallow users would likely experience this before users in the south North Faulder Aquifer or deeper wells.

3.3.6 Future Data Acquisition and Water Use Recommendations

Critical Data Acquisition

- There is no critical data acquisition for this aquifer. There is sufficient information to conclude that North Faulder Aquifer is fully allocated in dry years based on the geology, water level observations from local well logs, and from interviews with the RDOS and local residents.

Non-Critical but Easy to Obtain Data Acquisition

- None.

Non-Critical Data Acquisition

- Conduct flow accretion profiling/streamflow gauging/visual observations of Darke Creek. This would involve measuring streamflow at various locations along Darke Creek within the Faulder area, repeated multiple times during

[12] Okanagan Basin Water Board. https://www.obwb.ca/wsd/models/okanagan-water-demand-model.

the year to monitor streamflow changes. Note visual observations of where and when Darke Creek is flowing or not flowing. This will provide more robust recharge data via creek bed leakage from Darke Creek into the aquifer in this sub-region.

- Collect long term groundwater level monitoring data in one or more wells (potentially drill a monitoring well in the northern part of North Faulder Aquifer or identify an existing well that could be used with the owner's permission). This will allow a better understanding of groundwater fluctuations in this aquifer sub-region and aid in determination if/when groundwater use restrictions should be implemented. It will also help to better understand the hydrogeological characteristics of the potential no-flow boundary at the southern end of the South Meadow Valley Aquifer sub-region, including groundwater flow from the Meadow Valley area into the Faulder area. The water level data could be used to provide an early warning to private groundwater users when Aquifer #299 water levels are getting low.
  - An advantage of drilling a new well is that its location and geology will be more accurately known. The majority of existing wells observed during site visits do not have WTN or WPID numbers on the well and the location coordinates of the wells on the provincial database are often incorrect. Knowing the geology accurately helps us to confirm our conceptual model of groundwater flow.
- Investigate and note observations/timing/anecdotal evidence of mountainside creeks draining to ground within the valley (i.e., infiltrating into the aquifer), as these could provide additional sources of aquifer recharge.

Recommendations

- Provide the Ministry of Forests a copy of this report and recommend that they limit the number of new surface water diversions from Darke Creek or other mountainside creeks. Diversions will reduce the amount of water available to recharge the aquifer.
- Promote water conservation measures and encourage reduced groundwater and surface water extractions for private and domestic irrigation use in dry years.

3.4 Trout Creek Valley Aquifer Sub-Region

3.4.1 Aquifer Setting

Trout Creek Valley Aquifer is located at the southern and southeastern extent of Aquifer #299 (Figure 2-4). Its northern boundary is the southern end of North Faulder Aquifer, and its western and southern boundaries are roughly the western edge of Faulder. Its eastern boundary is essentially the one mapped for Aquifer #299 as mapped on GWELLS (MOE 2022) and where the western edge of the District of Summerland begins. Groundwater generally flows in a southeast direction toward Summerland; however, there is little consensus in the literature as to its discharge location. It could potentially partially discharge as springs into the Trout Creek Valley immediately west of the Summerland Rodeo Grounds. It may also partially or wholly discharge into Aquifer #297 (Deltaic aquifer) before discharging into Okanagan Lake (GWELLS – MOE 2022). Aquifer #299 in the Trout Creek Valley Aquifer is semi-confined in the sense that its water levels frequently fall below their confining layer and there are parts of the aquifer that do not have a confining layer.

Also note, Provincial observation well, OBS Well 366 (inactive since 2018) is in the southeast corner of this aquifer sub-region, near the Summerland Rodeo Grounds; there are no other Provincial observation wells in Aquifer #299.

The aquifer is composed of unconsolidated material, including sands, gravels, and cobbles. Well depths are between 14.9-120.4 m (49-395 ft), with a median of 42.4 m (139 ft). Well yields are between 0.3-41 L/s (5-650 USgpm), with a median of 3.2 L/s (50 USgpm).

3.4.2 Aquifer Recharge

Recharge to this aquifer is predominantly provided by leakage from Trout Creek as the creek flows over coarse sediment upgradient/west of the Trout Creek Aquifer. Due to the semi-confined nature of Trout Creek Valley Aquifer, leakage from Trout Creek is unlikely to directly infiltrate to the Trout Creek Aquifer directly below, but instead it is leakage from Trout Creek that percolates upgradient of the Trout Creek Aquifer and then enters the aquifer as groundwater inflow from an upgradient aquifer. There is no provincially mapped aquifer west of Trout Creek Aquifer; however, given the steep valley and coarse nature of sediment underlying Trout Creek, it is likely there is an aquifer underlying Trout Creek, akin to the Trout Creek Aquifer sub-region; there is just a lack of groundwater wells west of Faulder to prove its existence. Additionally, there is groundwater inflow from the adjacent North Faulder Aquifer that flows from the north into Trout Creek Aquifer. Another form of recharge includes direct infiltration of precipitation along the valley fringes where there are gaps in the confining layers. Given the thicker nature of the overburden in the Trout Creek Valley, flow inputs may be significant.

3.4.3 Water Use

Trout Creek Valley Aquifer consists primarily of lands zoned SH4, with some lands zoned AG3 which are not within the ALR, Parks and Recreation (PR), SH3, and RA.

The Faulder Community Water System has a water licence for 59,170 m^3/year. This water licence serves 81 lots within the northernmost portion of the Trout Creek Valley Aquifer. This is roughly equal to 2000 L per lot, per day, which, assuming a family of four, is in line with the BC average of 490 L per person per day, and lower than the Okanagan average of 675 L per person per day (OBWB 2010)[13]. The Faulder Community Water System has come close to reaching this value in dry years, when the RDOS has not implemented severe water restrictions, including 2005, 2007, and 2017) (Table 3-1). With housing becoming less affordable, in the future it is reasonable to expect that each home may have more than four people. For example, if each home had five people living in it, using the Canadian average of 500 L per person per day, the Faulder Community Water System would need to provide 73,963 m^3/year. As such, RDOS is already at the limit of what the Faulder Community Water System water licence with existing build-out.

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[13] When RDOS applied for their existing use groundwater licence, a larger per capita volume was used in the original application. However, Ministry of Forests rejected the higher volume and in their opinion, instructed the RDOS that they were only allowed to apply for up to their metered volume. However, by only relying on metered data, Ministry of Forests is not taking into account meter variability, as well as any use of the wells before the meters were in place. For example, meters may not have been in use during the driest years. Using average Okanagan water demand values as a surrogate data set when metered readings are not available is, in our opinion, acceptable practice. The RDOS may wish to pursue increasing their existing water groundwater licence under this premise.

Table 3-1
Summary of Faulder Community Water System Usage Since 2005 Compared to the Water Licence Volume

Year	Volume (m^3/year)	% of Licenced volume
2005	56,813	96%
2006	52,140	88%
2007	56,372	95%
2008	31,218	53%
2009	35,318	60%
2010	25,813	44%
2011	35,197	59%
2012	40,557	69%
2013	38,021	64%
2014	40,742	69%
2015	37,177	63%
2016	34,046	58%
2017	53,938	91%
2018	42,071	71%
2019	36,294	61%
2020	40,803	69%
2021	48,109	81%
Licence Volume	59,170	

The properties not in the Faulder Area are outside the Faulder Community Water System; therefore, these properties require their own water source for domestic and commercial use. There are 20 wells registered with the Province. Several of the wells appear to be used for purposes other than domestic, and are unlicenced (Appendix A). The *Water Sustainability Act* requires that all non domestic groundwater use be licenced.

There are 41 active water licences, with diversions of 874,200 m^3/year from Aquifer 299, 18,709,338 m^3/year from Trout Creek, and 18,771,208 m^3/year for all surface water. Note there may be duplications included in this total as the District of Summerland appears to have two water licences with similar volumes, but with slightly different dates of priority. The Ministry of Forests is responsible for maintaining the water licence database. The oldest priority date is

1888, and the most recent dates are 2015 for groundwater extraction on Aquifer 299 and 1993 for a domestic surface water intake on Trout Creek.

3.4.4 Groundwater Availability

Based on the data reviewed, there is sufficient groundwater availability in Trout Creek Valley Aquifer Sub-Region for RDOS to meet the Faulder Community Water System's demand up to the volume on the groundwater licence (59,170 m^3/year, Licence Number 500125). This is based on the geology of the aquifer and that the aquifer's water levels and recharge is dominated by freshet and precipitation, rather than groundwater withdrawals. The geology of the aquifer where the new FCW2 is located relative to FCW1 is thicker by 28 m and deeper by 30 m, allowing for significantly more drawdown, which should allow for continued pumping during successive dry years. As described in Section 3.4.2, the aquifer's water levels and recharge show a strong positive correlation with precipitation and creek discharge (Figure 2-11) and does not show a correlation to groundwater use (Figure 2-12).

