INTEGRATED SUSTAINABILITY

Hydrology Assessment

Charlie Lake

Prepared for
Peace River Regional District

Integrated Sustainability

7 September 2023

Report Submission To:	Daris Gillis
Legal Company Name:	Peace River Regional District
Company Address:	1981 Alaska Highway Dawson Creek, BC V1G 4H8
Contact Phone Number:	+1 (250) 784-4845
Contact Email Address:	Daris.Gillis@prrd.bc.ca

Submitted By:	Farnaz Adli
Legal Company Name:	Integrated Sustainability
Company Address:	1600, 400 - 3rd Avenue S.W. Calgary, AB T2P 4H2
Contact Phone Number:	+1 (587) 352-5867
Contact Email Address:	Farnaz.Adli@integratedsustainability.ca

Document Number:	VP22-PRD-02-00-RPT-WR-CharlieLakeHydrologyAssessment-Rev0
Document Path:	P:\PRD\VP22-PRD-02-00\5.0_Tech_Exec\5.6_GeoSci\5. Report Rev 0\Report\VP22-PRD-02-00-RPT-WR-CharlieLakeHydrologyAssessment-Rev0.docx
Document Revision Number:	0

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Any questions concerning the information or its interpretation should be directed to Farnaz Adli.

Document Revision History

Rev No.	Rev Description	Author	Reviewer	Approver	Rev Date
0	Issued as Final	[redacted] Fatemeh Madaeni	[redacted] Dalei Chen	[redacted] Ian Grant	07-Sept-2023

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1 INTRODUCTION

1.1 Project Description

Integrated Sustainability has been retained by Peace River Regional District (PRRD) to prepare a hydrological assessment for Charlie Lake (the Lake) to support a licence required for withdraw of water from it. PRRD is considering a plan to divert up to 91,250 m^3/year of water at a rate of up to 0.003 m^3/s by installing an intake by the Lake at a location within 7-17-84-19-W6 to suply a bulk potable water fill station.

1.2 Objectives

The objectives of this hydrology assessment are to:

- Provide a site description of the proposed Point of Diversion (POD) for the Project.
- Evaluate the existing flow conditions in the Lake.
- Assess the potential impact of the proposed diversion on other water users/allocations.
- Assess the impact of the proposed diversion on flows in the Lake.

2 PROJECT AREA

2.1 Project Location

The Project is located along the southwest reach of Charlie Lake, approximately 9 kilometers (km) northwest of the Town of Fort St John, British Columbia (Figure A). The POD location, Location B, was selected based on a feasibility study (Potable Water Feasibility Study, 2022) that was conducted earlier. It was selected based on the lake bathymetry, site access, and existing fill stations. More information (such as water quality, substrate type, topographic, and bathymetric qualities) on the selected site is collected through a site assessment. The proposed POD at Location B is located as follows (Figure A):

- Within 7-17-84-19-W6.
- Access to the POD is via a road off British Columbia Highway 97.
- The proposed POD is located along the southwest reach of Charlie Lake. Charlie Lake Watershed.

Charlie Lake originates approximately 40 km northwest of the proposed POD. The headwaters are situated at an elevation of 2,800 m above sea level (masl). The Charlie Lake catchment area is within the Peace River Basin limnological region at an elevation of 693 m and has a total catchment area of 296 km^2. The lake's surface area is estimated to be approximately,17.56 km^2 with a maximum depth of 13 m. The Lake drains into

Stoddart Creek and Fish Creek which flows into the Beaton River approximately 15 km downstream of the POD and eventually enters into the Peace River.

