

Memo

To:	Daris Gillis and Kari Bondaroff
Cc:	
From:	Emily Guzman and Troy Vassos
Date:	8 July 2022
Project #:	VP22-PRD-01-00
Priority:	Normal
Subject:	Charlie Lake Feasibility Study – Water Quantity

1 INTRODUCTION

Integrated Sustainability has been retained by the Peace River Regional District (PRRD) to conduct a feasibility study to identify suitable locations for a bulk potable water fill station along Charlie Lake, located approximately 6 km northwest of Fort St. John, British Columbia. The study included an evaluation of the potential water availability based on the current water resource evaluation to determine the existing water allocations and sustainable withdrawal thresholds that apply to Charlie Lake. The purpose of this memo is to provide an overview of the existing allocations and licencing requirements for Charlie Lake. Provided with an understanding of the current lake conditions, a review of potential risks associated with obtaining a Water Approval under the *Water Sustainability Act* (WSA) will be completed to assist PRRD in their decision-making process when evaluating potential water sources.

2 WATER ALLOCATION

A search of the Northeast Water Tool (NEWT) was conducted on 14 June 2022 for the Charlie Lake watershed (Attachment 1). The NEWT report indicated that the mean annual discharge (MAD) of the lake is approximately 0.649 cubic meters per second (m³/s). Based on the number and volume of current allocations licenced under Charlie Lake, approximately 34.6% of the MAD has been allocated, for a total allocation volume of 7,095,189 m³/year (0.225 m³/s). Of the remaining potential allocation for Charlie Lake, availability is managed in accordance with the *Environmental Flow Needs Policy*, where management measures are suggested to assess or mitigate potential effects of withdrawals. The measures are associated with risk levels 1, 2, and 3 and are intended to

guide where more caution may be needed in reviewing an application or making a decision.

Based on the mean monthly flows with respect to the MAD, potential allocations have been estimated for each risk level. This takes into consideration any periods throughout the calendar year where flow availability is considered low or unavailable. Specifically, winter lake withdrawal limits are applied to water licences on Charlie Lake where a cumulative maximum drawdown of 10 cm applies from December 1 to March 31. During the winter months, maximum withdrawal volume is 1,814,348 m³ and current winter allocations from the lake are approximately 2,242,282 m³ (i.e. remaining potential allocation is -427,934 m³). Thus, there are no new allocations are available during the winter months and existing licence holders are held subject to terms and conditions depending on the water availability and seasonal flows.

Outside of the winter months, flow sensitivity along Charlie Lake is considered low (i.e. from April to October). During this time, potential allocations under each risk management level are considered available, as shown in the monthly water supply and demand table of the NEWT report (Appendix 1). Water withdrawals could be conducted from May to July, where estimated mean monthly flows suggest there are sufficient volumes to support new allocations in addition to the existing allocations, as shown in Table A.

Table A. Potential Allocations at Charlie Lake

Month	Potential Allocations (m ³ /s)		
	Risk Level 1	Risk Level 2	Risk Level 3
May	4,415,040	8,199,360	-
June	1,576,800	4,730,400	946,080
July	>1,576,800	>4,730,400	>946,080

2.1 Existing Licence Holders

A review of the NEWT report indicates that there are currently five active Water Licences with a total current allocation of 14,274,192 m³, that account for 34% of the total source allocations and are held by municipal or industrial owners and the remaining are used for domestic purposes.

The Ministry of Forests also confirmed that there are three applications to Charlie Lake currently under review (pers. comm. Lenore Mallis, Licensed Authorizations Officer – Water Ministry of Forests, 15 June 2022).

The City of Fort St. John (the City) holds the largest water allocation on Charlie Lake for a total of 6,640,000 m³/year for the purpose of waterworks and 7,400,000 m³/year for the purpose of storage. The City no longer uses Charlie Lake as a water source for municipal purposes and no withdrawals have been made since 1996 (pers. comm. Garland Durnford Utilities Treatment Supervisor, City of Fort St. John, 16 June 2022).

From previous discussions with commercial licence holders on Charlie Lake, Stoddart Creek Water Services Inc., currently diverts water under a deep well aquifer licence that is treated and sold to the community. Historical data is available from Stoddart Creek, however, at this time PRRD indicates there are no plans to enter into discussions or to collaborate with Stoddart Creek regarding water supply.

2.2 Water Allocation Notation Policy

In 1979, a notation of interests 'NO34774' indicating the source is fully recorded, was placed on Charlie Lake. Notations are placed on streams and aquifers to alert provincial staff, regulatory reviewers and prospective applicants to current or potential water allocation concerns. New application submitted on sources with a notation of interest may be refused or granted with conditions due to current or potential water allocation concerns related to insufficiency of water.

Furthermore, confirmation from the Ministry of Forests was received that a Section 16 Reserve was applied to Charlie Lake, for the maintenance of water quantity and water quality (Lenore Mallis, Licensed Authorizations Officer – Water Ministry of Forests, 15 June 2022). The purpose of the Section 16 Reserve is to ensure maintenance of intact riparian habitats and managing upland habitats to protect fine scale habitat features and ensure intact functioning ecosystems.

It is assumed that new licence applications submitted to Charlie Lake would likely trigger additional regulator review to determine if the requested allocation meets the environmental flow needs and/or if there are impacts to the biological environment or other water users.

3 DISCUSSION

Based on review of the current water availability at Charlie Lake, it is anticipated that a hydrological assessment will need to be carried out to support a potential Water Licence application. This assessment would need to consider potential impacts to the environment in the lake, as well as impacts to existing licence holders. Any applications will need to consider measures to mitigate withdrawal activities during low flow periods such as carrying out monitoring of flow and water levels in the lake throughout the calendar year to ensure withdrawals are conducted with respect to the *Environmental Flow Needs*.

Additional considerations in obtaining a Water Licence on Charlie Lake include:

- Temporary storage
 - As diversion activities would be limited to the summer months (May to July), temporary freshwater storage infrastructure is recommended to mitigate low flow periods over the spring and winter. During periods where flow is sufficient, water would be diverted and stored temporarily for use when diversion is limited.



Appendix 1 – NEWT Report

VP22-PRD-01-00

Charlie Lake

Watershed Number: 7577133

June 14, 2022

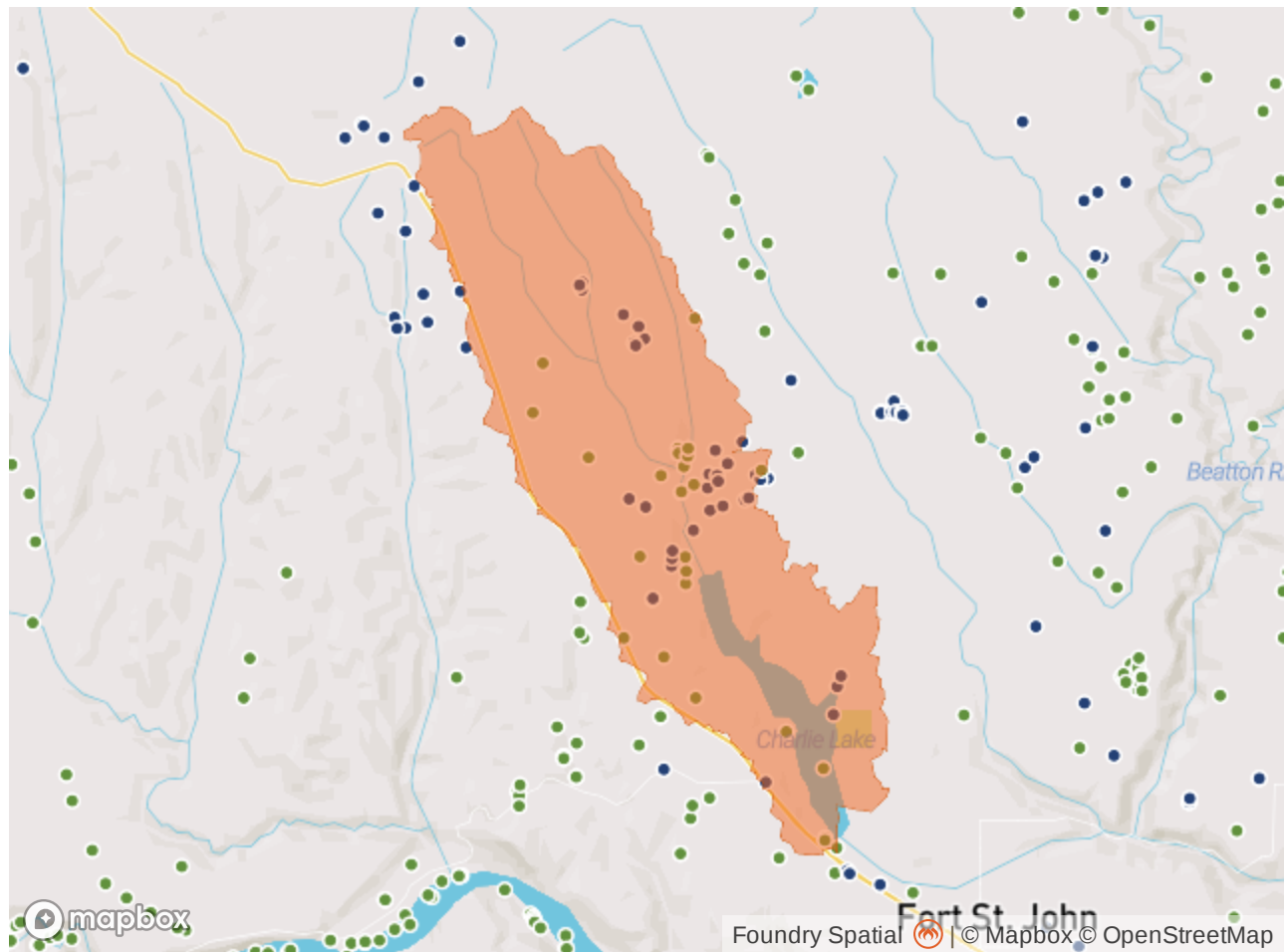


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User Notes

Current water allocations on Charlie Lake

Introduction

Thank you for generating a report using the Northeast Water Tool! In this report, you'll find a detailed water resource evaluation for the watershed you selected. Naturally, the information in the report is contextual; based on the stream, river or lake you selected, the report describes:

- The quantity and timing of water flow;
- Existing water allocations;
- The needs of the environment, and sustainable withdrawal thresholds; and
- Other characteristics of the watershed, such as landcover, climate, and topography.

Some of the information presented in this report was generated by hydrology models using large data sets of streamflow measurements, and physical and environmental characteristics. In general, this report estimates what the average conditions are like – not necessarily what may be happening at this moment or this year in particular.