Regarding future groundwater availability, there is not a sufficient surplus in the volume on the water licence to allow for future growth for the following reasons:

- The Faulder Community Water System water licence is sufficient for a "per lot" use of 2000 L per person, per day (Section 3.4.3). With affordable housing a challenge in the region, the RDOS can expect the sizes of households to rise. In the years that RDOS implemented severe water restrictions (e.g.: 2008-2010), RDOS only used as low as 44% of the licenced volume. As such, with prudent outdoor watering management as has occurred in the past, the Faulder Community Water System should be able to manage an increase in the per lot water demand. For example, average indoor water use in Canada is only 150 L per person per day; if an average of two additional people lived on each of the 81 lots, that is equal to an increase in demand of only 8,875 m^3/year. Changes in habits in outdoor landscape watering has a much larger impact on the change in water use (OBWB 2010).
- If the RDOS would like to increase the water licence volume, an application to the Ministry of Forests would be required, and as described in Section 1.4, under the *Water Sustainability Act* (WSA), the Statutory Decision Maker must consider other water users (including the District of Summerland, who has water rights on Trout Creek), and environmental flow needs (EFNs). Securing additional volume would require large studies, and consultation with the District of Summerland, First Nation communities. A licence would only be granted if there is evidence to suggest that other water users and EFNs are not going to be negatively impacted, and the application process can take 1-5 years to complete.

In addition, additional surface water licences on Trout Creek or springs and streams feeding Trout Creek above the Faulder Community Water System should not be granted without further study because Trout Creek and it's watershed is providing important recharge to the Faulder Community Water System wells. Likewise, no additional sub-dividing of properties outside of the Faulder Community Water System upgradient of the Faulder Community Water System should be allowed without further study to ensure the existing wells (both Faulder Community Water System and private wells) in the vicinity of the prospective new lot are not being negatively impacted by the additional groundwater demands.

For the properties south (downgradient) of the Faulder Community Water System, domestic groundwater use can continue, and as long as the properties are overlying Aquifer #299, the aquifer can support domestic use. Domestic use on surface water sources and commercial uses on groundwater sources will require a water licence. Decision makers must consider Environmental Flow needs and other water users, including District of Summerland. As such, further study would be needed and the water licence is not guaranteed.

3.4.5 Interaction Between Other Sub-Regions

Groundwater and surface water use in Trout Creek Valley Aquifer, in particular the Faulder Community Water System, will not affect other users in North Faulder Aquifer and likely not affect other users in Trout Creek Valley Aquifer. The Faulder Community Water System and Trout Creek Valley Aquifer are downgradient of North Faulder Aquifer, and Figure 3-1 shows minimal drawdown during FCW2's (WTN 111310) pumping test at the Mearns well (WTN 83231) 57 m northwest of FCW2 and FCW1 (WTN 83205) 39 m south of FCW2. This is largely due to the high transmissivity of the sand and gravel aquifer. Additionally, since Trout Creek Valley Aquifer is predominantly sourced from leakage from upgradient portions of Trout Creek rather than much smaller Darke Creek leakage, it is far less likely to impact other groundwater users in Trout Creek Valley Aquifer. Golder (2013) stated about 88% of the recharge for Trout Creek Valley Aquifer is from Trout Creek whereas only 12 % is from Darke Creek, this was based on relative catchment sizes of Trout Creek versus Darke Creek.

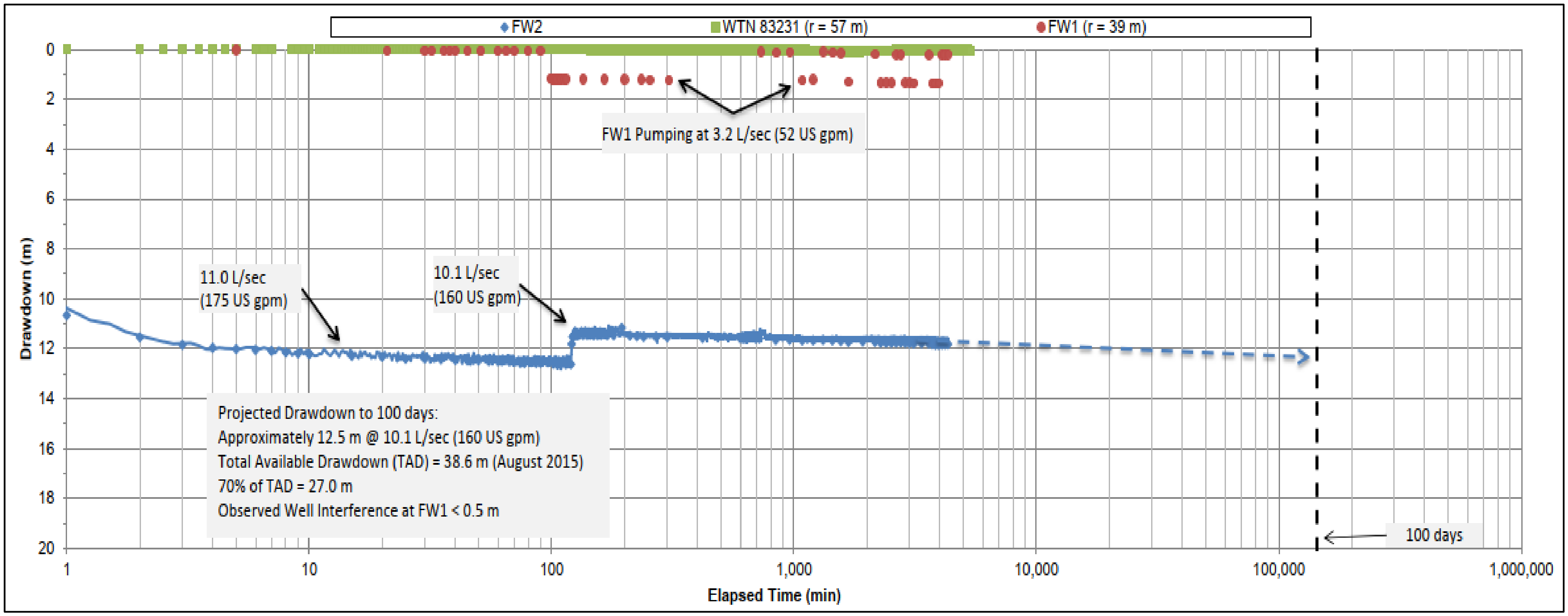

Figure 3-1
Drawdown Curves for FCW1, FCW2, and Mearns well During Constant Rate Pumping Test of FCW2 (from Golder 2015)

3.4.6 Future Data Acquisition and Water Use Recommendations

Critical Data Acquisition

- Continue groundwater monitoring at FCW1, FCW2, and well WTN 82797. Monitoring water levels in FCW1 and FCW2 should continue indefinitely while the wells are in use. The data logging system deployed in well WTN 82797 in May 2022 should remain in place until at least Fall 2023 (this will require the continued approval from the landowner) to obtain one full season of data, which can be compared against the Faulder Community Water System wells. All datasets allow groundwater levels to be observed in order to gain a better understanding of groundwater fluctuations in response to recharge and extractions. The data will show when aquifer water levels are getting low (i.e., close to the available drawdown in FCW1) and provide early warning for possible adjustments to well operation.
- Conduct flow accretion profiling/streamflow gauging of Trout Creek. This would involve measuring streamflow at various locations along Trout Creek, repeated multiple times during the year to monitor streamflow changes. This will provide more robust aquifer recharge data via creek bed leakage from Trout Creek. As a minimum it is recommended that the flow gauging undertaken on Trout Creek by Golder in 2013 is repeated to confirm those findings.

Non-Critical but Easy to Obtain Data Acquisition

- Not applicable for this aquifer sub-region.

Non-Critical Data Acquisition

- Drill and complete a monitoring well at southern extent of North Faulder Aquifer. This would be used to determine more accurate groundwater inflow into Trout Creek Valley Aquifer from the Faulder valley area.
- Conduct a long-term pumping test on FCW2 (and potentially FCW1) and monitor groundwater levels in the North Faulder Aquifer. This will demonstrate that aggressive pumping/water use of the Faulder Community Water System in Trout Creek Valley Aquifer does not negatively impact groundwater users in North Faulder Aquifer or have a significant impact on aquifer water levels.
- Drill and install 2-3 monitoring wells at the western edge of Trout Creek Valley Aquifer to confirm the aquifer extends further to the west within Trout Creek Valley. Data obtained from these wells would allow the determination of more accurate groundwater inflow into Trout Creek Valley Aquifer. This information will increase the accuracy of the existing water budget (prepared by Golder [2008]) and determination of water quantity available for potentially adding additional connections to the Faulder Community Water System.