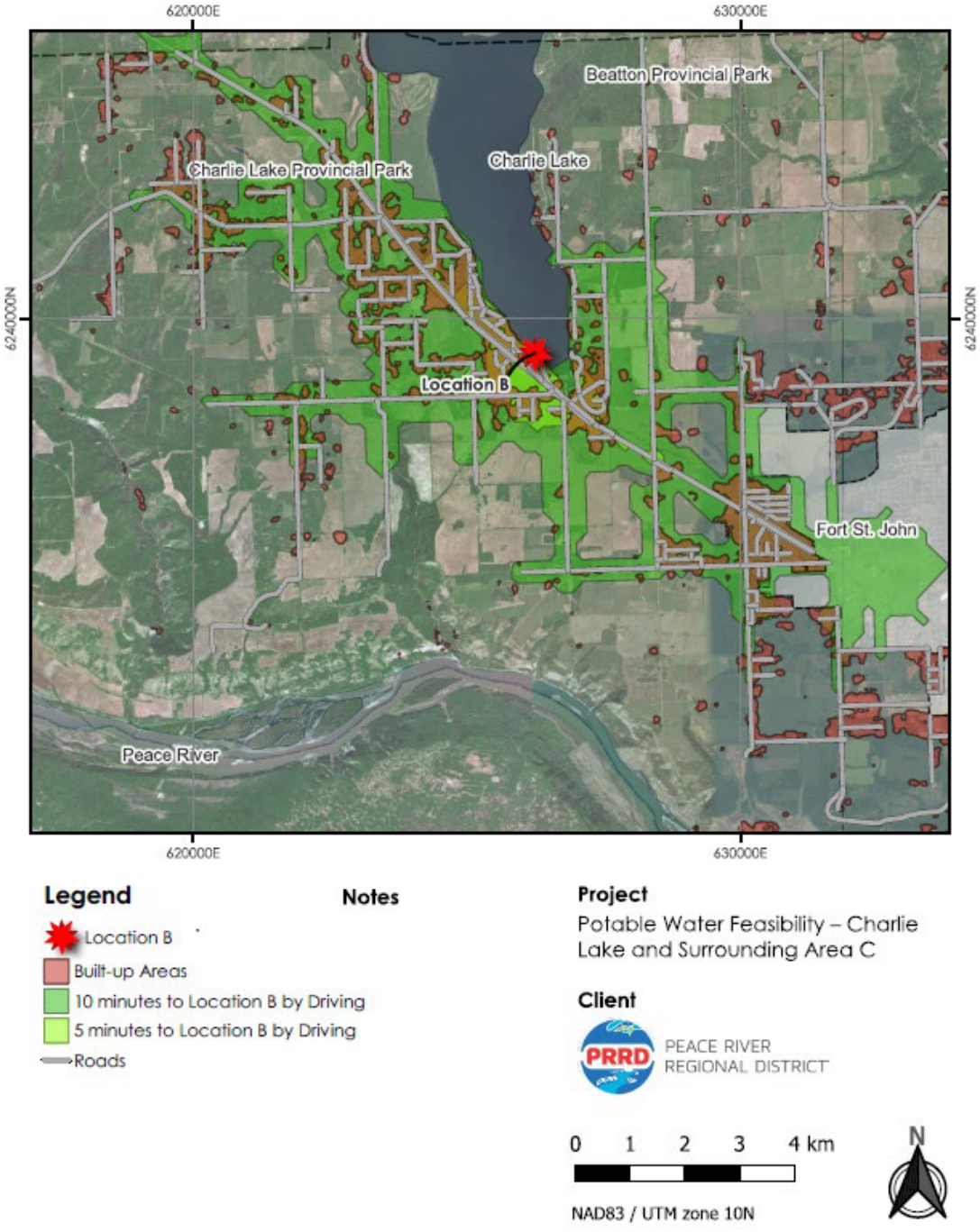

Figure A. Location of the proposed POD (Location B) by Charlie Lake

2.2 Climate

The Project area has a humid continental climate, typical of northeastern British Columbia. The climate in this region typically consists of long cold winters and short warm summers. From ClimateNA, which is an interactive platform for visualization and climate data access from the Faculty of Forestry at the University of British Columbia (UBC), the mean annual temperature is 1.9 °C, and the mean annual precipitation (MAP) is 458 mm/year (UBC 2022). On average, this area receives 267 mm precipitation from May to September and 148 mm snow per annum. Precipitation is heaviest in the summer and autumn. The average temperature is above zero for 154 days per year (UBC 2022). The average monthly minimum, maximum, average temperature, and precipitation for the POD are presented in Table A.

Table A. Average Monthly Minimum, Maximum, Average Temperature, and Precipitation at POD

Month	T_{max} (°C)	T_{min} (°C)	$T_{average}$ (°C)	Precipitation (mm)
January	-8.3	-17.4	-12.8	28
February	-4.5	-14.8	-9.6	23
March	0.8	-9.7	-4.5	25
April	9.7	-2.2	3.7	23
May	16.6	2.4	9.5	35
June	19.9	6.2	13.1	76
July	22	8.3	15.2	70
August	20.7	6.6	13.6	46
September	15.7	2.9	9.3	39
October	7.4	-1.4	3	32
November	-2.9	-10	-6.4	34
December	-7.4	-16.2	-11.8	27

3 METHODOLOGY

3.1 Background Data Review

Integrated Sustainability carried out a comprehensive data review utilizing both publicly available information as shown below, and information provided by PRRD.

- Water Survey of Canada (WSC) discharge records (WSC 2022).
- ClimateNA (UBC 2022).
- BC Water Tool reports (NEWT, Appendix 1).
- BC Environmental Flow Needs Policy (Appendix 2).

3.2 Hydrological Analysis

There is a well-developed network of WSC hydrometric monitoring stations (Stations) in northeastern British Columbia. The regional stations cover a range of basin sizes and terrains, including mountains, forested foothills, and highland prairie. The nearest WSC gauge is 07FC004 at Stoddart Creek with a drainage area of 298 km^2. The discharge is recorded in this station from 1969 to 1992. Annual flow rates for the proposed POD that are modeled in the NorthEast BC Water Tool (NEWT, Foundry Spatial 2022) estimate the mean annual discharge from the POD to be 0.649 m^3/s (Appendix 1). The NEWT monthly streamflow estimate was compared to the nearest WSC gauge to ensure the timing and intensity of flows aligned with the open water record nearby. The correlation was reasonable, with peak flows in May and low flows in February (Figure B).

Therefore, a flow estimate for the proposed POD was obtained by pro-rating flows at the WSC monitoring station 07FC004 at Stoddart Creek at the outlet of Charlie Lake. The gauge is located approximately 1 km downstream of the POD and flows at this location are used to identify risk management levels on the Charlie Lake.