As you read through the material, if you find yourself wanting to know more, all of the details regarding our methods, data sources, and the performance of the Northeast Water Tool are provided at the end of the report, along with contact information to reach government departments with any questions about water rights or water management in BC¹.

I hope that you find the information very useful. If you have any questions, comments, or ideas on how to improve the information presented, we would love to talk. You can reach the Northeast Water Tool team at bcwatertool@foundryspatial.com.

Sincerely,

Ben Kerr, P.Ag.

Foundry Spatial



Overview



Coordinates

56.316 ° N
-120.975 ° W



Watershed Area

296 km²



Watershed Elevation

864 m (max)
770 m (mean)
634 m (min)



Mean Annual Discharge

0.649 m³/s

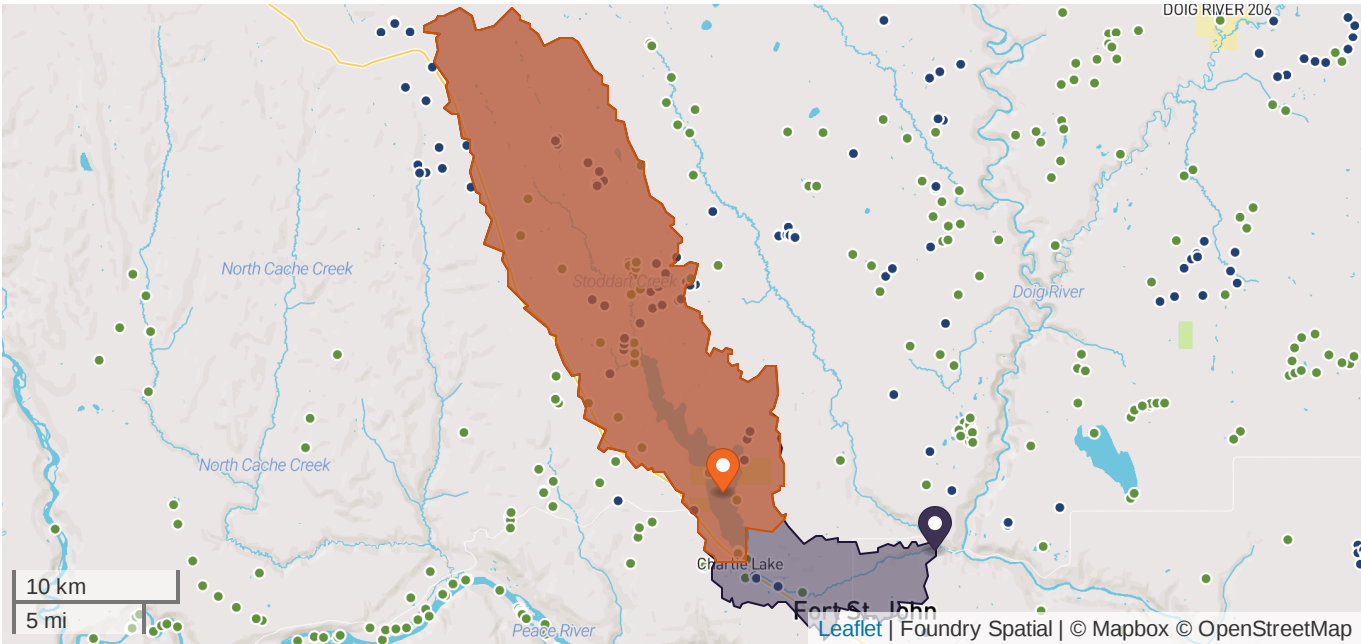
Estimates of water supply represent long-term average conditions. These estimates were generated from hydrology models³. The models incorporate information about climate, terrain, land cover, evapotranspiration, watershed boundaries and connectivity, and observed hydrology, and are calibrated using long-term streamflow monitoring data collected by the Water Survey of Canada, United States Geological Survey, and other organizations. Detailed information on models and performance is provided in the methods section of this report. Environmental flow needs calculations identify the amount of water rivers require to maintain healthy aquatic ecosystems. The calculations presented in this report are based on the Province of BC's *Environmental Flow Needs Policy*⁷.

Water allocations represent existing water rights and are sourced directly from government databases. These allocations include both short-term (temporary diversion) and long-term licences at the time of licence extract as noted within the report. Volumes of water indicated as consumptive use associated with these allocations are summarized and integrated with the estimates of water supply to provide a complete picture of the resource. Licences for all purposes are included. Both surface water and groundwater allocations within the watershed have been summarized. In some cases, assumptions have been made around timing of use (e.g. agriculture) where that information is not explicitly supplied with the source data. Information on all licences are included in this report along with notes indicating any assumptions made.

This report was generated by the BC Water Tool, an automated water resource reporting engine powered by Foundry Spatial at nwwt.bcwatertool.ca. This report contains information generated from hydrologic models, government databases, and other sources. All data sources may contain errors. As such, no warranty or representation is expressed or implied, and all liability from any decision made, based in whole or in part on the information contained within this report, is the sole responsibility of the party making said decision. Concerns or inquiries may be directed to bcwatertool@foundryspatial.com.

Annual Water Supply and Demand

This section describes the annual water supply and demand, for the location (Charlie Lake) that you selected. The watershed is outlined in orange on the map below. The watershed associated with the next downstream confluence² (Fish Creek) has also been outlined in purple, with summary statistics for both watersheds provided in the table below. Please note that all values presented are estimates and are subject to error³.



Legend

Query Watershed 

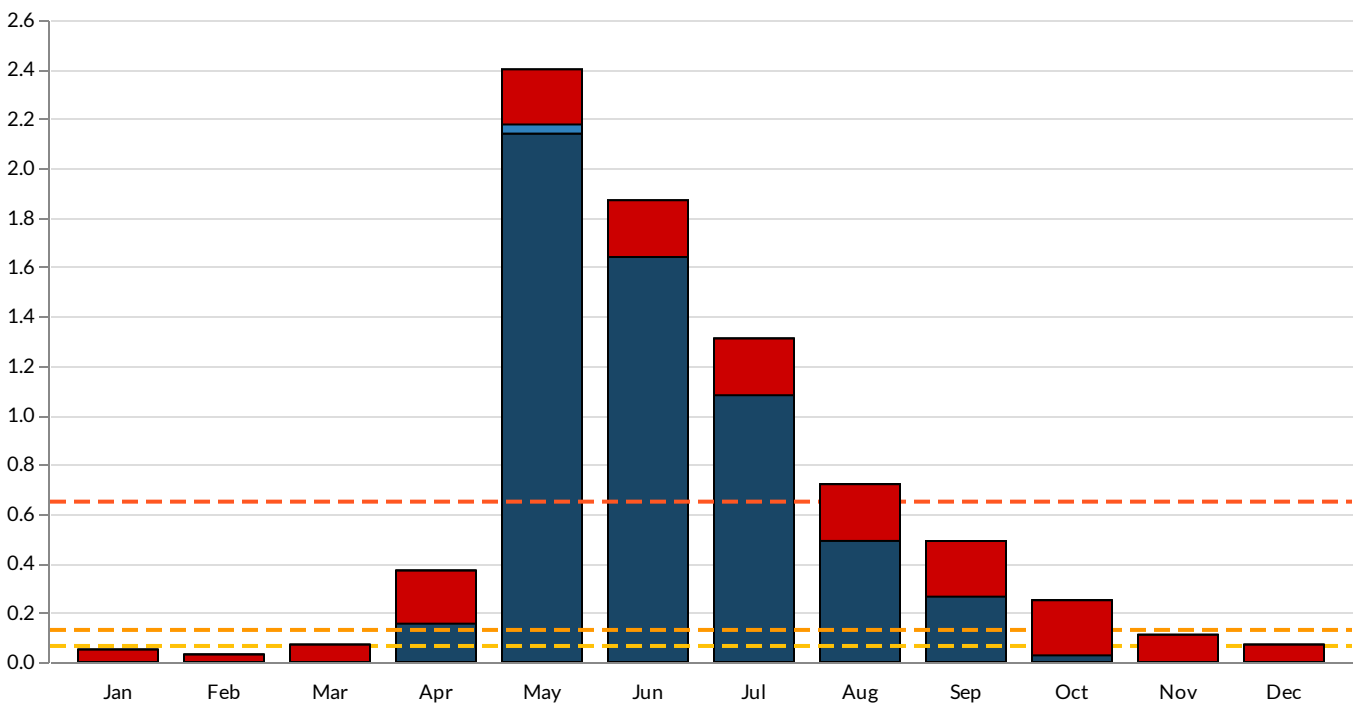
Downstream Watershed 

Annual Statistics	Charlie Lake	Fish Creek
Area (km ²)	296	348
Mean Annual Discharge (MAD, m ³ /s)	0.649	0.714
Allocations (average, m ³ /s) ⁹	0.225	0.227
Allocations (average, % of MAD)	34.6	31.8
Reserves & Restrictions ⁴	Present	Present
Volume Runoff (m ³ /yr)	20,494,187	22,538,275
Volume Allocations (m ³ /yr)	7,095,189	7,157,994
Seasonal Flow Sensitivity ⁵	Winter, Summer	Winter, Summer

Monthly Water Supply and Demand - Charlie Lake

Hydrologic models⁶ have been developed to produce estimates of mean monthly flows. The Province of BC's *Environmental Flow Needs Policy*⁷ has been applied to these estimates, identifying risk management levels⁸ to support water management decisions. Information on active water licences and approvals (collectively, 'allocations') in the watershed have been extracted and summarized from government databases⁹ and integrated with the hydrology model data and risk management level calculations, to account for the volume of water already allocated.

In the chart below, the height of each column represents the mean monthly discharge - the long term, estimated average flow for that month of the year. The dark, medium, and light blue areas of the columns show the potential amount of water allocations within each risk management level. When allocations exist in the watershed, a red box hangs down from the top of each column to represent the volume of existing allocations in the context of mean monthly supply. The table below corresponds to the data shown on the chart.