Recommendations

- Use FCW2 and FCW1 simultaneously (each at a lower extraction rate than if just one well used) during dry years when aquifer water levels are low. This will reduce the drawdown level in both wells during pumping.
- Maintain continuous monitoring of FCW1 and FCW2 water levels. Track water levels on a monthly basis during spring, summer, and fall to forewarn when private wells constructed in shallower parts of the aquifer (North Faulder Aquifer and Trout Creek Valley Aquifer) may start to go dry – this data can be used to provide information to the community about when to expect their wells to go dry.

4 CLIMATE CHANGE CONSIDERATIONS

4.1 Climate Projections

Climate change conditions were considered using the ClimateBC[14] tool to average future climate projections for the Study Area (centred on 49.66829, -119.81321; 1,253 m elevation). Projected mean monthly temperatures, total monthly precipitation, and total monthly precipitation as snow were extracted for the climate normal periods of 2011-2040, 2041-2070, and 2071-2100, hereafter referred to as the 2025, 2055, and 2085 climate periods, respectively, and compared to the historic climate period of 1995 (Table 4-1).

Table 4-1
Mean Monthly Temperature and Precipitation Estimates for the Study Area Under Climate Change

Variable	Climate period[1]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
Mean Monthly Temperature (°C)	1995	-5.1	-3.4	0.1	4	8.5	12.4	15.7	15.7	10.8	4.8	-1.6	-5.3	4.7
	2025	-5.3	-2.8	0.7	4.9	9.5	14.1	17.2	17.6	12.4	6.4	-0.2	-4.4	5.8
	2055	-4.2	-1.5	1.7	6.1	10.8	15.1	18.6	18.9	13.7	7.6	0.9	-3.4	7.0
	2085	-3.5	-0.8	2.5	7	11.6	16	19.7	20	14.6	8.2	1.8	-2.3	7.9
Total Monthly Precipitation (mm)	1995	58	40	39	34	42	60	44	34	37	44	68	63	563
	2025	71	46	40	39	41	44	37	34	39	37	67	80	575
	2055	74	47	41	43	43	46	35	34	38	41	71	84	597
	2085	76	47	42	43	43	45	33	32	39	42	72	87	601
Total Monthly Precipitation as Snow (mm)	1995	41	29	23	8	2	0	0	0	1	4	34	49	191
	2025	51	30	19	6	1	0	0	0	1	1	24	56	189
	2055	45	24	13	3	1	0	0	0	1	1	19	50	157
	2085	41	20	10	2	0	0	0	0	0	0	15	40	128

Notes:

1. Climate normal periods are as follows: 1995 is from 1981 to 2010, 2025 is from 2011 to 2040, 2055 is from 2041 to 2070, and 2085 is from 2071 to 2100.

Mean monthly air temperatures are expected to increase in all months, with the mean annual temperature projected to increase by 3.2°C (i.e., to 7.9°C) by the 2085 climate period, compared to the 1995 climate period average (4.7°C). In addition, annual precipitation is projected to increase from an average of 563 mm in the 1995 climate period to an average of 601 mm in the 2085 climate period. The increase in precipitation is anticipated during spring, fall, and winter months, with a decrease in June, July, and August. It is expected that an increased proportion of winter precipitation will fall as rain rather than snow due to the increasing winter air temperatures. These climate projections may change the way groundwater recharge occurs (for example via direct infiltration or losing streams). However, there is insufficient information to conclude whether these projections will result in a positive or negative impact to

[14] ClimateBC uses the "13 General Circulation Model (GCM) Shared Socioeconomic Pathway 2-4.5 ensemble" (Wang et al 2016).

groundwater recharge (for example, quick snowmelt can result in rapid run-off [and less recharge] whereas periods of steady rain may allow for increased infiltration [and more recharge] into the ground).

4.2 Water Demand Projections

RHF Systems Ltd. provided water demand model results based on historic climate data for the 1995 climate period (1981-2010), and two future periods, 2055 (2041-2070) and 2085 (2071-2100), using three predictive climate model datasets provided by the Pacific Climate Impacts Consortium (PCIC)[15] (Appendix C).

The three climate models chosen were ACCESS1-0 representative concentration pathway (rcp) 8.5, CanESM2 rcp 8.5, and CNRM-CM5 rcp 4.5. These models were selected to capture the changes in extremes of those climate indices most significant to water supply (winter precipitation and maximum temperature) and agricultural water use (summer precipitation and maximum temperature) as represented by a subset of PCIC's upsampled Coupled Model Intercomparison Project simulations[16]. It is important to note that none of the three predictive models selected for this study is considered better or worse than another; combined, they encompass a selection of available climate projections.

Water demand results were grouped into two categories:

- non-domestic demand including agricultural irrigation, livestock and animal, indoor industrial, and indoor institutional uses; and
- domestic demand including landscape irrigation and indoor residential uses.

Table 4-2 summarizes the historic water demand per Aquifer Sub-Region and their sources. Most of the water demand within the study area is related to non-domestic use, furthermore, most water demand is currently sourced from surface water (80%). However, groundwater sources contribute considerably to non-domestic water demand in some Aquifer Sub-Regions (e.g., North Meadow Valley Aquifer and South Meadow Valley Aquifer). Most non-domestic water demand is currently sourced from surface water (83%), whereas most domestic water demand is source from groundwater (80%).

[15] https://www.pacificclimate.org/

[16] Cannon, A.J., 2015. Selecting GCM scenarios that span the range of changes in a multimodel ensemble: application to CMIP5 climate extremes indices. Journal of Climate, 28(3): 1260-1267. doi:10.1175/JCLI-D-14-00636.1.

Table 4-2
Summary of Historic (1981 – 2010) Water Demands Per Aquifer Sub-Region

Aquifer Sub-Region	Average Annual Total Water Demand (m^3)	Average Annual Non-Domestic Water Demand (m^3)	Percentage of Non-Domestic Water Demand from Groundwater (%)	Percentage of Non-Domestic Water Demand from Surface Water (%)	Average Annual Domestic Water Demand (m^3)	Percentage of Domestic Water Demand from Groundwater (%)	Percentage of Domestic Water Demand from Surface Water (%)
North Meadow Valley Aquifer	132435	130471	100	0	1964	99	1
South Meadow Valley Aquifer	118024	116403	10	90	2054	55	45
North Faulder Aquifer	6674	2671	99	1	4003	89	11
Trout Creek Valley Aquifer	19353	16243	12	88	3110	52	48
Total	276276	252130	17	83	10487	80	20

Understanding that the impacts of changes in demand will likely impact both surface water and groundwater sources (e.g., if alternate sources are required), it is appropriate to assess changes to surface water demand and groundwater demand together. Potential changes in water demand for both surface water and groundwater demands within each Aquifer Sub-Region in relation to the 1995 (1981 – 2010) climate period are summarized in Table 4-3.

Table 4-3
Percent Change in Water Demand Per Aquifer Sub-Region Under Climate Change Conditions

Climate Period	Climate Model	Percent Change in Water Demand in Relation to the 1995 Climate Period (%)			
		North Meadow Valley Aquifer	South Meadow Valley Aquifer	North Faulder Aquifer	Trout Creek Valley Aquifer
2055	Access	50	28	18	39
	canesm2	33	18	12	26
	cnrmcm5	34	16	12	23
	Average	39	20	14	30
2085	Access	60	50	38	26
	canesm2	44	40	26	17
	cnrmcm5	27	19	11	8
	Average	44	36	25	17

Notes:

1. Climate normal periods are as follows: 2055 is from 2041 to 2070 and 2085 is from 2071 to 2100.

Increased water demands are predicted to occur in all Aquifer Sub-Regions. Average increases from 14% to 39% are estimated to occur for the 2055 climate period, whereas increases from 17% to 44% are estimated to occur for the 2085 climate period.

5 CONCLUSIONS AND RECOMMENDATIONS

Associated completed a review of all available information to further develop the hydrogeological conceptual model for Aquifer #299 and to assess groundwater availability within the aquifer, with a particular focus on the Faulder Community Water System and Meadow Valley area. The following sub-sections provide a summary of the main conclusions and recommendations from this study.

5.1 Conclusions

Based on our study, Associated concludes:

- Aquifer #299 is a long, relatively narrow, valley floor, surficial aquifer of a heterogeneous nature and varies between being an unconfined, semi-confined, or confined aquifer depending on the exact location.
- The dominant recharge mechanism to Aquifer #299 is via creek bed leakage from Darke Creek and Trout Creek, and leakage from other mountainside creeks when they flow over the surficial deposits in the valley floor. To a lesser extent, aquifer recharge is also likely provided by direct infiltration of precipitation and from mountain block recharge.
- The amount of preceding winter and spring precipitation and, consequently, aquifer recharge, has the largest impact on Aquifer #299 water levels.
- Extraction from the Faulder Community Wells has a minimal effect on Aquifer #299 water levels; the impact is very localised around the well, as demonstrated by pumping tests undertaken on FCW1 and FCW2.
- Aquifer #299 can be divided into four sub-regions based on geology, hydrogeology, aquifer geometry, and sources of recharge, North Meadow Valley Aquifer sub-region, South Meadow Valley Aquifer sub-region, North Faulder Aquifer sub-region, and Trout Creek Valley Aquifer sub-region. The individual characteristics of these Sub-Regions are important in terms of understanding groundwater availability in each area, and are discussed below.
- Increased water demands are predicted to occur in all aquifer sub-regions due to a changing climate. Average increases from 14% to 39% are estimated to occur for the 2055 climate period, whereas increases from 17% to 44% are estimated to occur for the 2085 climate period.