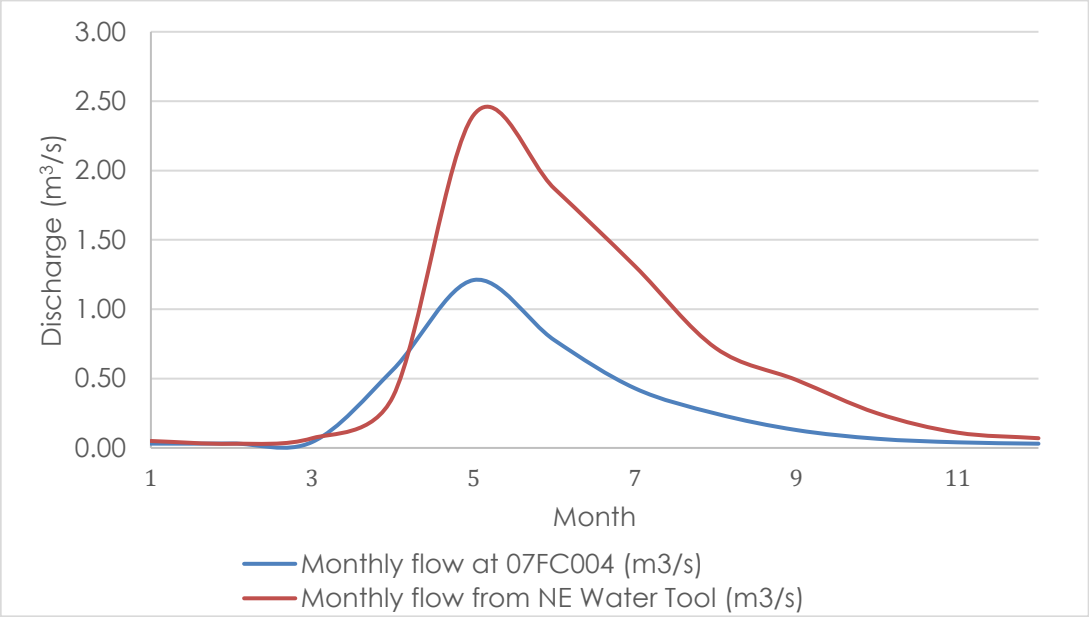

Figure B. Average Monthly Flows at the WSC Station and from NE Water Tool

4 CHARACTERISTICS OF THE PROPOSED POD LOCATION

The POD site selection along the Lake was based on the lake and the site characteristics such as the lake bathymetry, site access, and existing fill stations. A site visit (Appendix 3) is conducted to support the location of the POD.

The selected location exhibits the following characteristics:

- The lake is generally shallow with a smooth and gradual slope, averaging a grade of 2.7% toward the deepest section.
- This location is densely vegetated.
- The land slopes from the East to the West side of the site with a grade of 6.9%.
- The shore experiences an average 1.5 m drop-off to the beach.
- The beach primarily consists of small to medium cobbles (sized 10-30 cm).
- The shoreline is composed of a mixture of beach materials and gravels (sized 1 to 10 cm).
- The percentage of fine sediments increases mildly with depth.
- Water quality is generally good, with the exception of slightly elevated manganese levels.

5 ENVIRONMENTAL FLOW NEEDS POLICY

The Government of British Columbia has recommended an environmental flow needs (EFN) risk assessment methodology. This methodology uses information about aquatic ecosystem values within a watershed of interest (WOI), long-term mean annual discharge (MAD) and mean monthly discharge (MMD) at the point of interest (POI), and cumulative monthly withdrawals above the POI to characterize the EFN risk management levels associated with an application as 1 (low); 2 (medium); or 3 (high), and to review the applications that require 'special consideration.'

EFN risk assessment considers the sensitivity of the proposed water source to water withdrawals for each month during which the applicant proposes to divert and use water.

For EFN risk assessment, flow sensitivity is based on long-term mean monthly discharge (MMD) as a percentage of long-term mean annual discharge (MAD) at the Point of Interest, and is represented by the equation:

(MMD/MAD) x 100%

The EFN Risk Assessment Framework assumes that the mean monthly discharge:

- Greater than 20% MAD represents low flow sensitivity.
- Between 10 and 20% MAD represents moderate flow sensitivity.
- Less than 10% of MAD represents high flow sensitivity.

The last step in the EFN risk assessment considers cumulative withdrawals above the POI. Cumulative withdrawals include existing authorized demand and demand proposed in the application – as a percent of flow for each of the months during which the applicant proposes to divert and use water. This can be represented as the equation:

((Existing diversion + Proposed diversion in the application)/MMD) x 100%.

As per Appendix 1, currently, 33.3% of the Charlie Lake mean annual flow is allocated through existing licences for a total term licence allocation of 6,821,251 m^3/year. Including the proposed PRRD licence (91,250 m3/year), the total allocation will be 6,912,501 m^3/year, or 33.7% of the mean annual discharge (MAD).

Based on the Charlie Lake watershed summary (Appendix 1), mean monthly flows are the primary criteria for calculating allocation limits based on the Province of BC's Environmental Flow Needs Policy.

The monthly withdrawal limit provided by the Charlie Lake watershed summary for each level of risk management is compared to the proposed diversion in Table 1.

6 BASELINE HYDROLOGY AND RISK

To calculate natural flow statistics at the proposed POD, it was first necessary to develop an estimate of daily flow data representative of the POD's location in the watershed. A pro-rating factor was used to translate the recorded daily flow data at the WSC Station Stoddart Creek at the outlet of Charlie Lake (07FC004) for the period of 1968-1992 (Table B). It is acknowledged that the WSC Station has data records from 1968 to 1992. It

was also noted that flow data was missing from the record from January 1 to May 14, 1968. As a result, the partial year in 1968 was not included in the analysis.

6.1 Pro-Rating Factor

Table B presents the information used to develop the pro-rating factor for the proposed POD on Charlie Lake from the gauge data at 07FC004.

Table B. Drainage area for WSC station and POD and pro-rating factor

Location	Drainage Area (km^2)
WSC Station Stoddart Creek at the outlet of Charlie Lake	298
POD on Charlie Lake	296
Proportional Pro-rating Factor	0.993

6.2 Natural Flows at the POD

Natural flow statistics for the Charlie Lake at the POD were analyzed on a daily and weekly basis using the flow dataset from WSC gauge 07FC004. Weekly average flows for the POD and, as well as the Q_{80} at the proposed POD are depicted in the hydrograph in Figure C. High and low flow period statistics for weekly flows are provided in Table C. The modeled flow of Charlie Lake at the POD fluctuates throughout the year as described below:

- MAD of 0.299 m^3/s, corresponds to an annual runoff volume of 9,430,742 m^3/year.
- Flow rates increase rapidly in early April during freshet to reach peak flows from melting snowpack.
- Precipitation events from late spring through mid-summer result in increased streamflow events of short duration and relatively high intensity, at some points reaching flows that exceed the spring freshet. Flows decline through August and into the fall, remaining low through the winter and early spring months as summarized in Table C.