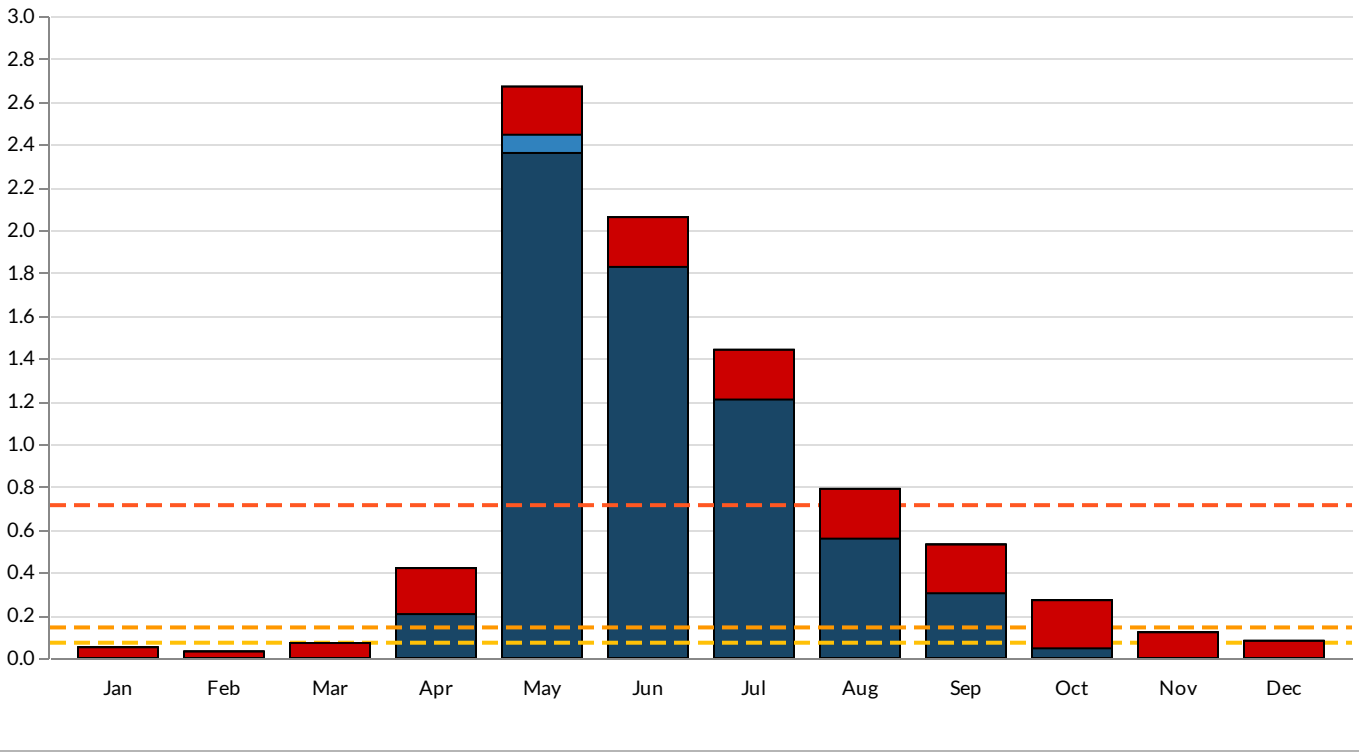
Legend

- Existing Allocations 
- Risk Management 1 
- Risk Management 2 
- Risk Management 3 
- MAD 10% 0.06 m³/s 
- MAD 20% 0.13 m³/s 
- MAD 0.65 m³/s 

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
% of MAD	7.1	5.1	10.0	57.7	369.1	288.6	202.3	111.5	75.1	38.3	17.3	10.9
Flow Sensitivity	High	High	Mod	Low	Low	Low	Low	Low	Low	Low	Mod	Mod
Existing Water Licences* (m³/s)	0.21	0.21	0.21	0.21	0.21	0.22	0.22	0.22	0.22	0.21	0.21	0.21
Existing Short Term Approvals* (m³/s)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mean Monthly Discharge (m³/s)	0.05	0.03	0.07	0.37	2.40	1.87	1.31	0.72	0.49	0.25	0.11	0.07
Potential Allocation (m³/s, Risk Mgmt 1) ²³	L	L	L	0.00	0.14	0.05	0.00	0.00	0.00	0.00	0.00	L
Potential Allocation (m³/s, Risk Mgmt 2) ²³	L	L	L	0.00	0.26	0.15	0.03	0.00	0.00	0.00	0.00	L
Potential Allocation (m³/s, Risk Mgmt 3) ²³	L	L	L	≥ 0.00	≥ 0.26	≥ 0.15	≥ 0.03	≥ 0.00	≥ 0.00	≥ 0.00	≥ 0.00	L

Monthly Water Supply and Demand - Fish Creek

Similar to the previous section, which described the water supply and demand for the location that you selected, this section describes the water supply and demand for the downstream basin. The hydrology model and risk management calculations are the exact same, but the calculation logic for existing allocations is different, taking into account non-consumptive, or ‘flow-through’ water rights.⁹



Legend

- Existing Allocations
- Risk Management 1
- Risk Management 2
- Risk Management 3
- MAD 10% 0.07 m³/s
- MAD 20% 0.14 m³/s
- MAD 0.71 m³/s

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
% of MAD	6.9	4.9	10.0	58.2	373.8	288.1	201.1	110.1	74.5	37.5	17.0	10.7
Flow Sensitivity	High	High	High	Low	Low	Low	Low	Low	Low	Low	Mod	Mod
Existing Water Licences* (m³/s)	0.21	0.21	0.21	0.21	0.21	0.22	0.22	0.22	0.22	0.21	0.21	0.21
Existing Short Term Approvals* (m³/s)	0.01	0.01	0.01	< 0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mean Monthly Discharge (m³/s)	0.05	0.03	0.07	0.42	2.67	2.06	1.44	0.79	0.53	0.27	0.12	0.08
Potential Allocation (m³/s, Risk Mgmt 1)	0.00	0.00	0.00	0.00	0.18	0.08	0.00	0.00	0.00	0.00	0.00	0.00
Potential Allocation (m³/s, Risk Mgmt 2)	0.00	0.00	0.00	0.00	0.31	0.18	0.06	0.00	0.00	0.00	0.00	0.00
Potential Allocation (m³/s, Risk Mgmt 3)	≥0.00	≥0.00	≥0.00	≥0.00	≥0.31	≥0.18	≥0.06	≥0.00	≥0.00	≥0.00	≥0.00	≥0.00

Allocations By Industry

Water licences and approvals (allocations) in British Columbia are administered under the Water Sustainability Act. Existing, active water allocations in the watershed are summarized by water source, type, and term in the table below. On the following pages, each individual water allocation is listed with information on the specific water source and quantity, ordered by seniority.

Industry	Annual Volume	Ground Water (m³)		Surface Water (m³)	
		STUA	Licence	STUA	Licence
Agriculture		0	13,438	0	63,814
Commercial		0	3,411	273,938	1,660
Domestic		0	0	0	7,472
Municipal		0	159,430	0	6,755,305
Oil & Gas		0	0	0	0
Other		0	0	0	0
Power		0	0	0	0
Storage		0	80,730	0	130,348

Purpose Use Code Groupings

Agriculture

Crop Harvest, Protect & Compost, Crops: Crop Suppression, Crops: Flood Harvesting, Crops: Frost Protection, Greenhouse & Nursery, Greenhouse & Nursery: Greenhouse, Greenhouse & Nursery: Nursery, Irrigation: Local Provider, Irrigation: Private, Livestock & Animal, Livestock & Animal: Game Farm, Livestock & Animal: Kennel, Livestock & Animal: Stockwatering

Commercial

Bulk Shipment for Marine Transfer, Camps & Pub Facil, Camps & Pub Facil: Church/Com Hall, Camps & Pub Facil: Exhibition Grounds, Camps & Pub Facil: Institutions, Camps & Pub Facil: Non-Work Camps, Camps & Pub Facil: Public Facility, Camps & Pub Facil: Work Camps, Camps and Public Facilities, Comm. Enterprise, Comm. Enterprise: Amusement Park, Comm. Enterprise: Enterprise, Fish Hatchery, Fresh Water Bottling, Heat Exchanger, Ind'l & Comm., Ice & Snow Making, Ind'l Waste Mgmt: Effluent, Ind'l Waste Mgmt: Garbage Dump, Ind'l Waste Mgmt: Sewage Disposal, Industrial Waste Mgmt, Industrial (Well Drill/Transp Mgmt), Industrial-dewatering, Mineralized Water: Bottling & Dist, Mineralized Water: Comm. Bathing Pool, Mining: Hydraulic, Mining: Placer, Mining: Processing Ore, Mining: Washing Coal, Misc Ind'l, Misc Ind'l: Dewatering, Misc Ind'l: Fire Protection, Misc Ind'l: Overburden Disposal, Misc Ind'l: Sediment Control, N/A, Pond & Aquaculture, Processing & Mfg, Processing & Mfg: Fire Prevention, Processing & Mfg: Processing, Processing & Mfg: Wharves, Pulp Mill, Transport Mgmt: Dust Control, Transport Mgmt: Road Maint, Vehicle & Eqpt, Vehicle & Eqpt: Brake Cooling, Vehicle & Eqpt: Mine & Quarry, Vehicle & Eqpt: Truck & Eqpt Wash, Well Drilling/Transport Management

Domestic

Domestic, Incidental - Domestic

Municipal

Heat Exchanger, Residential, Land Improvement: General, Land Improvement: Ind'l for Rehab or Remed, Lwn, Fairway & Grdn, Lwn, Fairway & Grdn: Res L/G, Lwn, Fairway & Grdn: Watering, Swimming Pool, Waterworks (other than LP), Waterworks: Local Provider, Waterworks: Water Delivery, Waterworks: Water Sales

Oil & Gas

Industrial: Fire Suppression, Industrial: Pressure Testing, Industrial: Road Maintenance, Industrial: Work Camp, Oil & Gas Purpose: Hydraulic Fracturing, Oil & Gas Purpose: Oil Field Injection, Oil & Gas Purpose: Other, Oil & Gas Purpose: Well Drilling, Oil & Gas: Drilling, Oil & Gas: Hydraulic Fracturing (deep GW), Oil & Gas: Hydraulic Fracturing (non-deep GW), Oil & Gas: Oil field inject. (non-deep GW)

Other

Conservation: Construction Works, Conservation: Use of Water, Ice & Snow Making: Ice, Ice & Snow Making: Snow, Permit to Occupy Crown Land, River Improvement

Power

Cooling, Power: Commercial, Power: General, Power: Residential

Storage

Aquifer Storage: Non-Power, Conservation: Storage, Stream Storage: Non-Power, Stream Storage: Power

Water Licences (Surface Water)

Water licences²¹ and short term use approvals^{20, 21} (collectively, 'allocations') for surface water and groundwater in British Columbia are managed under the Water Sustainability Act¹⁰. These allocations are authorized by the Ministry of Forests, Lands, Natural Resource Operations, and Rural Development, and the BC Oil and Gas Commission (associated with activities regulated under the Oil and Gas Activities Act¹¹). Existing allocations, and active applications²² for water licences within the query basin, are summarized and listed in the charts and tables below.