North and South Meadow Valley Aquifer Sub-Regions:

- These two sub-regions cover the Meadow Valley area located north of Faulder. Recharge to the aquifer sub-region is predominantly from creek bed leakage from Darke Creek and other creeks that drain the mountainside and flow into the valley.
- Streamflow in Darke Creek across North and South Meadow Valley is highly regulated with licensed points of diversion mainly for irrigation purposes (Meadow Valley Irrigation District and private irrigation). Following dry periods, there is often minimal streamflow in Darke Creek at the southern end of South Meadow Valley.
- Following a series of dry (lower recharge) years, groundwater levels in North and South Meadow Valley Aquifer sub-regions are low with minimal groundwater available. This is a consequence of the generally thin aquifer thickness in this region limiting the amount of available drawdown in wells constructed in the aquifer.

In addition, during dryer years, there is a reduction in recharge to the aquifer from creek bed leakage due to less flow, as well as a probable increase in the amount of surface water and groundwater used for irrigation purposes. This impact is exacerbated by a series of low recharge years.

- Groundwater extraction from the Faulder Community Supply Wells has no impact on groundwater availability in North and South Meadow Valley.

North Faulder Aquifer Sub-Region:

- This narrow aquifer sub-region extends most of the length of the Faulder community, Aquifer #299 here is relatively thin and unconfined, particularly at the northern end of Faulder where bedrock is found at a shallower depth. Recharge to the aquifer sub-region is predominantly from creek bed leakage from Darke Creek and via groundwater flow from the Meadow Valley area.
- Streamflow in Darke Creek often dries before it reaches Trout Creek due to low streamflow from Meadow Valley and creek bed leakage along its length. Following a series of low recharge years, groundwater levels in North Faulder Aquifer sub-region decrease, and on some occasions private wells going dry. Anecdotal evidence suggests that the first wells to go dry are at the northern end of this aquifer sub-region, with wells to the south going dry as aquifer water levels fall. This is unsurprising given the shallower depth to bedrock in the northern part of the aquifer sub region.
- Groundwater extraction from the Faulder Community Supply Wells has negligible impact on groundwater availability in the North Faulder Aquifer sub-region.

Trout Creek Valley Aquifer Sub-Region:

- This is the largest aquifer sub-region extending from the southern end of Faulder to Summerland Rodeo Grounds. The aquifer here is typically confined and significantly thicker than other parts of Aquifer #299. The Faulder Community Supply Wells are constructed within this thicker part of the aquifer within the Trout Creek valley.
- Recharge to the aquifer sub-region is predominantly from creek bed leakage from Trout Creek and, to a lesser extent, Darke Creek, and also via groundwater flow from the North Faulder Aquifer sub-region and likely from an unmapped aquifer that exists below Trout Creek to the west of Faulder.
- Trout Creek is a significantly regulated creek with many points of diversion along its length, with the District of Summerland being a large water licence holder on Trout Creek with points of diversion and storage upgradient of Faulder.
- Following a series of low recharge years, groundwater levels in Trout Creek Valley Aquifer sub-region decreased. In 2010 and 2011, this resulted in the groundwater level in FCW1 getting close to the top of the well screen, limiting the amount of drawdown available in the well for pumping. Consequently, FCW2 was constructed in 2015 in a deeper part of the aquifer which provides significantly more available drawdown and, therefore, the well is at significantly less risk of not being able to provide potable water to the Faulder community.
- Pumping test data from FCW2 showed minimal drawdown (<0.5 m) in wells located within 60 m, suggesting that the majority of groundwater extracted is rapidly replaced rather than a depletion of aquifer storage, which would result in a reduction in aquifer water levels.

5.2 Recommendations

Recommendations for each of the four aquifer sub-regions are provided in Section 3. Below is a summary of the key recommendations.

- Limit or prevent additional development, land uses or activities that draw water out of surficial Aquifer #299 within the Meadow Valley or North Faulder areas.
- Within the Faulder Community Water System, promote water conservation measures and raise public awareness about the importance of water conservation. The existing water licence for the Faulder Community System is restricted to about 2000 L per person per day for the existing 81 connections. While this is sufficient to meet all indoor watering needs for the system users, best management practices for outdoor watering needs must be followed to stay under this limit as water demand goes up due to more residents per household and due to climate change. Continue to monitor water use and consider working with the Ministry of Forests to determine what technical studies would be needed to apply for a new groundwater use licence application.
- As the Province has jurisdiction with issuing water licences for all surface water diversions and non-domestic groundwater use, notify the Ministry of Forests of the findings of this study with respect to groundwater supply constraints in Meadow Valley and North Faulder areas of Aquifer #299, and no new groundwater licences should be granted in these areas. In addition, share this report with the Ministry of Forests to highlight the importance of Darke Creek in providing recharge to Aquifer #299, with the aim of restricting further surface water licences being granted within these aquifer sub-regions. The Province may wish to measure existing surface water diversions on Darke Creek, Trout Creek and other surface water bodies within the Darke Creek watershed to ensure that the quantity of water diverted does not exceed the licensed quantity, if feasible, as the licensed volumes on the water licence query were unclear.
- Related to continuing to collect data to support primarily on-going management of the Faulder Community Water System (and as a secondary objective management of the North Faulder and South Meadow Valley aquifer sub-regions areas as a whole):
  - Continue groundwater level monitoring in FCW1 and FCW2.
  - Consider additional groundwater monitoring locations in South Meadow Valley and North Faulder aquifer sub-regions (including potentially drilling new monitoring wells). This will allow a greater understanding of aquifer water level fluctuations in the different aquifer sub-regions in response to recharge and groundwater/surface water extractions, as well as providing more information on groundwater flow between the aquifer sub-regions. A partnership with Ministry of Forests, who manages the Provincial Observation Well network, should be pursued.
  - Conduct flow gauging on Darke Creek and Trout Creek to better understand the location, timing, and amount of creek bed leakage. This will help to gain confidence around the groundwater recharge mechanisms to the Trout Creek Valley Aquifer sub-region in the vicinity of FCW1 and FCW2.
  - Conduct a long-term pumping test on FCW2 and monitor water levels in wells within Faulder to clearly demonstrate that extraction from FCW2 has no/negligible impact on water levels in private wells.

CLOSURE

This report was prepared for the Regional District Okanagan Similkameen to better understand the conceptual model of groundwater flow and groundwater availability in the Meadow Valley and Faulder communities.

The services provided by Associated Environmental Consultants Inc. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty expressed or implied is made.

Respectfully submitted,
Associated Environmental Consultants Inc.