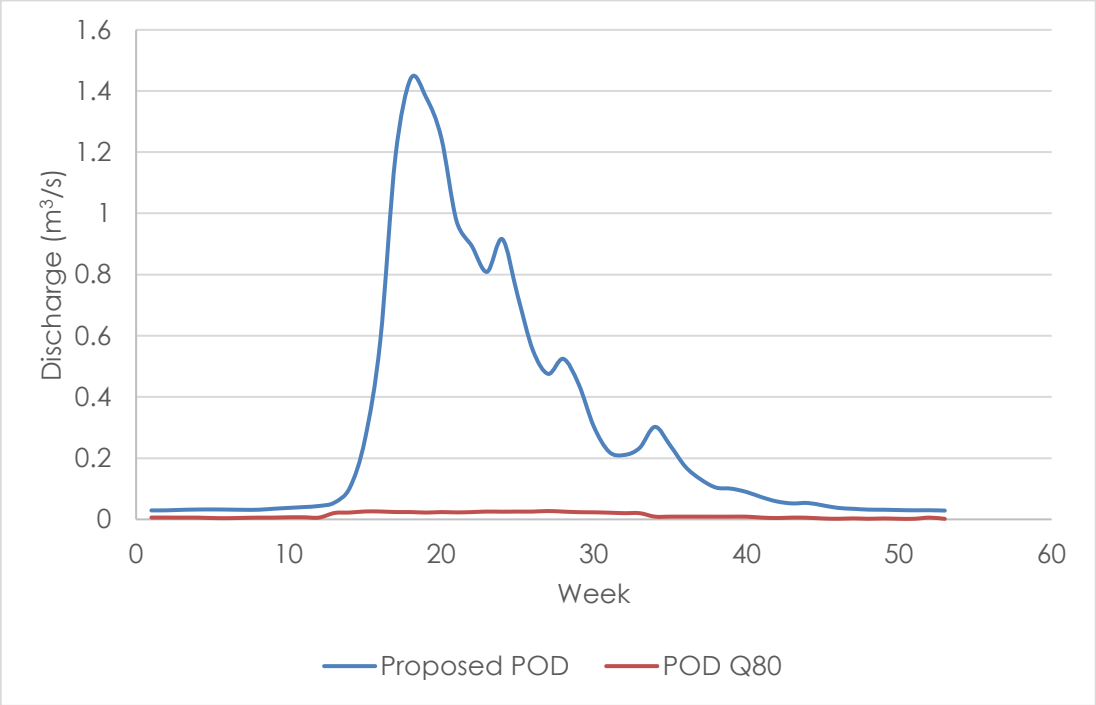

Figure C. Average Weekly Discharge – Charlie Lake at the Proposed POD

Table C. Flow Statistics for Highest and Lowest Flow Weeks at the Proposed POD

Week Number	Mean (m^3/s)	Q_{80} (m^3/s)
Week 18	1.441	0.024
Week 9	0.029	0.002

7 ENVIRONMENTAL FLOW NEEDS RISK ASSESSMENT

Based on the results of the NE Water Tool, the flow in December, January, February, and March is limited. The proposed diversion lies within the risk management level 3 which needs supplemental measures (based on the EFN policy) to assess potential effects on EFN. These supplemental measures include preparing a detailed habitat assessment or issuing a limited license term.

Per EFN policy, the requested monthly diversion volume is possible in May, June, and July with the risk management levels 1 (low risk) for May and June which is unlikely to affect EFN. The requested monthly diversion for July is possible with risk management level 2 (medium). Based on the EFN policy risk management level 2 might require more information (such as reconnaissance-level fish and fish habitat impact assessment) before a decision can be made.

7.1 Hydrologic Conditions and Restrictions

Historic flows and variability, including seasonal flow variation, are discussed in Section 6. There are no water conservation objectives in place for this lake system.

7.2 Existing Users

Existing licenced water users in the Charlie Lake watershed have been considered as part of the risk assessment and proposed diversion.

In addition to the proposed diversion, the Charlie Lake watershed supplies a number of Term Licences. As per the watershed report in Appendix 1, at the time of writing the most significant use of surface water from Charlie Lake is for Municipal purposes with a volume of 6,755,305 m^3/year.

7.3 Evaluation and Description of Impacts

The timing and volume of diversions proposed in this application are in compliance with the requirements of the Charlie Lake EFN policy.

To consider the impact of Charlie Lake's proposed diversion on the other licence holders and the downstream river flow needs, the analysis in Table 1 was completed. In this analysis, the maximum instantaneous monthly rate of diversion (0.003 m^3/s) in Charlie Lake was combined with the existing surface water term licence allocations to assess the impact on streamflow on a monthly basis.

Other licences that may or may not have concurrent operations are listed in Appendix 1 and have been included in this analysis. Allocation values do not represent instantaneous pumping rates, and as such, this should be considered a conservative estimate, as licensees follow a schedule with variable diversion rates based on measured flow and do not allow for the maximum rate of diversion during every month of the year.

The potential monthly diversions in Table 1 were based upon the rate of diversion that has been approved for the intake by PRRD, and in several temporary diversion licenses that have been issued to Charlie Lake at this location. The potential diversion was modelled for the potential allocation under risk management levels 1 and 2 for each month of the year to evaluate the potential for impact on the hydrology and other water users. The potential allocations under risk management are the limiting factors in this watershed as the naturalized flow (Mean monthly flow at POD – existing diversion) is higher than the potential allocation under risk management in this watershed. However, the naturalized flow is zero in the autumn and winter months as well as in March. In May and June, there is sufficient water to exceed the supply of all existing users and the proposed diversion under risk management level 1. And in July, there is a potential for proposed diversion under risk management level 2.

The cumulative withdrawal shows an average of 33% for the three months (May, June, and July) when the proposed diversion is possible in the Lake (Table 1).

The following conclusions regarding the impact of diversion on flows in the Charlie Lake can be made:

- The Charlie Lake has a mean annual runoff of approximately 9 million m^3 of water per year at the proposed point of diversion.
- PRRD proposed diversion of 250 m^3/day for three months is 0.24% of the mean annual runoff.
- The cumulative diversion, including all other upstream surface water licences, amounts to 2.9% of the mean annual runoff.
- As per the EFN policy, Charlie Lake expects to be able to divert at its maximum instantaneous rate of diversion for approximately 3 months of the year. However, real flow conditions may allow for different diversions than those modelled.