Existing Allocations

Current approved surface water rights

Licence	Number	POD	Date	Quantity	Flag ¹²
PRIVATE INDIVIDUAL NAME Domestic from Crown Spring (Surface water)	C118102 File # 7001654	PD36661	Priority: Jul 31, 1958 Status: Mar 12, 2003	2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Roper Creek (Surface water)	C118018 File # 7001678	PD36642	Priority: Aug 11, 1961 Status: Feb 11, 2003	4.55 m³/day	T
PRIVATE INDIVIDUAL NAME Vehicle & Eqpt: Truck & Eqpt Wash from Charlie Lake (Surface water)	C118562 File # 7001693	PD36348	Priority: Jun 08, 1964 Status: Jun 20, 2003	4.55 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Landsgard Spring (Surface water)	C060265 File # 7000061	PD36662	Priority: Sep 02, 1982 Status: Mar 26, 1991	4.55 m³/day	T
North Shore Ranches Ltd. (126988) Domestic from Duncan Spring (Surface water)	C062674 File # 7000062	PD36663	Priority: Sep 10, 1982 Status: Mar 26, 1991	2.27 m³/day	T
North Shore Ranches Ltd. (126988) Livestock & Animal: Stockwatering from Duncan Spring (Surface water)	C062674 File # 7000062	PD36663	Priority: Sep 10, 1982 Status: Mar 26, 1991	2.27 m³/day	T
PRIVATE INDIVIDUAL NAME Domestic from Melba Spring (Surface water)	C068832 File # 7000390	PD36681	Priority: Sep 18, 1986 Status: Mar 26, 1991	2.27 m³/day	T
Lake Point Golf and Country Club (16958) Lwn, Fairway & Grdn: Watering from Charlie Lake (Surface water)	C123464 File # 7001004	PD36645	Priority: Jun 26, 1992 Status: Feb 28, 2008	111,013 m³/year	T
Lake Point Golf and Country Club (16958) Stream Storage: Non-Power from Charlie Lake (Surface water)	C123464 File # 7001004	PD36645	Priority: Jun 26, 1992 Status: Feb 28, 2008	123,348 m³/year	T, N
North Shore Ranches Ltd. (126988) Livestock & Animal: Stockwatering from East Stoddart Creek (Surface water)	C130742 File # 9000007	PD67262	Priority: Jan 08, 1993 Status: Mar 18, 2014	6.82 m³/day	M
North Shore Ranches Ltd. (126988) Livestock & Animal: Stockwatering from East Stoddart Creek (Surface water)	C130742 File # 9000007	PD186180	Priority: Jan 08, 1993 Status: Mar 18, 2014	6.82 m³/day	M, N
North Shore Ranches Ltd. (126988) Livestock & Animal: Stockwatering from Stoddart Creek (Surface water)	C130742 File # 9000007	PD67263	Priority: Jan 08, 1993 Status: Mar 18, 2014	6.82 m³/day	M, N
Multiple Licence Holders Domestic from Edith Spring (Surface water)	C130743 File # 7001052	PD67258	Priority: Jan 08, 1993 Status: Mar 18, 2014	2.27 m³/day	M
Multiple Licence Holders Domestic from Victor Spring (Surface water)	C130743 File # 7001052	PD67260	Priority: Jan 08, 1993 Status: Mar 18, 2014	2.27 m³/day	M, N

Licence	Number	POD	Date	Quantity	Flag ¹²
Multiple Licence Holders Livestock & Animal: Stockwatering from Edith Spring (Surface water)	C130743 File # 7001052	PD67258	Priority: Jan 08, 1993 Status: Mar 18, 2014	6.82 m³/day	M
Multiple Licence Holders Livestock & Animal: Stockwatering from Victor Spring (Surface water)	C130743 File # 7001052	PD67260	Priority: Jan 08, 1993 Status: Mar 18, 2014	6.82 m³/day	M, N
PRIVATE INDIVIDUAL NAME Domestic from Coffee Creek (Surface water)	C107496 File # 7001123	PD68642	Priority: Oct 19, 1993 Status: Jul 07, 1995	2.27 m³/day	T
City of Fort St John (16960) Waterworks: Local Provider from Charlie Lake (Surface water)	C118223 File # 7001185	PD36349	Priority: Feb 07, 1995 Status: Mar 26, 2003	6,637,291 m³/year	M
PRIVATE INDIVIDUAL NAME Irrigation: Private from Charlie Lake (Surface water)	C124880 File # 7001998	PD82791	Priority: Jun 26, 2009 Status: Oct 08, 2009	2.47 m³/year	T
PRIVATE INDIVIDUAL NAME Irrigation: Private from Stoddart Creek (Surface water)	C133152 File # 9000070	PD187680	Priority: Nov 24, 2015 Status: Jun 28, 2017	58,000 m³/year	T
Multiple Licence Holders Land Improvement: General from Llama Creek (Surface water)	502792 File # 20010353	PD201115	Priority: Mar 22, 2019 Status: Mar 04, 2021	7,000 m³/year	T, N
Multiple Licence Holders Stream Storage: Non-Power from Llama Creek (Surface water)	502792 File # 20010353	PD201115	Priority: Mar 22, 2019 Status: Mar 04, 2021	7,000 m³/year	T, N

Water Licences (Groundwater)

Existing Allocations

Current approved groundwater rights

Licence	Number	POD	Date	Quantity	Flag ¹²
PRIVATE INDIVIDUAL NAME Livestock & Animal from 451 (Dugout, ditch, quarry, etc)	503407 File # 20017628	PG202684	Priority: Aug 01, 1970 Status: May 27, 2021	913 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from 451 (Dugout, ditch, quarry, etc)	503407 File # 20017628	PG202681	Priority: Aug 01, 1970 Status: May 27, 2021	913 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from 451 (Dugout, ditch, quarry, etc)	503407 File # 20017628	PG202682	Priority: Aug 01, 1970 Status: May 27, 2021	913 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from 451 (Dugout, ditch, quarry, etc)	503407 File # 20017628	PG202683	Priority: Aug 01, 1970 Status: May 27, 2021	913 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from 451 (Dugout, ditch, quarry, etc)	503407 File # 20017628	PG202685	Priority: Aug 01, 1970 Status: May 27, 2021	913 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from 451 (Dugout, ditch, quarry, etc)	503407 File # 20017628	PG202686	Priority: Aug 01, 1970 Status: May 27, 2021	913 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from 451 (Dugout, ditch, quarry, etc)	503407 File # 20017628	PG202687	Priority: Aug 01, 1970 Status: May 27, 2021	913 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from 451 (Well)	503407 File # 20017628	PW202625 WTN: 122882	Priority: Aug 01, 1970 Status: May 27, 2021	913 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	501165 File # 20005792	PG196654	Priority: May 15, 1974 Status: Aug 21, 2019	1,240 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	501165 File # 20005792	PG196650	Priority: May 15, 1974 Status: Aug 21, 2019	1,240 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	501165 File # 20005792	PG196651	Priority: May 15, 1974 Status: Aug 21, 2019	1,240 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	501165 File # 20005792	PG196652	Priority: May 15, 1974 Status: Aug 21, 2019	1,240 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	501165 File # 20005792	PG196653	Priority: May 15, 1974 Status: Aug 21, 2019	1,240 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	503514 File # 20017881	PG203067	Priority: Jan 01, 1983 Status: Jun 29, 2021	2,190 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	503514 File # 20017881	PG203054	Priority: Jan 01, 1983 Status: Jun 29, 2021	2,190 m³/year	M, N

Licence	Number	POD	Date	Quantity	Flag ¹²
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	503514 File # 20017881	PG203055	Priority: Jan 01, 1983 Status: Jun 29, 2021	2,190 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	503514 File # 20017881	PG203056	Priority: Jan 01, 1983 Status: Jun 29, 2021	2,190 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	503514 File # 20017881	PG203057	Priority: Jan 01, 1983 Status: Jun 29, 2021	2,190 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	503514 File # 20017881	PG203058	Priority: Jan 01, 1983 Status: Jun 29, 2021	2,190 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	503514 File # 20017881	PG203059	Priority: Jan 01, 1983 Status: Jun 29, 2021	2,190 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	503514 File # 20017881	PG203060	Priority: Jan 01, 1983 Status: Jun 29, 2021	2,190 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	503514 File # 20017881	PG203062	Priority: Jan 01, 1983 Status: Jun 29, 2021	2,190 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	503514 File # 20017881	PG203063	Priority: Jan 01, 1983 Status: Jun 29, 2021	2,190 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	503514 File # 20017881	PG203066	Priority: Jan 01, 1983 Status: Jun 29, 2021	2,190 m³/year	M, N
BC Parks - Victoria (148515) Comm. Enterprise from 451 (Well)	502979 File # 20016382	PW201484 WTN: 93901	Priority: Sep 15, 1983 Status: Jan 21, 2021	8.14 m³/day	T, N
Multiple Licence Holders Livestock & Animal from 451 (Well)	503500 File # 20017853	PW203004 WTN: 123042	Priority: Jan 01, 1985 Status: Jun 24, 2021	150 m³/year	T, N
BC Parks - Victoria (148515) Comm. Enterprise from 451 (Well)	502925 File # 20016089	PW201235 WTN: 25255	Priority: Sep 17, 1991 Status: Dec 22, 2020	1.20 m³/day	T, N
Multiple Licence Holders Livestock & Animal from 451 (Well)	502983 File # 20014102	PW201039 WTN: 108374	Priority: Apr 28, 2012 Status: Jan 20, 2021	3,650 m³/year	T, N
Shadow Creek Developments Ltd (138020) Livestock & Animal from 451 (Well)	502964 File # 20014428	PW190297 WTN: 107148	Priority: Aug 15, 2012 Status: Feb 12, 2021	1,825 m³/year	M, N
Shadow Creek Developments Ltd (138020) Livestock & Animal from 451 (Well)	502964 File # 20014428	PW201259 WTN: 121799	Priority: Aug 15, 2012 Status: Feb 12, 2021	1,825 m³/year	M, N
Shadow Creek Developments Ltd (138020) Livestock & Animal from 451 (Well)	502964 File # 20014428	PW201260 WTN: 121806	Priority: Aug 15, 2012 Status: Feb 12, 2021	1,825 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	503518 File # 20017858	PG203032	Priority: Aug 15, 2013 Status: Jun 29, 2021	2,740 m³/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from Fort St John Unconsolidated (Dugout, ditch, quarry, etc)	503518 File # 20017858	PG203033	Priority: Aug 15, 2013 Status: Jun 29, 2021	2,740 m³/year	M, N
Multiple Licence Holders Aquifer Storage: Non-Power from 451 (Well)	500696 File # 20005387	PW192520 WTN: 113684	Priority: Oct 13, 2017 Status: Feb 13, 2019	60,000 m³/year	M, N
Multiple Licence Holders Aquifer Storage: Non-Power from 451 (Well)	500696 File # 20005387	PW192519 WTN: 113671	Priority: Oct 13, 2017 Status: Feb 13, 2019	60,000 m³/year	M, N
Multiple Licence Holders Waterworks: Water Sales from 451 (Well)	500696 File # 20005387	PW192519 WTN: 113671	Priority: Oct 13, 2017 Status: Feb 13, 2019	139,430 m³/year	M, N
Multiple Licence Holders Waterworks: Water Sales from 451 (Well)	500696 File # 20005387	PW192520 WTN: 113684	Priority: Oct 13, 2017 Status: Feb 13, 2019	139,430 m³/year	M, N