Dylan Riley, GIT
Hydrogeologist

for Steve Colebrook, M.Sc.
Environmental Scientist

2022-08-09

Marta Green, P.Geo.
Senior Hydrogeologist

Associated Environmental Consultants Inc.
Permit to Practice 1001754

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APPENDIX A – SUMMARY OF WELLS BY AQUIFER SUB-REGION

Summary of Registered Wells in North Meadow Valley Aquifer

Well Tag Number	Well ID Plate #	Well Status	Well Class	Intended Well Use	Licence Statu	Aquifer ID	Well depth (ft)	Well depth (m)	Yield (Usgpm)	Yield (L/s)	Aquifer Material and Other Comments
117	0	New	Water Supply	Private Domestic	Unlicensed	unknown	40	12.2	3	0.2	Unconsolidated
19686	0	New	Unknown	Unknown Well Use	Unlicensed	unknown	50	15.2			Unconsolidated
26708	0	New	Unknown	Unknown Well Use	Unlicensed	unknown	35	10.7	92	5.8	Unconsolidated
26857	0	New	Unknown	Not Applicable	Unlicensed	unknown	52	15.8	15	0.9	Unconsolidated
45027	0	New	Unknown	Unknown Well Use	Unlicensed	unknown	78	23.8	20	1.3	Unconsolidated
45044	0	New	Unknown	Unknown Well Use	Unlicensed	unknown	70	21.3	15	0.9	Unconsolidated
53873	0	New	Water Supply	Irrigation	Unlicensed	299	220	67.1	55	3.5	Unconsolidated
57926	0	New	Water Supply	Private Domestic	Unlicensed	unknown	110	33.5	1	0.1	Unconsolidated
58093	0	New	Water Supply	Private Domestic	Unlicensed	unknown	67	20.4	6	0.4	Unconsolidated
59015	53245	New	Water Supply	Irrigation	Licensed	299	97	29.6	200	12.6	Unconsolidated
61472	0	New	Water Supply	Private Domestic	Unlicensed	unknown	59	18	72	4.5	Unconsolidated
68383	0	New	Water Supply	Private Domestic	Unlicensed	unknown	126.3	38.5	25	1.6	Unknown
69193	0	New	Water Supply	Private Domestic	Unlicensed	unknown	61	18.6	70	4.4	Unknown
82544	0	New	Water Supply	Private Domestic	Unlicensed	unknown	180	54.9	2	0.1	Unknown
97265	0	New	Water Supply	Private Domestic	Unlicensed	unknown	60	18.3			Unknown
97276	0	New	Water Supply	Irrigation	Unlicensed	unknown	30	9.1	75	4.7	Unconsolidated
98948	24099	New	Water Supply	Other	Licensed	unknown	28.5	8.7	70	4.4	Unconsolidated
99044	24067	New	Water Supply	Private Domestic	Unlicensed	unknown	197	60	30	1.9	Unconsolidated
105398	34643	New	Water Supply	Unknown Well Use	Unlicensed	unknown	171	52.1			Unknown
105401	34642	New	Water Supply	Unknown Well Use	Unlicensed	unknown	254	77.4			Unknown
105411	34645	New	Water Supply	Private Domestic	Unlicensed	unknown	177.5	54.1	24	1.5	Unknown
113019	29376	New	Water Supply	Unknown Well Use	Licensed	300	500	152.4	17	1.1	Unknown
113020	29378	New	Water Supply	Unknown Well Use	Licensed	300	274	83.5	80	5	Unknown
116551	48858	New	Water Supply	Private Domestic	Unlicensed	unknown	496	151.2	7.25	0.5	Unknown
121069	63448	New	Water Supply	Irrigation	Licensed	unknown	164	50	60	3.8	
124920	0	New	Water Supply	Private Domestic	Unlicensed	unknown	400	121.9			
124922	0	New	Water Supply	Private Domestic	Unlicensed	unknown	390	118.9			
						count			**27**		
						average	**162.5**	**49.5**	**44.7**	**2.8**	
						median	**110**	**33.5**	**25**	**1.6**	
						min	**28.5**	**8.7**	**1**	**0.1**	**WTN 57926**
						max	**500**	**152.4**	**200**	**12.6**	**WTN 59015**

Summary of Registered Wells in South Meadow Valley Aquifer

Well Tag Number	Well ID Plate #	Well Status	Well Class	Intended Well Use	Licence Statu	Aquifer ID	Well depth (ft)	Well depth (m)	Yield (Usgpm)	Yield (L/s)	Aquifer Material and Other Comments
42213	0	New	Water Supply	Private Domestic	Unlicensed	299	40	12.2	12	0.8	Unconsolidated
42214	0	New	Unknown	Not Applicable	Unlicensed	299	45	13.7	12	0.8	Unconsolidated
47163	0	New	Unknown	Unknown Well Use	Unlicensed	unknown	260	79.2	6	0.4	Unconsolidated
55738	0	New	Water Supply	Private Domestic	Unlicensed	299	76	23.2	20	1.3	Unconsolidated
82941	0	New	Water Supply	Private Domestic	Unlicensed	unknown	47	14.3	80	5	Unknown
84783	0	New	Water Supply	Private Domestic	Unlicensed	unknown	200	61	8	0.5	Unknown
89190	0	New	Water Supply	Private Domestic	Unlicensed	unknown	39	11.9	40	2.5	Unknown
97258	0	New	Water Supply	Unknown Well Use	Unlicensed	unknown					Unknown
99004	27872	New	Water Supply	Private Domestic	Licensed	unknown	149	45.4	25	1.6	Unknown
123920	0	New	Water Supply	Private Domestic	Unlicensed	unknown	40	12.2	20	1.3	Unconsolidated
124923	0	New	Water Supply	Private Domestic	Unlicensed	unknown					
						Count			**11**		
						average	**99.6**	**30.3**	**24.8**	**1.6**	
						median	**47**	**14.3**	**20**	**1.3**	
						min	**39**	**11.9**	**6**	**0.4**	**WTN 47163**
						max	**260**	**79.2**	**80**	**5**	**WTN 82941**

Summary of Registered Wells in North Faulder Aquifer

Well Tag Number	Well ID Plate #	Well Status	Well Class	Intended Well Use	Licence Statu	Aquifer ID	Well depth (ft)	Well depth (m)	Yield (Usgpm)	Yield (L/s)	Aquifer Material and Other Comments
152	Unknown	New	Unknown	Unknown Well Use	Unlicensed	unknown	154	46.9	3	0.2	Unconsolidated
20677	Unknown	Abandoned	Unknown	Unknown Well Use	Unlicensed	unknown	159	48.5			Unconsolidated
38853	Unknown	New	Unknown	Unknown Well Use	Unlicensed	unknown	280	85.3			Unconsolidated
38857	Unknown	New	Unknown	Unknown Well Use	Unlicensed	unknown	160	48.8			Unconsolidated
38858	Unknown	New	Unknown	Unknown Well Use	Unlicensed	unknown	385	117.3			Unconsolidated
40247	Unknown	New	Unknown	Unknown Well Use	Unlicensed	299	204	62.2	40	2.5	Unconsolidated
45196	Unknown	New	Unknown	Unknown Well Use	Unlicensed	299	192	58.5	8	0.5	Unconsolidated
45198	Unknown	New	Unknown	Unknown Well Use	Unlicensed	299	192	58.5	15	0.9	Unconsolidated
45466	Unknown	New	Unknown	Unknown Well Use	Unlicensed	unknown	192	58.5	12	0.8	Unconsolidated
46918	Unknown	New	Unknown	Unknown Well Use	Unlicensed	unknown	178	54.3	50	3.2	Unconsolidated
47422	Unknown	New	Unknown	Unknown Well Use	Unlicensed	unknown	156	47.5	8	0.5	Unconsolidated
48596	Unknown	New	Water Supply	Private Domestic	Unlicensed	unknown	178	54.3	25	1.6	Unconsolidated
51510	Unknown	New	Unknown	Unknown Well Use	Unlicensed	unknown	186	56.7	15	0.9	Unconsolidated
51514	Unknown	New	Unknown	Unknown Well Use	Unlicensed	299	204	62.2	8	0.5	Unconsolidated
52838	Unknown	New	Unknown	Unknown Well Use	Unlicensed	unknown	196	59.7	10	0.6	Unconsolidated
55579	Unknown	Alteration	Water Supply	Private Domestic	Unlicensed	unknown	162	49.4	9	0.6	Unconsolidated
55808	Unknown	New	Water Supply	Private Domestic	Unlicensed	unknown	300	91.4			Unconsolidated
57848	Unknown	Abandoned	Water Supply	Private Domestic	Unlicensed	unknown	161	49.1			Unconsolidated
58250	Unknown	New	Unknown	Unknown Well Use	Unlicensed	unknown	310	94.5			Unconsolidated
58537	Unknown	New	Water Supply	Private Domestic	Unlicensed	unknown	310	94.5	2	0.1	Unconsolidated
58635	Unknown	Abandoned	Unknown	Unknown Well Use	Unlicensed	unknown	144	43.9			Unconsolidated
83231	Unknown	New	Water Supply	Unknown Well Use	Unlicensed	unknown					Unknown
122608	32775	New	Water Supply	Private Domestic	Unlicensed	unknown	500	152.4	4	0.3	Unknown
123686	0	New	Water Supply	Private Domestic	Unlicensed	unknown	440	134.1	3	0.2	Unknown
						Count	**0**		**24**		
						average	**232.3**	**70.8**	**14.1**	**0.9**	
						median	**192**	**58.5**	**9**	**0.6**	
						min	**144**	**43.9**	**2**	**0.1**	**WTN 58357**
						max	**500**	**152.4**	**50**	**3.2**	**WTN 46918**