Based on the analysis above, the impacts to hydrology and the other licence holders in the watershed resulting from the proposed diversions are expected to be within the range permitted under the risk management Level 1 (low). But for July with the risk management level 2 (medium), the aquatic environment is flow-limited for the proposed withdrawal period, or cumulative water withdrawals are greater than a specified threshold of concern. A result of Risk Level 2 suggests that more information may be required prior to a decision to grant or decline an application, or that the authorization (if granted) may include terms and conditions to minimize potential impacts to EFN.

7.4 Identification of Mitigation Options

Supplemental measures to assess potential effects on EFN:

- 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 EFN:

- Limit pump intake size.
- Require authorization-holder to monitor (e.g. install flow gauge) and report water use during specified periods.
- Require authorization-holder to monitor flows and limit withdrawals when flows drop below a certain level (EFN policy).

8 CONCLUSION

This hydrology assessment evaluated the feasibility and potential impacts associated with a proposed *Water Act* Term Licence to divert 250 m^3 /day from Charlie Lake at 7-17-84-19-W6. The assessment concluded the following:

- Baseline hydrology found the POD is best related to the WSC Station 07FC004 of Stoddart Creek at the outlet of Charlie Lake which is approximately 1 km downstream of the POD. The pro-rated flows for the POD were estimated through a drainage area relationship.
- The proposed monthly diversion volume is possible in May and June with the risk management levels 1 (low risk) which is unlikely to affect EFN, based on the EFN policy.
- The requested monthly diversion for July is possible with risk management level 2 (medium). Based on the EFN policy, risk management level 2 might require more information (such as reconnaissance-level fish and fish habitat impact assessment) before a decision can be made.
- The proposed monthly diversion volume in the remaining months is under risk management level 3 (high risk) and needs supplemental measures such as preparing a detailed habitat assessment or issuing a limited-term license.
- Water can be stored in the months when water is available and can be used later in the months with the water shortage.
- The Lake has an estimated mean annual runoff of approximately 9 million m^3 of water per year, therefore, the proposed diversion of 22,500 m^3 over May, June, and July would use 0.25% of the mean annual runoff.
- The proposed diversion rates and total monthly allocation volumes are in line with the environmental flow needs policy in British Columbia. As such, they are intended to protect the rights of existing users and downstream limitations for the Lake.

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9 CLOSURE

Integrated Sustainability would like to thank PRRD for the opportunity to support the Charlie Lake Term Licence application. We trust that this report meets the needs and expectations of PRRD. If you have any questions, please contact the undersigned at any time.

Sincerely,

Integrated Sustainability

[redacted]

Fatemeh Madaeni, M.Sc.

Water Resource Specialist

Dalei Chen, M.Sc., P.Eng.

Principal Hydrotechnical Engineer

PERMIT TO PRACTICE
INTEGRATED SUSTAINABILITY

PERMIT NUMBER: 1001147
Engineers and Geoscientists of British Columbia (EGBC)

10 REFERENCES

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Potable Water Feasibility Study, Charlie Lake and Surrounding Area C. 2022. Integrated Sustainability.

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Tables

	Natural Flow Statistics		MMD/MAD	EFN Risk Assessment	Existing Diversion	Naturalized Flow	Potential allocation			Proposed Maximum Allocation				Max Proposed Diversion	Max Proposed Diversion (under risk management 1 & 2)	Cumulative Withdrawal	Existing Diversion + Proposed Diversion	Days in Month	Existing Diversion + Proposed Diversion
Month	Mean Monthly Flow (m^3/s) at POD	Q80 Flow at POD(m^3/s)	(% of MAD)		Current Diversion Rate for other allocations (m^3/s)	(m3/s)	Risk management 1 (m3/s)	Risk management 2 (m3/s)	Risk management 3 (m3/s)	Risk management 1 (m3/s)	Risk management 2 (m3/s)	Risk management 3 (m3/s)		(m3/s)	(m3/s)	%	(m3/s)		(m3/month)
Jan	0.031	0.006	10%	Medium	0.21	0	Limit	Limit	Limit	Limit	Limit	Limit		0			0.210	31.000	562,464
Feb	0.032	0.005	11%	Medium	0.21	0	Limit	Limit	Limit	Limit	Limit	Limit		0			0.210	28.000	508,032
Mar	0.043	0.007	14%	Medium	0.21	0	Limit	Limit	Limit	Limit	Limit	Limit		0			0.210	31.000	562,464
Apr	0.560	0.024	187%	Low	0.21	0.350	0	0	≥ 0	0	0	≥ 0	**Risk M L3**	**0.003**			0.210	30.000	544,320
May	1.202	0.024	402%	Low	0.21	0.992	0.15	0.26	≥ 0.26	0.150	0.260	-	**Risk M L1**	**0.003**	**0.003**	18%	0.213	31.000	570,214
Jun	0.772	0.026	258%	Low	0.22	0.552	0.06	0.15	≥ 0.15	0.060	0.150	-	**Risk M L1**	**0.003**	**0.003**	29%	0.223	30.000	577,740
Jul	0.426	0.024	143%	Low	0.22	0.206	0	0.04	≥ 0.04	0	0.040	-	**Risk M L2**	**0.003**	**0.003**	52%	0.223	31.000	596,998
Aug	0.246	0.020	82%	Low	0.22	0.026	0	0	≥ 0	0	0	≥ 0	**Risk M L3**	**0.003**			0.220	31.000	589,248
Sep	0.128	0.009	43%	Low	0.22	0	0	0	≥ 0	0	0	-		0			0.220	30.000	570,240
Oct	0.066	0.006	22%	Low	0.21	0	0	0	≥ 0	0	0	-		0			0.210	31.000	562,464
Nov	0.040	0.002	13%	Medium	0.21	0	0	0	≥ 0	0	0	-		0			0.210	30.000	544,320
Dec	0.030	0.003	10%	Medium	0.21	0	Limit	Limit	Limit	Limit	Limit	Limit		0			0.210	31.000	562,464