Licence	Number	POD	Date	Quantity	Flag ¹²
Full Bore Directional Inc (164943) Aquifer Storage: Non-Power from 451 (Dugout, ditch, quarry, etc)	503382 File # 20017178	PG202190	Priority: Jul 08, 2019 Exp.: Dec 31, 2031 Status: May 17, 2021	20,730 m³/year	T, N
Full Bore Directional Inc (164943) Livestock & Animal from 451 (Dugout, ditch, quarry, etc)	503382 File # 20017178	PG202190	Priority: Jul 08, 2019 Exp.: Dec 31, 2031 Status: May 17, 2021	730 m³/year	T, N
Full Bore Directional Inc (164943) Waterworks: Water Sales from 451 (Dugout, ditch, quarry, etc)	503382 File # 20017178	PG202190	Priority: Jul 08, 2019 Exp.: Dec 31, 2031 Status: May 17, 2021	20,000 m³/year	T, N

Short Term Use Approvals (Surface Water)

Existing Allocations

Current active short term use approvals

Licence	Number	POD	Date	Quantity	Flag ¹²
N/A N/A from Unknown (Unknown source)	App ID: 9000625	N/A	Start: Apr 01, 2021 Exp.: Apr 01, 2023	150 m³/day (max rate: 0.012 m³/sec)	
N/A N/A from Unknown (Unknown source)	App ID: 9000625	N/A	Start: Apr 01, 2021 Exp.: Apr 01, 2023	150 m³/day (max rate: 0.012 m³/sec)	
N/A N/A from Unknown (Unknown source)	App ID: 9000625	N/A	Start: Apr 01, 2021 Exp.: Apr 01, 2023	150 m³/day (max rate: 0.012 m³/sec)	
N/A N/A from Unknown (Unknown source)	App ID: 9000625	N/A	Start: Apr 01, 2021 Exp.: Apr 01, 2023	150 m³/day (max rate: 0.012 m³/sec)	
N/A N/A from Unknown (Unknown source)	App ID: 9000625	N/A	Start: Apr 01, 2021 Exp.: Apr 01, 2023	150 m³/day (max rate: 0.012 m³/sec)	

Water Licence Applications (Surface Water)

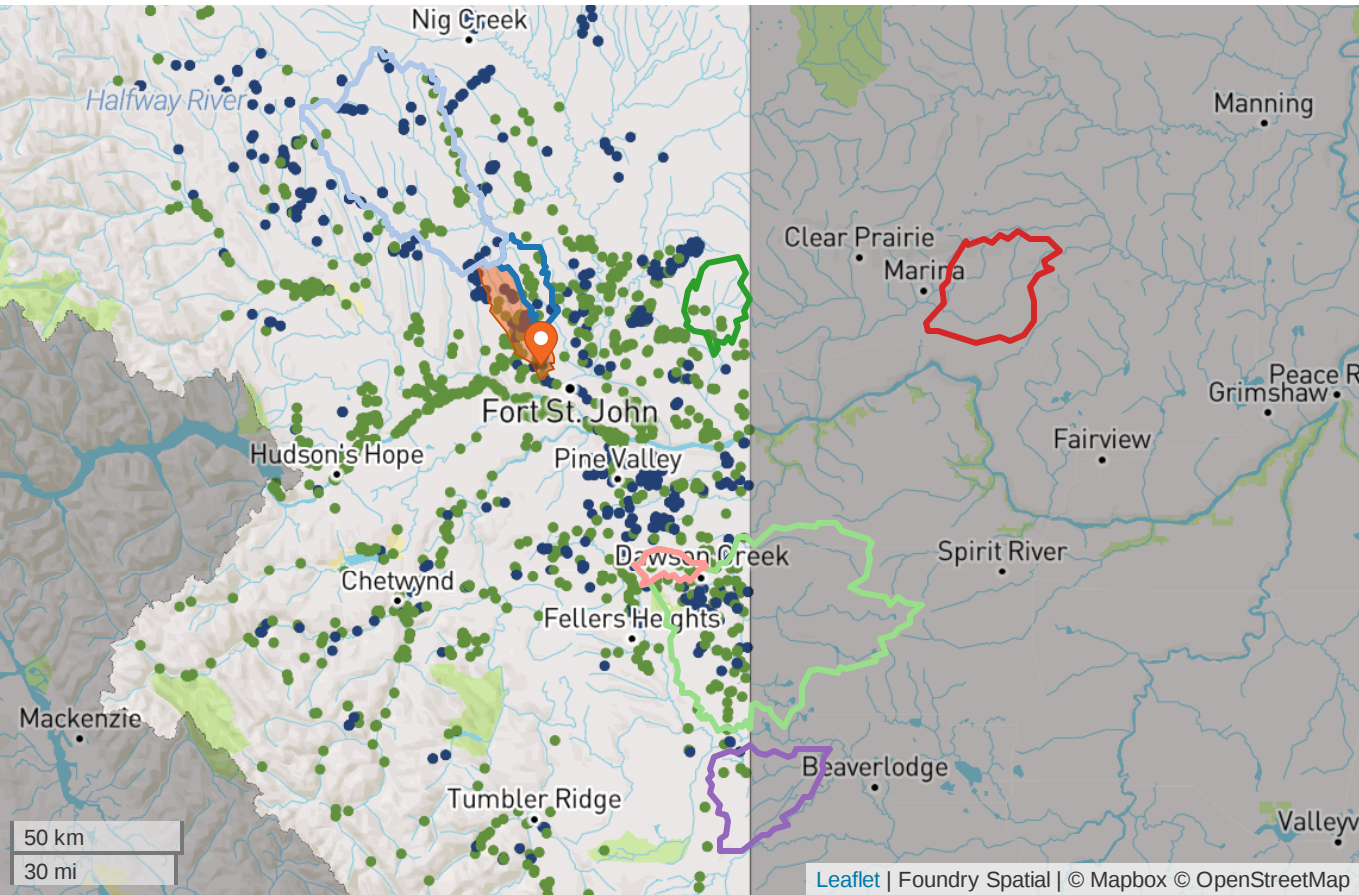
Active Applications

Active applications for surface water licences

Licence	Number	POD	Date	Quantity	Flag ¹²
Multiple Licence Holders Livestock & Animal from Unknown	113824 File # 20013824	PD201599		max rate: 0.012 m ³ /sec	N
Multiple Licence Holders Livestock & Animal from Unknown	113824 File # 20013824	PD201617		max rate: 0.012 m ³ /sec	N
Multiple Licence Holders Livestock & Animal from Unknown	113824 File # 20013824	PD201618		max rate: 0.012 m ³ /sec	N

Hydrologic Variability

The potential variability of flows in the query basin has been estimated by comparing its physical and environmental characteristics to other watersheds which have hydrometric monitoring records. A similarity score was used to quantify the basin comparisons using multiple physical and environmental metrics¹³. The statistical distribution of streamflows for each month from the monitored watersheds, was then used to estimate a potential range of flows for the query basin. The physical and hydroclimatic characteristics and comparisons are based on those used for hierarchical clustering of river ecosystems in BC¹⁴. The location of the basins is shown on the map below.