Summary of Registered Wells in Trout Creek Valley Aquifer

Well Tag Number	Well ID Plate #	Well Status	Well Class	Intended Well Use	Licence Statu	Aquifer ID	Well depth (ft)	Well depth (m)	Yield (Usgpm)	Yield (L/s)	Aquifer Material and Other Comments
41261	Unknown	New	Unknown	Unknown Well Use	Unlicensed	299	126	38.4	40	2.5	Unconsolidated
45772	Unknown	New	Unknown	Unknown Well Use	Unlicensed	299	49	14.9	7	0.4	Unconsolidated
50893	Unknown	New	Unknown	Unknown Well Use	Unlicensed	299	60	18.3	6	0.4	Unconsolidated
52546	Unknown	New	Monitoring	Not Applicable	Unlicensed	299	120	36.6	50	3.2	Unconsolidated
55752	Unknown	New	Water Supply	Private Domestic	Unlicensed	299	108	32.9	6	0.4	Unconsolidated
61480	Unknown	New	Water Supply	Private Domestic	Unlicensed	299	124	37.8	36.67	2.3	Unconsolidated
82373	28503	New	Water Supply	Water Supply System	Unlicensed	299	177	53.9	80	5	Unknown material. Municipality of Summerland owned-well (Rodeo Grounds)
82985	Unknown	New	Water Supply	Irrigation	Unlicensed	299	132	40.2			Unknown
83205	28564	New	Water Supply	Water Supply System	Unlicensed	299	209	63.7	290	18.3	Unconsolidated material. Faulder Community Water System
83206	Unknown	New	Water Supply	Water Supply System	Unlicensed	299	274	83.5	270	17	Unconsolidated
83207	Unknown	Abandoned	Unknown	Not Applicable	Unlicensed	unknown	120.1	36.6	5	0.3	Unknown
83209	28502	New	Water Supply	Water Supply System	Unlicensed	unknown	395	120.4	325	20.5	Unconsolidated material. Trout Creek Water System - Well #3. District of Summerland owned
83210	Unknown	New	Water Supply	Water Supply System	Unlicensed	unknown	360	109.7	250	15.8	Unconsolidated
83211	28501	New	Water Supply	Water Supply System	Unlicensed	299	370	112.8	650	41	Unconsolidated material. Trout Creek Water System - Well #5. District of Summerland owned
84774	53192	New	Water Supply	Irrigation	Licensed	299	139	42.4	36	2.3	Unconsolidated
85744	10107	New	Monitoring	Not Applicable	Unlicensed	299					Unconsolidated
102093	27850	New	Water Supply	Water Supply System	Unlicensed	unknown	218	66.4	50	3.2	Unconsolidated
107560	38604	New	Water Supply	Private Domestic	Unlicensed	unknown	440	134.1			Unknown
111310	41800	New	Water Supply	Water Supply System	Licensed	299	306	93.3			Unknown
122480	52900	New	Water Supply	Private Domestic	Unlicensed	unknown	120	36.6	50	3.2	Unknown
						count	**0**		**20**		
						average	**202.4789**	**61.7**	**134.479375**	**8.5**	
						median	**139**	**42.4**	**50**	**3.2**	
						min	**49**	**14.9**	**5**	**0.3**	**WTN 83207**
						max	**440**	**134.1**	**650**	**41**	**WTN 83211 (District of Summerland water supply well)**

APPENDIX B – SUMMARY OF WATER LICENCES BY AQUIFER SUB-REGION

Summary of Water Licences in North Meadow Valley Aquifer

Licence Number	Point of Diversion #	Primary Owner	Priority Date	Water Use/Purpose	Source Name	Annual Quantity (m^3/year)
500200	PW191772	Bearfoot Acres Inc. (139715)	20161227	WSA04 - Crop: Harvest/Protect/Co	300	500
500200	PW191772	Bearfoot Acres Inc. (139715)	20161227	08B - Aquifer Storage: NP	300	43,000
500200	PW191772	Bearfoot Acres Inc. (139715)	20161227	03B - Irrigation: Private	300	22,390
500200	PW191773	Bearfoot Acres Inc. (139715)	20161227	03B - Irrigation: Private	300	70,325
500200	PW191773	Bearfoot Acres Inc. (139715)	20161227	08B - Aquifer Storage: NP	300	43,000
500200	PW191773	Bearfoot Acres Inc. (139715)	20161227	WSA04 - Crop: Harvest/Protect/Co	300	500
502075	PW199083	PRIVATE INDIVIDUAL NAME	19890831	WSA08 - Livestock & Animal	299	1,830
502075	PW199083	PRIVATE INDIVIDUAL NAME	19890831	03B - Irrigation: Private	299	46,540
502075	PW199083	PRIVATE INDIVIDUAL NAME	19890831	03B - Irrigation: Private	299	46,540
502075	PW199083	PRIVATE INDIVIDUAL NAME	19890831	WSA08 - Livestock & Animal	299	1,830
503623	PW203417	PRIVATE INDIVIDUAL NAME	20080828	03B - Irrigation: Private	Summerland Uncons	768
503623	PW203416	PRIVATE INDIVIDUAL NAME	20080828	03B - Irrigation: Private	Summerland Uncons	768
504058	PD54621	PRIVATE INDIVIDUAL NAME	19260512	03B - Irrigation: Private	Acland Creek	24,395
504058	PD54621	PRIVATE INDIVIDUAL NAME	19260512	03B - Irrigation: Private	Acland Creek	24,395
504058	PD54621	PRIVATE INDIVIDUAL NAME	19260512	01A - Domestic	Acland Creek	830
504058	PD54621	PRIVATE INDIVIDUAL NAME	19260512	WSA08 - Livestock & Animal	Acland Creek	274
504058	PD54621	PRIVATE INDIVIDUAL NAME	19260512	WSA08 - Livestock & Animal	Acland Creek	274
504058	PD54621	PRIVATE INDIVIDUAL NAME	19260512	01A - Domestic	Acland Creek	830
C051317	PD54504	PRIVATE INDIVIDUAL NAME	19780220	01A - Domestic	Penny Creek	1,660
C058574	PD54621	North Crescent Cranberries Ltd. (81195)	19810309	01A - Domestic	Acland Creek	1,660
C064260	PD54603	Meadow Valley Irrigation District (34203)	19520319	03A - Irrigation: Local Provider	Darke Creek	267,665
C064260	PD54601	Meadow Valley Irrigation District (34203)	19520319	03A - Irrigation: Local Provider	Darke Creek	267,665
C103341	PD63356	PRIVATE INDIVIDUAL NAME	19910321	03B - Irrigation: Private	Brothers Brook	1,233
C103341	PD63356	PRIVATE INDIVIDUAL NAME	19910321	01A - Domestic	Brothers Brook	1,660
C103341	PD63356	PRIVATE INDIVIDUAL NAME	19910321	03B - Irrigation: Private	Brothers Brook	1,233
C103341	PD63356	PRIVATE INDIVIDUAL NAME	19910321	01A - Domestic	Brothers Brook	1,660
C103828	PD54619	PRIVATE INDIVIDUAL NAME	19800917	01A - Domestic	Kurger Spring	830
C103829	PD54619	PRIVATE INDIVIDUAL NAME	19800917	03B - Irrigation: Private	Kurger Spring	6,167
C103829	PD54619	PRIVATE INDIVIDUAL NAME	19800917	01A - Domestic	Kurger Spring	830
C105194	PD54580	PRIVATE INDIVIDUAL NAME	19860718	03B - Irrigation: Private	Meadow Creek	6,167
C124135	PD54623	PRIVATE INDIVIDUAL NAME	19810529	01A - Domestic	Acland Spring	830
C124135	PD54623	PRIVATE INDIVIDUAL NAME	19810529	01A - Domestic	Acland Spring	830
C124136	PD54623	PRIVATE INDIVIDUAL NAME	19810529	01A - Domestic	Acland Spring	830
F008422	PD54621	North Crescent Cranberries Ltd. (81195)	19260512	01A - Domestic	Acland Creek	830
F064258	PD54577	Meadow Valley Irrigation District (34203)	19450627	08A - Stream Storage: Non-Power	Darke Creek	795,595
F064258	PD54576	Meadow Valley Irrigation District (34203)	19450627	08A - Stream Storage: Non-Power	Munro Lake	98,678
F064259	PD54603	Meadow Valley Irrigation District (34203)	18921123	03A - Irrigation: Local Provider	Darke Creek	778,573
F064259	PD54601	Meadow Valley Irrigation District (34203)	18921123	03A - Irrigation: Local Provider	Darke Creek	778,573
					Count	**38**
				Sum for Aquifer 299		**98,276**
				Sum for Aquifer 300		**179,715**
				Sum for Darke Creek		**2,888,070**
					Sum for all SW	**3,064,172**
					Total Sum	**3,342,163**