Proposed diversion	
m3/d	250
m3/s	0.003
MAD (m3/yr)	9,430,743
Proposed Diversion (m3/yr)	22,500
Proposed Diversion/MAD	0.24%
Existing Diversion + Proposed Diversion (m3/s)	Variable
Existing Diversion + Proposed Diversion (m3/yr)	6,750,968
Existing Diversion + Proposed Diversion/MAD	71.58%

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Appendices

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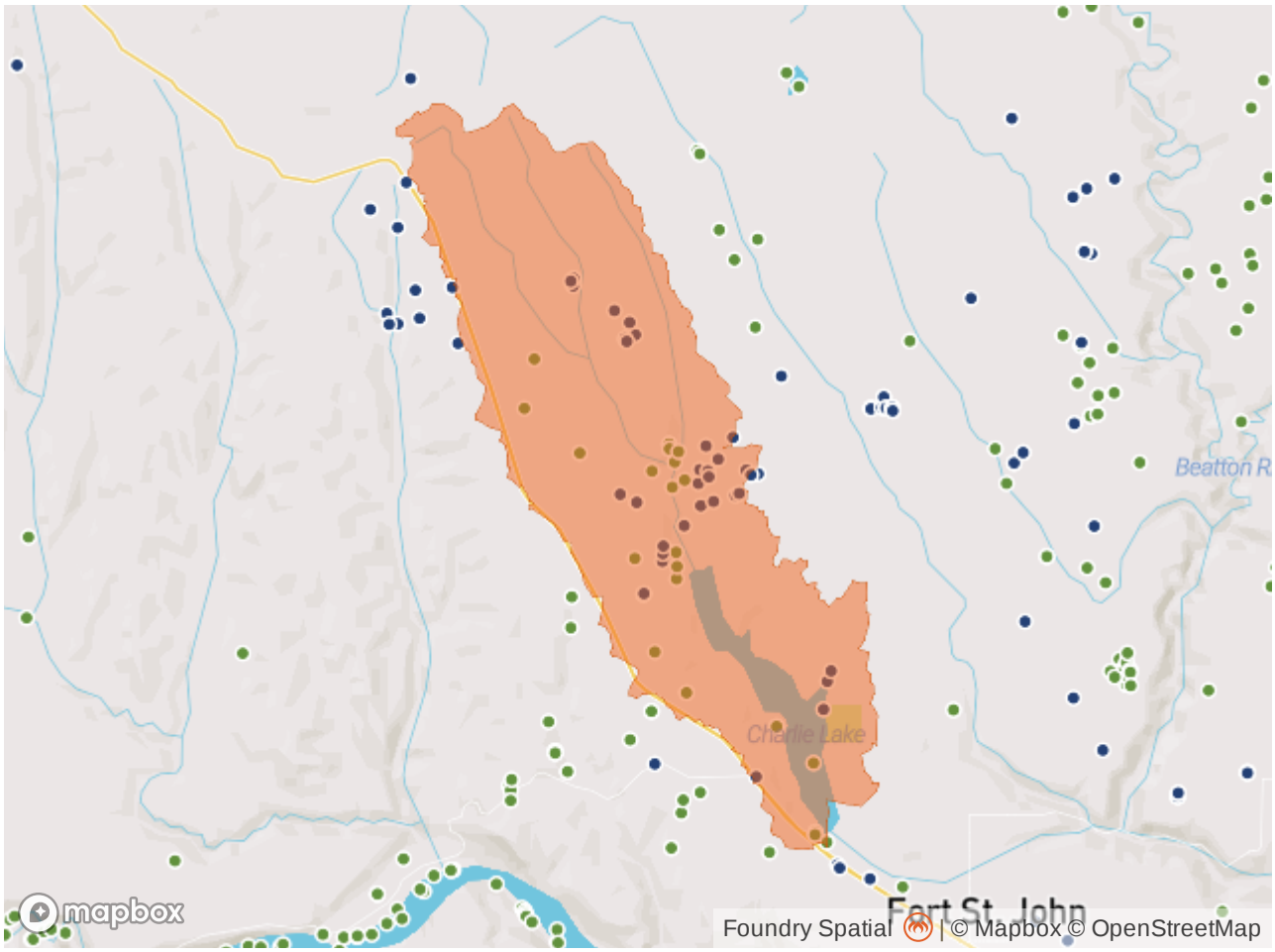
Appendix 1 – Charlie Lake BC Water Tool Reports

Watershed Summary

Charlie Lake

Watershed Number: 7577133

May 8, 2023



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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 BC[1].