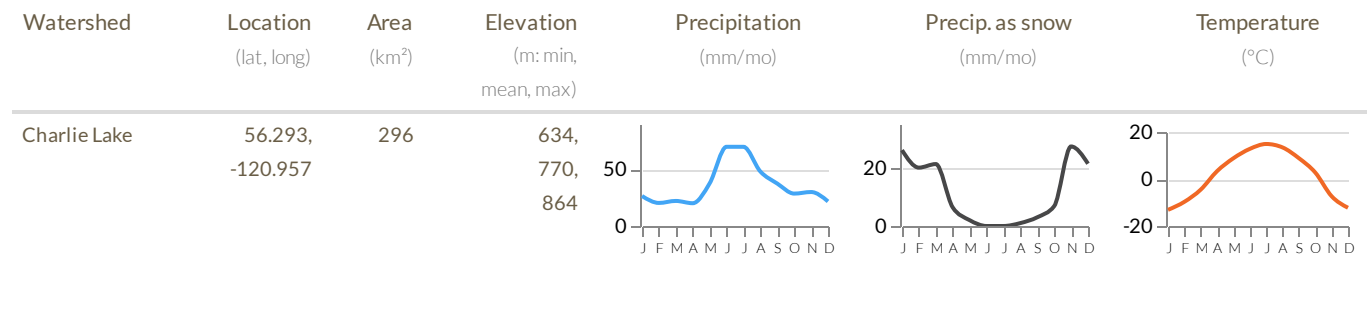


Legend

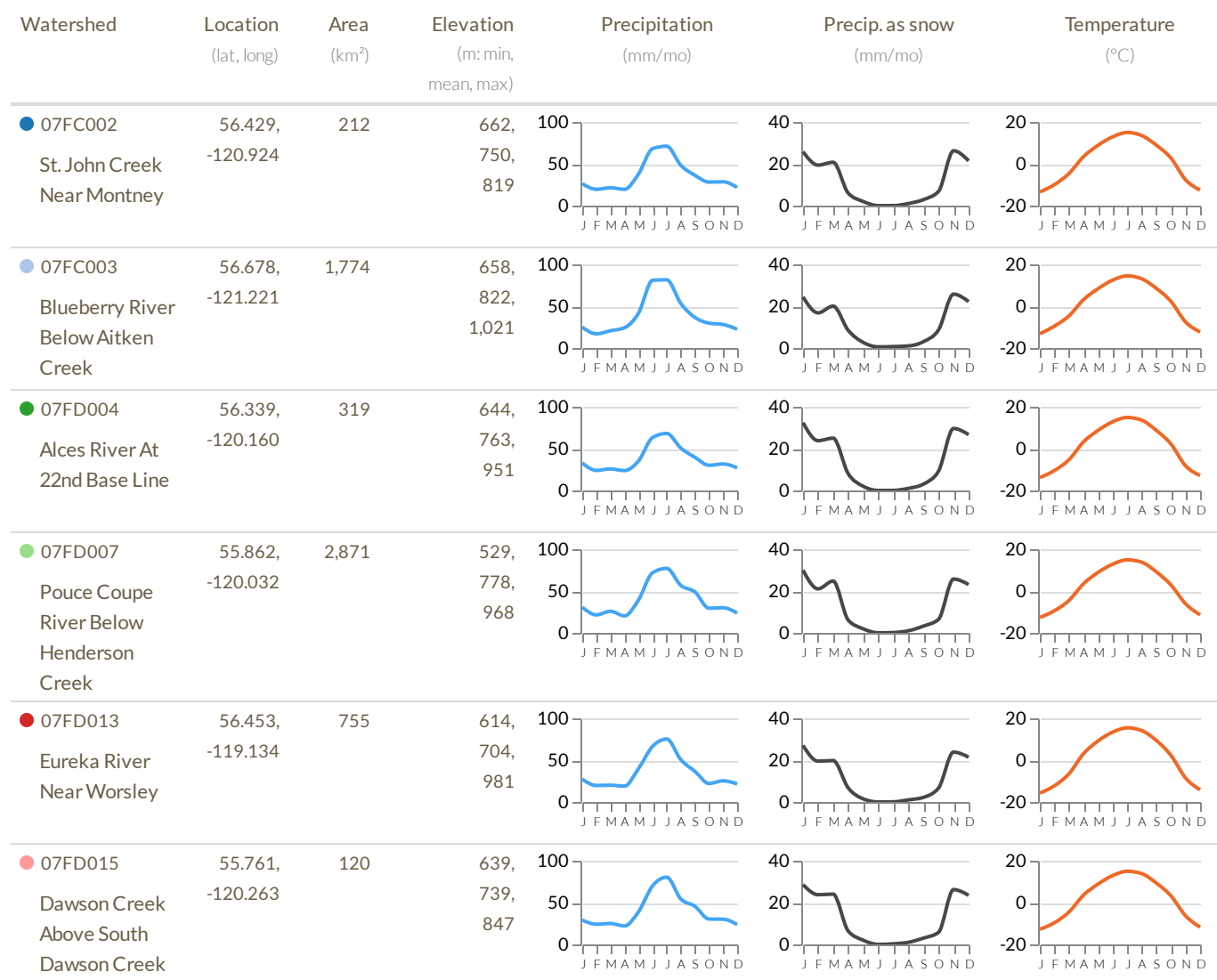
Query Watershed	07FC002	07FC003
07FD004	07FD007	07FD013
07FD015	07GD002	

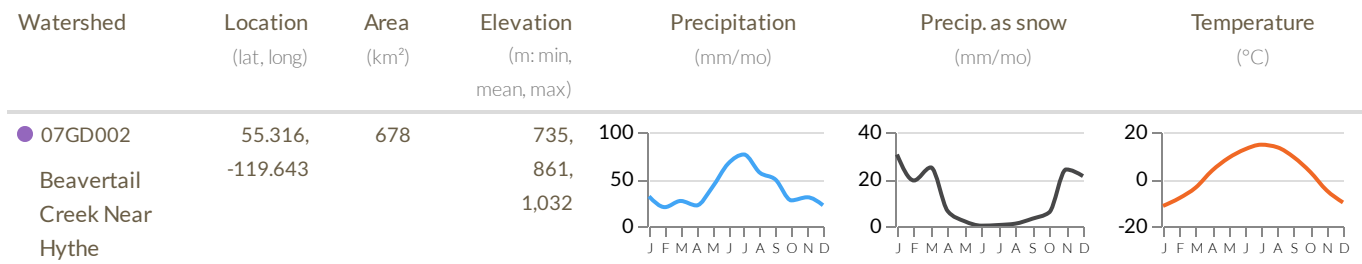
The watersheds shown on the map above have been identified as the most similar to the watershed described in this report. The table below shows key characteristics of these watersheds in relation to the watershed described in this report.

Query Watershed

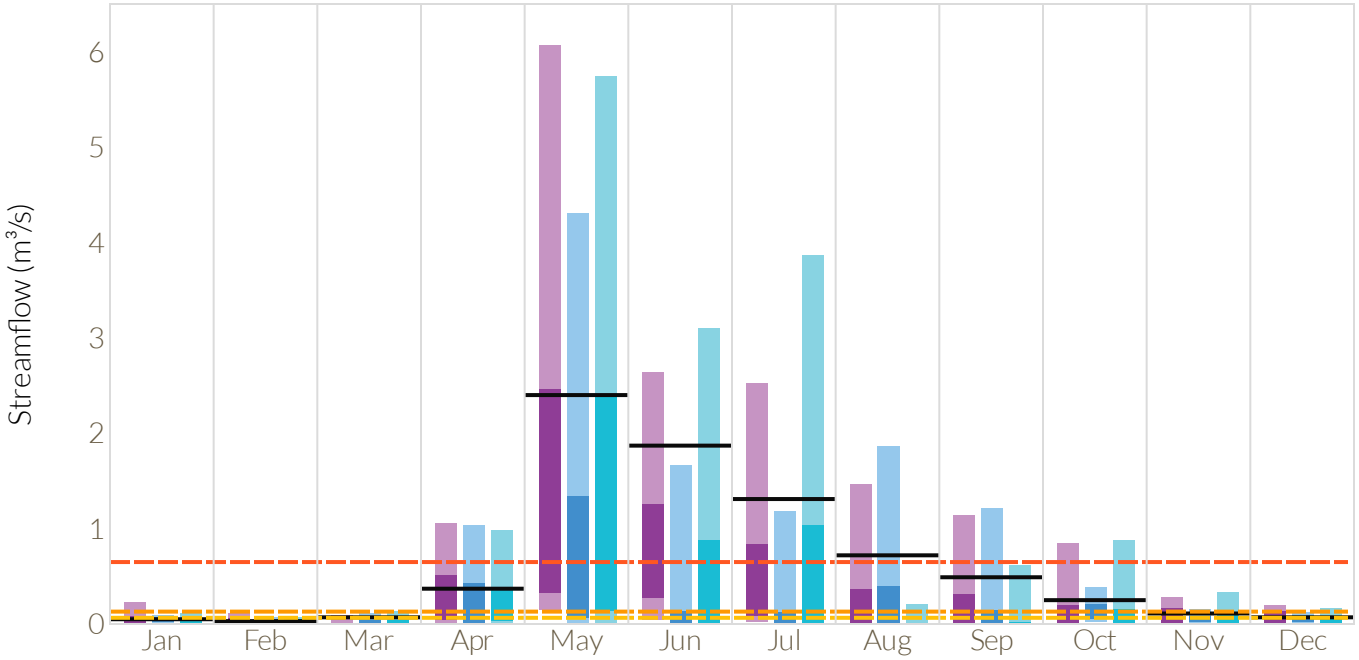


Candidate Watershed(s)

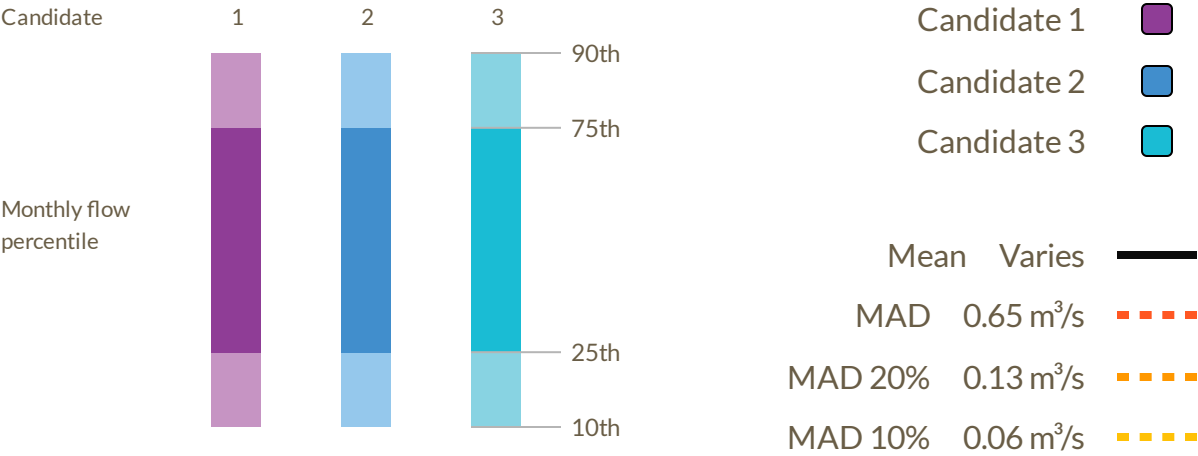




The statistical distribution of flows, from the top 3 candidate basins, has been applied to the estimated mean monthly flows of the watershed described in this report¹⁵. The chart and table below show the potential variability of flows using the flow duration curve replacement approach. Please refer to the Tabular Data - Hydrologic Variability section to determine the candidate gauges used for each month.