Summary of Water Licences in South Meadow Valley Aquifer

Licence Number	Point of Diversion #	Primary Owner	Priority Date	Water Use/Purpose	Source Name	Annual Quantity (m^3/year)
F064259	PD54605	Meadow Valley Irrigation District (34203)	18921123	03A - Irrigation: Local Provider	Darke Creek	778,573
C064260	PD54605	Meadow Valley Irrigation District (34203)	19520319	03A - Irrigation: Local Provider	Darke Creek	267,665
C133160	PD54625	Olgajack Holdings Inc. (162438)	19601230	WSA01 - Domestic (WSA01)	Taylor Spring	830
C133160	PD54625	Olgajack Holdings Inc. (162438)	19601230	03B - Irrigation: Private	Taylor Spring	2,467
C062106	PD54610	Forest District - Penticton (41301)	19820713	02I31 - Livestock & Animal: Stockwa	Berry Creek	3,321
C062106	PD54610	Ministry of Forests Lands and Natural Resourc	19820713	02I31 - Livestock & Animal: Stockwa	Berry Creek	3,321
C061924	PD54611	Ministry of Forests Lands and Natural Resourc	19820713	02I31 - Livestock & Animal: Stockwa	Berry Creek	3,321
C061924	PD54611	Forest District - Penticton (41301)	19820713	02I31 - Livestock & Animal: Stockwa	Berry Creek	3,321
C061925	PD54612	Ministry of Forests Lands and Natural Resourc	19820713	02I31 - Livestock & Animal: Stockwa	Nye Creek	3,321
C061925	PD54612	Forest District - Penticton (41301)	19820713	02I31 - Livestock & Animal: Stockwa	Nye Creek	3,321
C061926	PD54613	Ministry of Forests Lands and Natural Resourc	19820713	02I31 - Livestock & Animal: Stockwa	Nye Creek	3,321
C061926	PD54613	Forest District - Penticton (41301)	19820713	02I31 - Livestock & Animal: Stockwa	Nye Creek	3,321
C106948	PD68101	Ministry of Forests Lands and Natural Resourc	19930806	02I31 - Livestock & Animal: Stockwa	Camp Boyle Creek	1,660
C106948	PD68101	Forest District - Penticton (41301)	19930806	02I31 - Livestock & Animal: Stockwa	Camp Boyle Creek	1,660
C130338	PD54609	PRIVATE INDIVIDUAL NAME	19520319	03B - Irrigation: Private	Darke Creek	30,837
C130353	PD54609	PRIVATE INDIVIDUAL NAME	19491107	03B - Irrigation: Private	Darke Creek	30,837
503619	PW203389	PRIVATE INDIVIDUAL NAME	20080906	03B - Irrigation: Private	Summerland Unconsolidated	720
503619	PW203389	PRIVATE INDIVIDUAL NAME	20080906	03B - Irrigation: Private	Summerland Unconsolidated	720
					Count	**18**
					Sum for Aquifer 299	**1,440**
					Sum for Darke Creek	**1,107,912**
					Sum for all SW	**1,141,097**
					Total Sum	**1,142,537**

Summary of Water Licences in Trout Creek Valley Aquifer

Licence #	Point of Diversion #	Primary Owner	Priority Date	Water Use/Purpose	Source Name	Annual Quantity (m^3/year)
500125	PW190926	Regional District of Okanagan-Similkameen (35	19930727	00A - Waterworks: Local Provider	299	59,170
501456	PW197494	PRIVATE INDIVIDUAL NAME	20150701	WSA08 - Livestock & Animal	299	110
501456	PW197494	PRIVATE INDIVIDUAL NAME	20150701	03B - Irrigation: Private	299	2,590
C014569	PD54712	Corp of the District of Summerland (36565)	19400626	00A - Waterworks: Local Provider	Trout Creek	414,831
C016412	PD54712	Corp of the District of Summerland (36565)	18881218	03A - Irrigation: Local Provider	Trout Creek	3,910,132
C016413	PD54712	Corp of the District of Summerland (36565)	19030711	03A - Irrigation: Local Provider	Trout Creek	7,400,880
C043331	PD54643	PRIVATE INDIVIDUAL NAME	19740408	01A - Domestic	Trout Creek	830
C051674	PD54642	PRIVATE INDIVIDUAL NAME	19770415	01A - Domestic	Trout Creek	830
C052317	PD54646	PRIVATE INDIVIDUAL NAME	19020826	03B - Irrigation: Private	Trout Creek	740
C052388	PD54655	PRIVATE INDIVIDUAL NAME	19770421	01A - Domestic	Trout Creek	830
C056872	PD54653	PRIVATE INDIVIDUAL NAME	19760420	01A - Domestic	Trout Creek	830
C056873	PD54652	PRIVATE INDIVIDUAL NAME	19760420	01A - Domestic	Trout Creek	830
C058996	PD54656	PRIVATE INDIVIDUAL NAME	19820401	01A - Domestic	Trout Creek	830
C060898	PD54712	Corp of the District of Summerland (36565)	19730803	00A - Waterworks: Local Provider	Trout Creek	968,318
C060898	PD54712	Corp of the District of Summerland (36565)	19730803	03A - Irrigation: Local Provider	Trout Creek	1,850,220
C062101	PD54659	Forest District - Penticton (41301)	19820713	02I31 - Livestock & Animal: Stockwatering	O'Brien Spring	3,321
C062101	PD54659	Ministry of Forests Lands and Natural Resourc	19820713	02I31 - Livestock & Animal: Stockwatering	O'Brien Spring	3,321
C062102	PD54660	Forest District - Penticton (41301)	19820713	02I31 - Livestock & Animal: Stockwatering	Oates Spring	3,321
C062102	PD54660	Ministry of Forests Lands and Natural Resourc	19820713	02I31 - Livestock & Animal: Stockwatering	Oates Spring	3,321
C066291	PD54644	PRIVATE INDIVIDUAL NAME	19870304	01A - Domestic	Trout Creek	830
C066291	PD54644	PRIVATE INDIVIDUAL NAME	19870304	01A - Domestic	Trout Creek	830
C066455	PD54712	Corp of the District of Summerland (36565)	19880602	03A - Irrigation: Local Provider	Trout Creek	3,083,700
C066491	PD54712	Corp of the District of Summerland (36565)	19410526	03A - Irrigation: Local Provider	Trout Creek	92,511
C106967	PD68112	PRIVATE INDIVIDUAL NAME	19930812	01A - Domestic	Trout Creek	830
F010732	PD54647	PRIVATE INDIVIDUAL NAME	19000709	01A - Domestic	Trout Creek	830
F010732	PD54647	PRIVATE INDIVIDUAL NAME	19000709	03B - Irrigation: Private	Trout Creek	4,009
F010734	PD54654	PRIVATE INDIVIDUAL NAME	19000709	01A - Domestic	Trout Creek	830
F010734	PD54654	PRIVATE INDIVIDUAL NAME	19000709	03B - Irrigation: Private	Trout Creek	39,163
F047577	PD54650	PRIVATE INDIVIDUAL NAME	19760726	01A - Domestic	Trout Creek	830
F051673	PD54646	PRIVATE INDIVIDUAL NAME	19770922	01A - Domestic	Trout Creek	830
F051873	PD54645	PRIVATE INDIVIDUAL NAME	19020826	01A - Domestic	Trout Creek	415
F051873	PD54645	PRIVATE INDIVIDUAL NAME	19020826	03B - Irrigation: Private	Trout Creek	14,802
F052035	PD54647	PRIVATE INDIVIDUAL NAME	19020826	01A - Domestic	Trout Creek	415
F052035	PD54647	PRIVATE INDIVIDUAL NAME	19020826	03B - Irrigation: Private	Trout Creek	16,035
F052036	PD54647	PRIVATE INDIVIDUAL NAME	19020826	03B - Irrigation: Private	Trout Creek	5,551
F052036	PD54647	PRIVATE INDIVIDUAL NAME	19020826	01A - Domestic	Trout Creek	
F052036	PD54648	PRIVATE INDIVIDUAL NAME	19020826	01A - Domestic	Trout Creek	415
F052036	PD54648	PRIVATE INDIVIDUAL NAME	19020826	03B - Irrigation: Private	Trout Creek	
F052318	PD54645	PRIVATE INDIVIDUAL NAME	19020826	03B - Irrigation: Private	Trout Creek	8,511
F052318	PD54645	PRIVATE INDIVIDUAL NAME	19020826	01A - Domestic	Trout Creek	415
F066492	PD54712	Corp of the District of Summerland (36565)	18881218	03A - Irrigation: Local Provider	Trout Creek	859,736
F066492	PD54712	Corp of the District of Summerland (36565)	18881218	00A - Waterworks: Local Provider	Trout Creek	8,297
F066493	PD54712	Corp of the District of Summerland (36565)	18901220	03A - Irrigation: Local Provider	Trout Creek	6,167
					Count	**41**
					Sum for Aquifer 299	**874,200**
					Sum for Trout Creek	**18,709,338**
					Sum for all SW	**18,771,208**
					Total Sum	**18,771,208**

APPENDIX C – WATER DEMAND MODELING (RHF SYSTEMS LTD.)

See digital files:
historic_1981_2010.csv
access1_2041_2070.csv
access1_2071_2100.csv
canesm2_2041_2070.csv
canesm2_2071_2100.csv
cnrmcm5_2041_2070.csv
cnrmcm5_2071_2100.csv

Agriculture Water Demand Model
Meadow Valley AWDM Modeling
July 11, 2022

This describes the water demand modeling and data extracts performed for Associated Environmental's Meadow Valley Aquifers study.

Area of Interest

AE provided a shape file containing the aquifers of interest:

Figure 1 – focus aquifer outlines in red

All properties having any intersection, whole or partial, with these aquifers were included in the modeling process (with one exception – see note below). Where a property intersected more than one aquifer, the demands were assigned to the aquifer with the largest intersected area.