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
56.279 ° N
-120.950 ° W

Watershed Area
296 km²

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

Mean Annual Discharge
0.649 m³/s

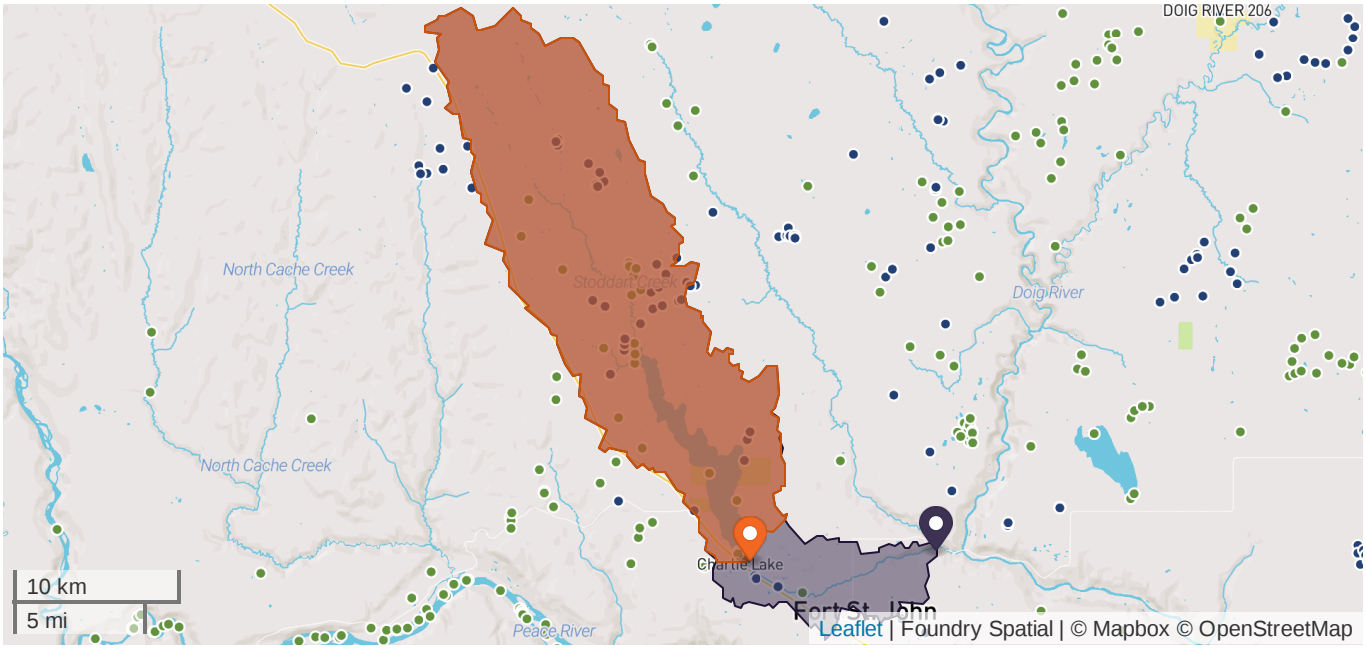
Estimates of water supply represent long-term average conditions. These estimates were generated from hydrology models[3]. The models incorporate information about climate, terrain, land cover, evapotranspiration, watershed boundaries and connectivity, and observed hydrology, and are calibrated using 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 confluence[2] (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 error[3].



Legend

Query Watershed

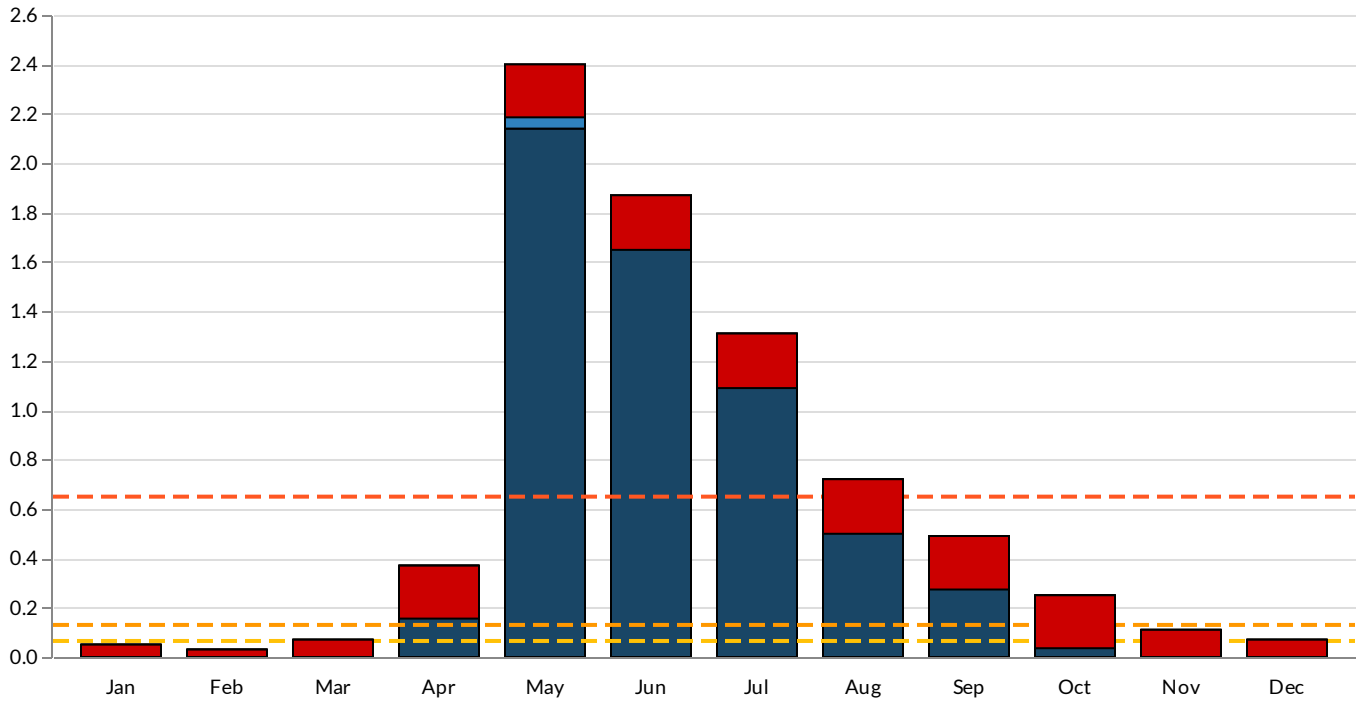
Downstream Watershed

Annual Statistics	Charlie Lake	Fish Creek
Area (km²)	296	348
Mean Annual Discharge (MAD, m³/s)	0.649	0.714
Allocations (average, m³/s)[9]	0.216	0.216
Allocations (average, % of MAD)	33.3	30.3
Reserves & Restrictions[4]	Present	Present
Volume Runoff (m³/yr)	20,494,187	22,538,275
Volume Allocations (m³/yr)	6,821,251	6,829,269
Seasonal Flow Sensitivity[5]	Winter, Summer	Winter, Summer