Legend



Tabular Data - Hydrologic Variability

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
90th	0.23	0.12	0.09	1.05	6.07	2.64	2.52	1.46	1.14	0.84	0.28	0.19
75th	0.08	0.06	0.01	0.51	2.46	1.26	0.83	0.37	0.31	0.19	0.16	0.13
Mean	0.05	0.03	0.07	0.37	2.40	1.87	1.31	0.72	0.49	0.25	0.11	0.07
25th	0.00	0.00	0.00	0.04	0.32	0.27	0.08	0.01	0.00	0.01	0.00	0.00
10th	0.00	0.00	0.00	0.01	0.15	0.04	0.02	0.00	0.00	0.00	0.00	0.00

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
90th	0.09	0.07	0.11	1.04	4.30	1.66	1.18	1.86	1.21	0.39	0.16	0.12
75th	0.07	0.04	0.04	0.43	1.34	0.13	0.13	0.39	0.14	0.21	0.08	0.09
Mean	0.05	0.03	0.07	0.37	2.40	1.87	1.31	0.72	0.49	0.25	0.11	0.07
25th	0.02	0.01	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.06	0.03	0.03
10th	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.03	0.02	0.02

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
90th	0.12	0.07	0.13	0.98	5.75	3.09	3.86	0.20	0.61	0.87	0.33	0.16
75th	0.06	0.05	0.03	0.38	2.38	0.88	1.03	0.01	0.02	0.15	0.11	0.08
Mean	0.05	0.03	0.07	0.37	2.40	1.87	1.31	0.72	0.49	0.25	0.11	0.07
25th	0.01	0.01	0.00	0.03	0.13	0.01	0.00	0.00	0.00	0.00	0.02	0.02
10th	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01

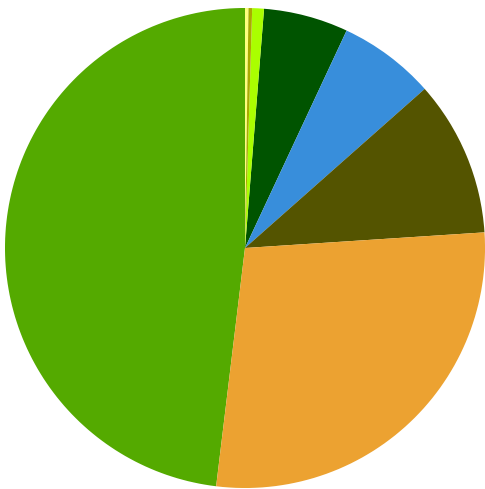
Candidate 1 

Candidate 2 

Candidate 3 

Landcover

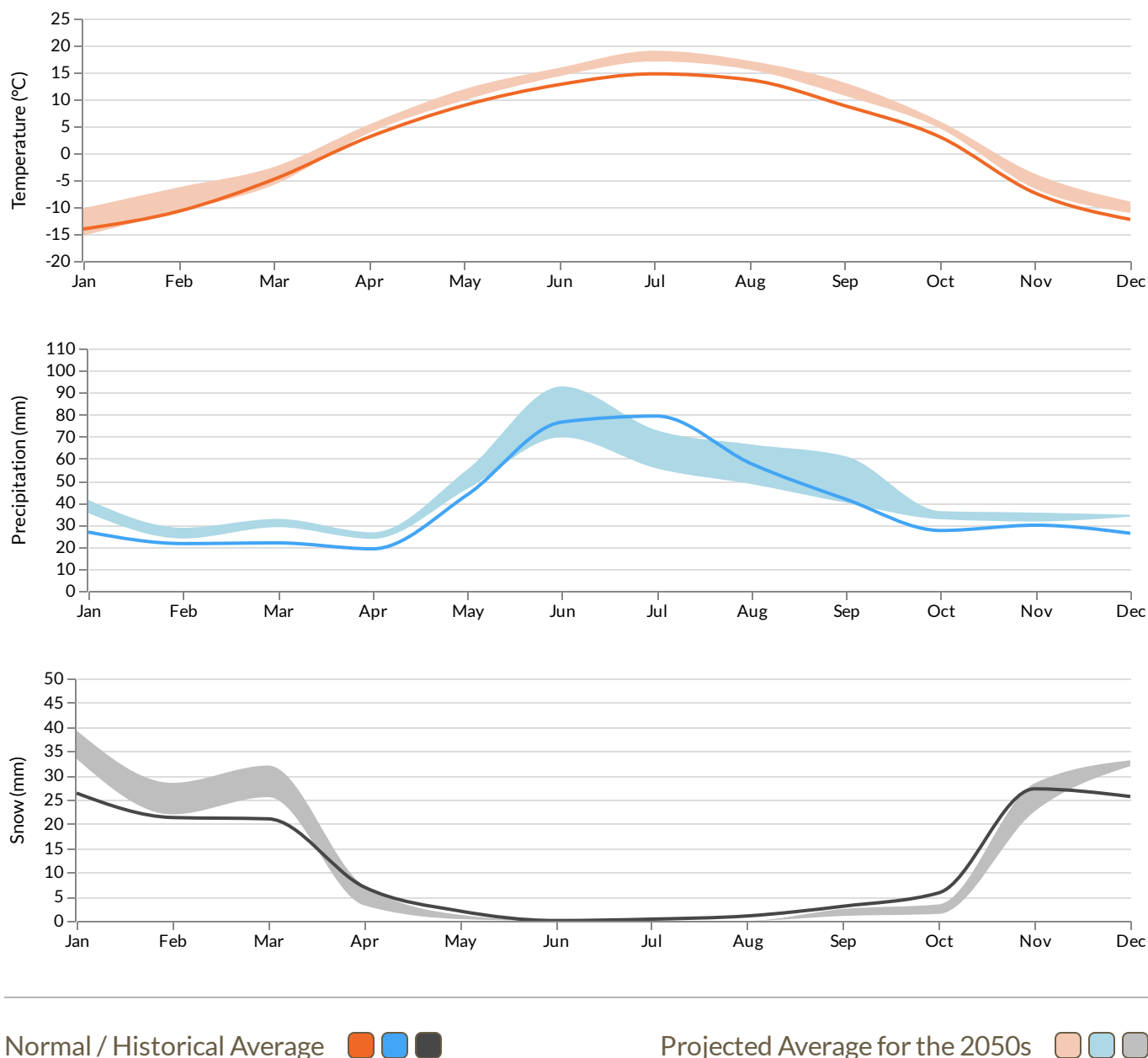
The landcover¹⁶ characteristics influence hydrologic processes in a watershed¹⁷. The chart below shows the landcover makeup of the Charlie Lake watershed. These components were incorporated in the hydrologic model that produces the water supply estimates in this report, primarily influencing the evapotranspiration component of the water budget calculations, which represent the amount of water that moves directly back to the atmosphere through direct evaporation or transpiration by vegetation.



Type	Area (km²)	% of Watershed
Barren	0.0	0.0%
Coniferous	16.8	5.7%
Cropland	82.6	27.9%
Deciduous	142.5	48.1%
Developed	0.0	0.0%
Grassland	0.7	0.2%
Herb	0.0	0.0%
Mixed	31.0	10.5%
Shrub	2.3	0.8%
Snow / Glacier	0.0	0.0%
Water	19.2	6.5%
Wetland	0.7	0.2%

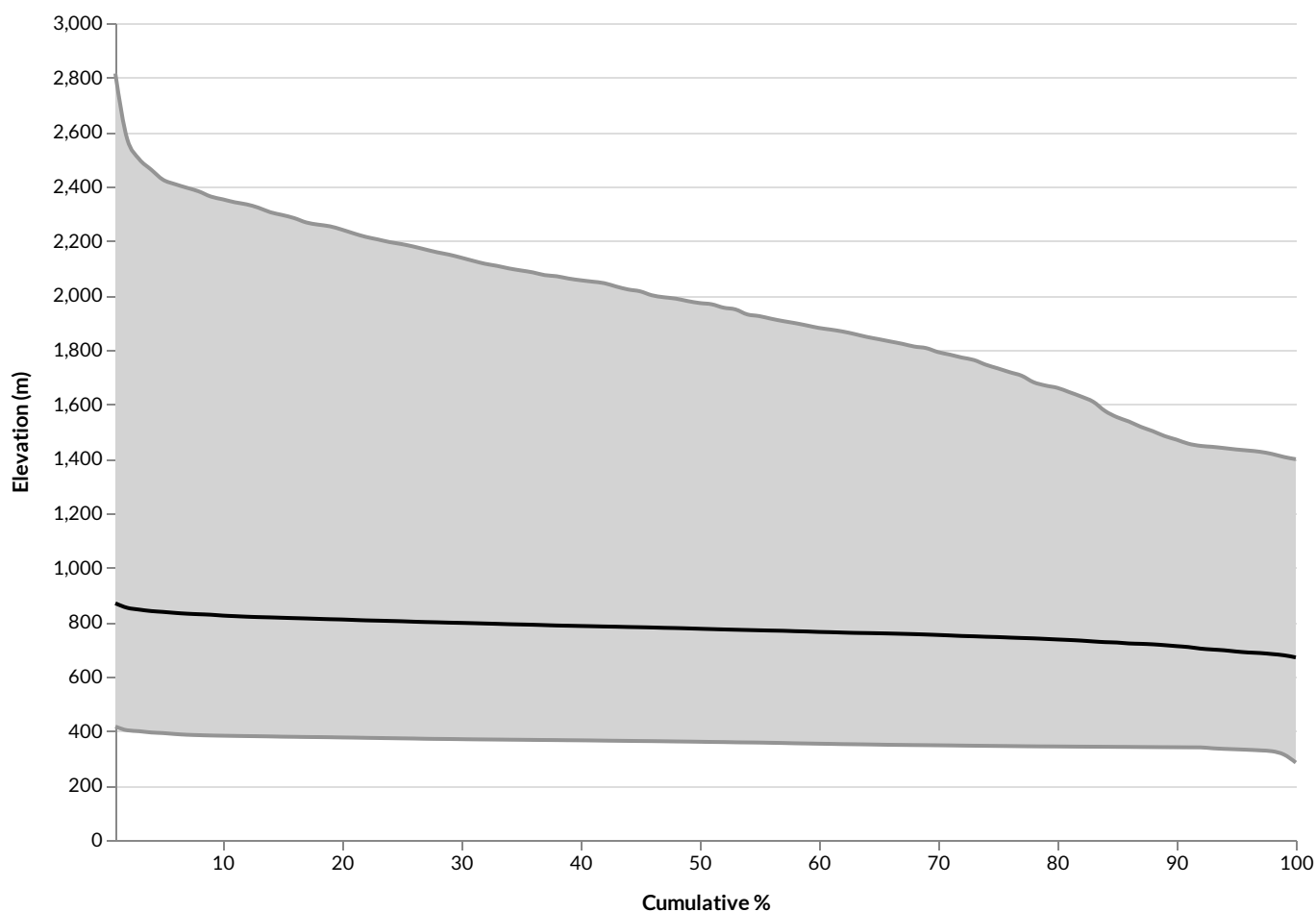
Climate

The climate of the Charlie Lake watershed has been characterized using gridded climate models¹⁸. These models have been used to calculate long term average temperature, rain and snow accumulations. The timing and amount of precipitation is a strong indicator of water availability, and the state it falls in (rain or snow) determines what happens when it reaches the ground - whether it accumulates and melts when temperatures warm, or infiltrates and runs off rapidly after reaching the ground. Three estimates of future climate for the 2041-2070 time period have been assessed and used to illustrate a range of potential future conditions. The shaded areas on each chart show a range of future conditions, and the relationship with the solid line (showing the historical average) helps understand at what time of the year the temperature, precipitation, and precipitation as snow may be different.



Topography

The elevation of a watershed is a primary control on climate, vegetation, and timing of hydrologic processes such as onset of spring melt. The amount, and state of precipitation changes with elevation. Temperatures vary by elevation, with gradients typically differing in direction between winter and summer (with valley bottoms typically colder in winter than higher elevations, and higher alpine areas colder in summer than the valley bottoms). The hypsometric curve shown in the chart below, shows the cumulative distribution of elevation by area in the watershed. Percent values on the x-axis can be used to determine the percentage of the watershed above a given elevation value.