Note: The southern tip of the South Faulder aquifer intersects a “property” shape which is in the Penticton Indian Band Reserve 1. The areas of the shape that generate water demands are far to the south of the aquifer set; these were excluded from the analysis.

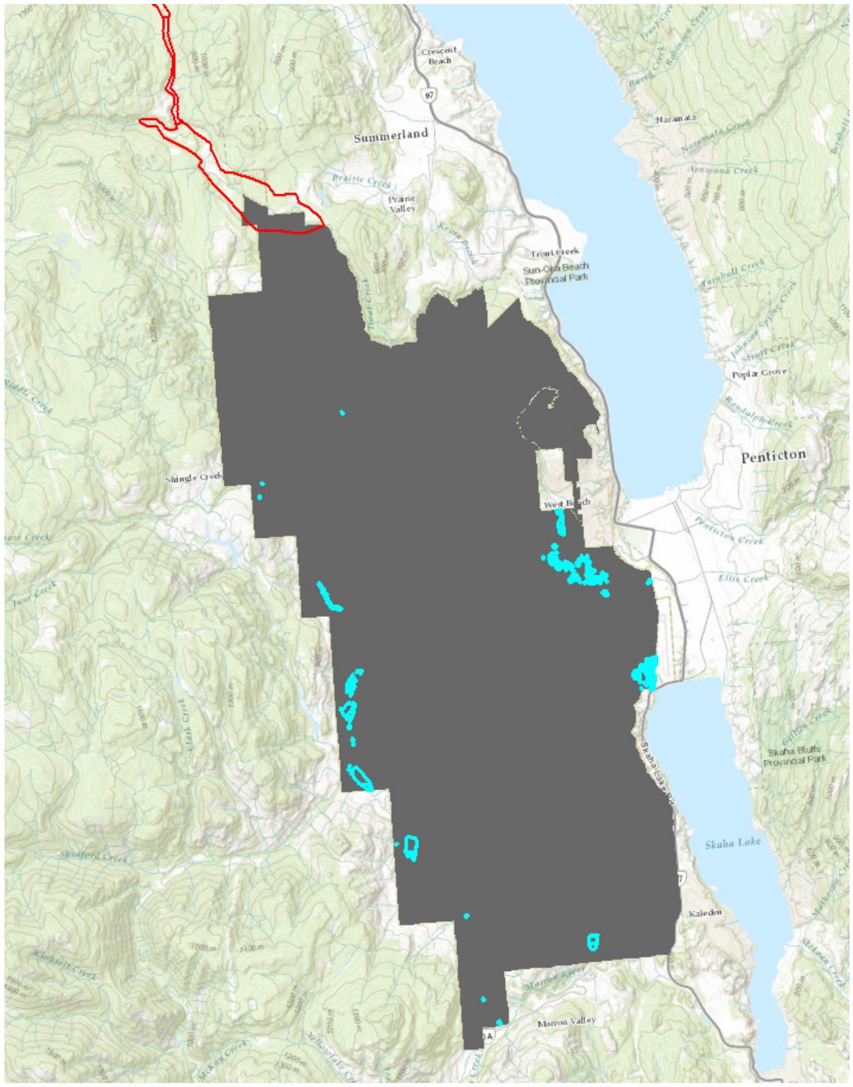

Figure 2 – water demand areas (highlighted in blue) within the grey Penticton Indian Band Reserve shape were excluded

Figure 3 illustrates the properties included in the model that have a water demand associated with them; the fill colours represent the aquifer assignments.

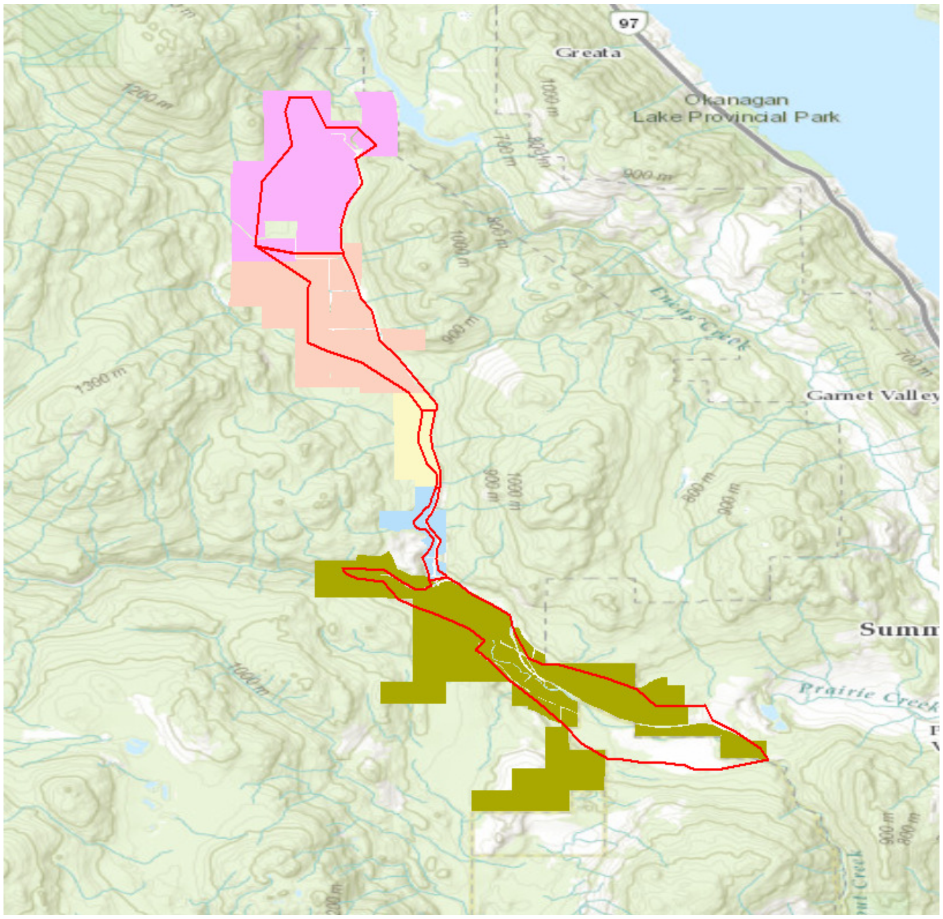

Figure 3 – properties generating water demands included in model

Climate Data

Models were run using historic climate data for 1981-2010, and for 2041-2070 and 2071-2100 using three predictive climate model datasets provided by the Pacific Climate Impacts Consortium:

- ACCESS1-0 representative concentration pathway 8.5
- CanESM2 rcp 8.5
- CNRM-CM5 rcp 4.5

Annual Soil Moisture Deficit

The Annual Soil Moisture Deficit is the amount of water that the farmer adds into the soil to bring it back to field capacity to prevent it from freezing. This is only applied in dry/cold climates; wet climates are assumed to have sufficient precipitation and warm enough temperatures to avoid the risk of freezing without this extra application of water.

There is no fixed date associated with irrigation to compensate for the annual soil moisture deficit - the farmer may choose to do it any time after the end of the growing season and before the freeze up. In the agriculture water demand model's summary reports, the demand associated with the annual soil moisture deficit shows as occurring at time 0 (week 0, month 0, etc.) simply to differentiate it from other demands that do have a date of occurrence during the crop's growing season.

Irrigation Season Overrides

An option within the water demand model allows the irrigation season to be restricted to start and end dates regardless of any demand calculated outside of that period. This is used to ensure that climate anomalies don't produce unrealistic irrigation demands; a year with a particularly long and warm fall period, for example, could theoretically show apples growing into the October or November timeframe when in reality they might be harvested in September regardless of the weather. These overrides were not used for this modeling; the irrigation season was determined solely on the basis of the climate data.

Irrigation Management Practices

Through the use of an Irrigation Management Practices setting, the model increases or decreases the amount of water assumed lost to deep percolation from over-watering. There are 3 sets of multipliers (good, average, poor) driving percolation loss calculations based on characteristics such as soil textures, crop rooting depths and water extraction coefficients, and irrigation system types. All of the scenarios in this analysis use an *average* irrigation management practice setting.

Data Tables

The water demand data is being delivered as comma-delimited text files (.csv), each corresponding to a separate climate model and period. All have the same structure:

year
- 1981-2010 (historic climate data) or 2041-2070 or 2071-2100 (predictive models)

aquifer
- aquifer name as in the provided map layer

waterSource
- ground or surface

monthNumber
- month of year 0 or 1-12
- month “0” includes water demands associated with the annual soil moisture deficit

useCategory
- agricultural and landscape irrigation, animal use, residential/commercial/industrial/institutional indoor use

demand_m3
- water demand in cubic metres

Animal and indoor residential water use is based on fixed daily estimates; the only difference between months is due to the number of days in the month. Indoor uses for some commercial, industrial and institutional operations vary from month to month.