Elevation range in watersheds > 300 km², NEBC



Notes

1. For more information please contact Frontcounter BC

✉ Email: frontcounterbc@gov.bc.ca

☎ Toll Free: 1-877-855-3222

☎ Outside North America: ++1-778-372-0729

🌐 On the web: <http://www.frontcounterbc.gov.bc.ca/>

2. The downstream watershed is defined at the mouth of the queried stream. If that downstream watershed's area is within 15% of the queried drainage area, then the watershed at the mouth of the next downstream stream is chosen as the downstream watershed. For information further downstream, please generate an additional report at a location of interest. Predictions for small watersheds (generally smaller than 50 sq. km.) may be less accurate due to the lack of hydrometric data available for watersheds of this size. These small watersheds are highly sensitive to localized weather events, resulting in highly variable conditions both within and between years.
3. The hydrologic model employed a water balance approach to estimate runoff in ungauged basins. The model was calibrated using stream flow measurements from the Water Survey of Canada, and validated using a leave-one-out cross validation. The model used 45 watersheds with hydrometric gauges, and included detailed information on climate, evapotranspiration, topography, vegetation and land cover. Error metrics calculated for mean annual discharge for the entire model domain are: Mean error = 5.5%, Median Error = 3.7%, Mean Absolute Error = 16.1%, Watersheds within +/- 20% = 77.8%.
4. Information on water reserves and restrictions can be found at the following links:

Water Reserves:
<https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-licensing-rights/water-reservations>

Water Allocation Notations:
<https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-licensing-rights/water-allocation-notations>
5. *Ptolemy, 2015.*
6. The hydrology model was developed following similar methods to those described in Chapman et al, 2018.
7. <https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-licensing-rights/water-policies/environmental-flow-needs>

8. Water volumes presented as "Potential Allocations" within this report are determined in consideration of the Province of BC's *Environmental Flow Needs Policy*⁷. Within the Policy, risk management measures are suggested to assess or mitigate potential effects of withdrawals from a stream, and provide an ecosystem perspective on environmental flow needs. The measures are associated with risk levels 1, 2, and 3 and are intended to guide where more caution may be needed in reviewing an application or making a decision.

Where there are known species or habitat sensitivities, more detailed, site-specific studies may be required. Where detailed assessments or studies exist, they will supersede policy recommendations.

Risk management levels, for assessing new applications to withdraw water, are determined for each month using the relationship of mean monthly flows to the mean annual discharge, and also using a stream size threshold based on mean annual flows. The calculations presented within this report assume all streams are fish-bearing. Where no water is indicated as available under a risk level, the stream may be very flow sensitive during that time, or the stream may have existing allocations in excess of the relevant threshold.

Inter-annual hydrologic variability may affect the amount of water available in a given year. The impact of this variability on water allocations should be considered separately from the information presented in this report.

The following risk management measures may be appropriate for consideration before a decision is made, could be completed by regional staff to inform a decision, or could be a condition of the licence or approval.

Risk management measures may differ for short-term approvals vs. licences and may vary in relation to withdrawal amounts.

Risk Level 1:

Supplemental measures to assess potential effects on environmental flow needs:

- Review relevant available information related to the WOI (e.g. water and fish reports on [Eco Cat](#)) and summarize it for the decision maker
- Consider potential impacts of proposed diversion and use on downstream values (e.g., authorized water users, riparian owners, species and habitats)

Risk Level 2:

In addition to Level 1 measures:

Supplemental measures to assess potential effects on environmental flow needs:

- Establish adequate baseline hydrological data (i.e., data representing flow conditions prior to water diversion and use proposed in the application)
- Prepare reconnaissance-level fish and fish habitat impact assessment (e.g., [RISC](#), 2001)
- Conduct an audit of actual water use within the basin use or a beneficial use review

Examples of authorization terms and conditions that may mitigate potential negative effects on environmental flow needs:

- Issue seasonal license, or restrict diversion and use during low flow or other relevant period(s)
- Require authorization-holder to develop storage
- Include a daily maximum quantity or instantaneous withdrawal rate, e.g., greater consideration of instantaneous demand over averages
- Limit pump intake size
- Require authorization-holder to monitor (e.g., install flow gauge) and report water use during specific periods
- Require authorization-holder to monitor flows and limit withdrawals when flows drop below a certain level

Risk Level 3:

In addition to Level 1 and Level 2 measures:

Supplemental measures to assess the potential effects on environmental flow needs:

- Prepare a detailed habitat assessment (e.g., [Lewis et al. 2004](#); [Hatfield et al. 2007](#)) Note that this includes development of a periodicity table.

Examples of authorization terms and conditions that may mitigate potential negative effects on environmental flow needs:

- Issues limited license terms (e.g., five years), allowing for review and potential adjustment

9. The annual allocation estimate for the queried basin is the sum of surface and groundwater short term use approvals^{19, 20} and surface water long term licences²¹ located within the queried basin. Long term licences and short term approvals with a non-consumptive or 'flow-through' water purpose as well as long term licences in an application stage were excluded from the summed annual estimate. The same rules apply to the downstream basin with one addition; for non-consumptive water use licences that are in the downstream basin but not in the query basin, the quantities are included in the allocation estimates. Stream or aquifer storage water use licences or approvals are not included in either the query or downstream calculations as it was assumed they have an associated consumptive licence or approval that uses the water from storage. The non-consumptive purposes are Aquifer Storage: Non-Power, Aquifer Storage: Power, Conservation: Construction Works, Conservation: Storage, Conservation: Use of Water, Land Improvement: General, Land Improvement: Ind'l for Rehab or Remed, Power: Commercial, Power: Dams, Power: General, Power: Residential, Stream Storage: Non-Power and Stream Storage: Power.

10. <https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/laws-rules/water-sustainability-act>

11. http://www.bclaws.ca/civix/document/id/complete/statreg/08036_01

12. Water Licence Flag Descriptions:

- D : Multiple PODs for PUC, qty at each are known, PODs on different sources
- M : Max licenced demand for purpose, multiple PODs, qty at each POD unknown
- P : Multiple PODs for PUC, qty at each are known, PODs on same source
- T : Total demand for PUC, one POD

Other:

- N : Licence volumes not used in annual or monthly allocation calculations

13. Physical and hydroclimatic characteristics of basins

Description	Source
Upstream area	Freshwater Atlas (Province of BC, 2020c)
Mean, max/min, and range elevation	Shuttle Radar Topography Mission (SRTM) (Farr 2007)
PCA axis 1 and 2 of Landcover	Land Cover of North America at 250 meters (2010)
Mainstem slope	Freshwater Atlas (Province of BC, 2020c)
Average monthly temperature	Climate WNA (version 5.6) – (Wang 2012)
Average monthly precipitation	Climate WNA (version 5.6) – (Wang 2012)
Average monthly evaporation	Climate WNA (version 5.6) – (Wang 2012)
Average monthly precipitation as snow	Climate WNA (version 5.6) – (Wang 2012)
Average no of monthly frost-free days	Climate WNA (version 5.6) – (Wang 2012)
Latitude and Longitude	HYDAT (2019) and Freshwater Atlas (Province of BC, 2020c)

14. *Ciruna et al, 2009.*

15. A flow duration curve (FDC) was estimated for the current ungauged basin, by substituting a dimensionless FDC from an observed gauged basin with the lowest dissimilarity measure (multi-dimensional Euclidean space) or highest similar physical and hydroclimatic properties. This is a modified approach to FDC substitution methods described in the literature (*Booker & Snelder, 2012; Ganora et al., 2009*) All hydrometric stations in Northern BC with at least five years of data for a given month, were used as the pool of candidates for ungauged basins. Recorded flows were normalized using the station's mean flow for the corresponding month. Once a candidate basin was selected, the substituted, normalized/dimensionless FDC was multiplied by the ungauged basin's modeled mean monthly flow.

16. The land cover data for BC was sourced from the 2000-Land Cover Vector product, produced and distributed by Natural Resources Canada. For Alaska, the land cover data was sourced from the 2001 national land cover database for the United States. Where the previous two sources were missing data, the land cover data was infilled with the 2013 North American Land Change Monitoring System Land Cover.

BC: *Geobase, 2009.*

AK: *Homer et al, 2004.*

Infill: *CEC, 2013.*

17. *Pike and Wilford, 2013.*

18. ClimateWNA v4.72 (*Wang et al, 2012*) was used to produce estimates for the 1971-2000 climate normal as well as 2041-2070 future climate scenarios. The three future climate scenarios used are the HadGEM A1B, CGCM3 A2, and HadCM3 B1. These represent a range of generally hot/dry, warm/very wet, and moderately warm/wet future climates, respectively.

19. FLNRORD Water Approval Points imported June 13, 2022 from <https://catalogue.data.gov.bc.ca/dataset/water-approval-points>

20. OGC Short term Approvals imported June 13, 2022 from https://data-bcogc.opendata.arcgis.com/datasets/fcc52c0cfb3e4bffb20518880ec36fd0_0

21. Water Rights Licences imported June 13, 2022 from <https://catalogue.data.gov.bc.ca/dataset/water-rights-licences-public>

22. Water Rights Applications imported June 13, 2022 from <https://catalogue.data.gov.bc.ca/dataset/water-rights-applications-public>

23. Winter lake withdrawal limits apply. Water withdrawal limits are based on lake surface area and cumulative maximum drawdown of 10 cm for December 1 - March 31. Maximum winter withdrawal volume is 1,814,348.31 m³. Winter allocations from the lake are currently 2,242,282.91 m³. Remaining potential allocation is -427,934.61 m³

24. Variability is defined as (Q90-Q10)/Q50. This represents how variable flows are in a given month in relation to the median flow in that month.

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Methods

Modeling

The hydrologic model driving the Northeast Water Tool was produced following similar methods to those described in:

Chapman A, Kerr B, Wilford D (2018) A water allocation decision-support model and tool for predictions in ungauged basins in northeast British Columbia. J Am Water Resour Assoc 54 (3): 676–693. <https://doi.org/10.1111/1752-1688.12643>

The Northeast Water Tool uses climate drivers from:

ClimateWNA v4.62 Normal 1961-1990

Calibration and validation was performed using hydrometric records which were selected based on length of record, seasonality, and other characteristics.

Hydrometric stations used: 45

Annual model performance:

Mean Error: 5.5%

Median Error: 3.7%

Mean Absolute Error: 16.1%

% of stations within +/- 20%: 77.8%