Monthly Water Supply and Demand - Charlie Lake

Hydrologic models[6] 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 levels[8] to support water management decisions. Information on active water licences and approvals (collectively, 'allocations') in the watershed have been extracted and summarized from government databases[9] 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 m^3/s

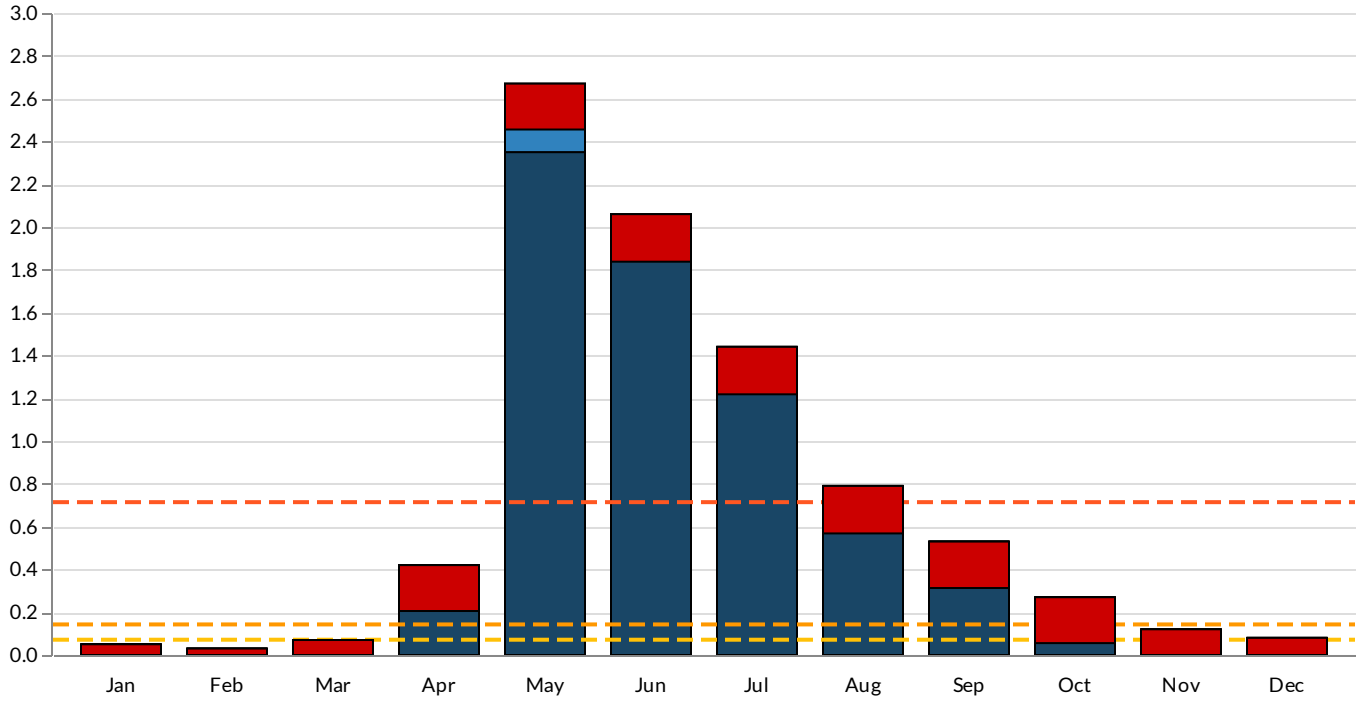
MAD 20% 0.13 m^3/s

MAD 0.65 m^3/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* (m^3/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* (m^3/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean Monthly Discharge (m^3/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 (m^3/s, Risk Mgmt 1)[23]	L	L	L	0.00	0.15	0.06	0.00	0.00	0.00	0.00	0.00	L
Potential Allocation (m^3/s, Risk Mgmt 2)[23]	L	L	L	0.00	0.26	0.15	0.04	0.00	0.00	0.00	0.00	L
Potential Allocation (m^3/s, Risk Mgmt 3)[23]	L	L	L	≥0.00	≥0.26	≥0.15	≥0.04	≥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 m^3/s

MAD 20% 0.14 m^3/s

MAD 0.71 m^3/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* (m^3/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* (m^3/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean Monthly Discharge (m^3/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 (m^3/s, Risk Mgmt 1)	0.00	0.00	0.00	0.00	0.19	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Potential Allocation (m^3/s, Risk Mgmt 2)	0.00	0.00	0.00	0.00	0.32	0.19	0.07	0.00	0.00	0.00	0.00	0.00
Potential Allocation (m^3/s, Risk Mgmt 3)	≥0.00	≥0.00	≥0.00	≥0.00	≥0.32	≥0.19	≥0.07	≥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 (m^3)		Surface Water (m^3)	
		STUA	Licence	STUA	Licence
Agriculture		0	13,438	0	63,814
Commercial		0	3,411	0	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 licences[21] and short term use approvals[20, 21] (collectively, 'allocations') for surface water and groundwater in British Columbia are managed under the Water Sustainability Act[10]. These allocations are authorized by the Ministry of Forests, and the BC Energy Regulator (associated with activities regulated under the Oil and Gas Activities Act[11]). Existing allocations, and active applications[22] 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

Licence	Number	POD	Date	Quantity	Flag[12]
Multiple Licence Holders Domestic from Victor Spring (Surface water)	C130743 File # 7001052	PD67260	Priority: Jan 08, 1993 Status: Mar 18, 2014	2.27 m^3/day	M, N
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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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	PG202682	Priority: Aug 01, 1970 Status: May 27, 2021	913 m^3/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 m^3/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 m^3/year	M, N
PRIVATE INDIVIDUAL NAME Livestock & Animal from 451 (Dugout, ditch, quarry, etc)	503407 File # 20017628	PG202684	Priority: Aug 01, 1970 Status: May 27, 2021	913 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/year	T, N

Water Licence Applications (Surface Water)

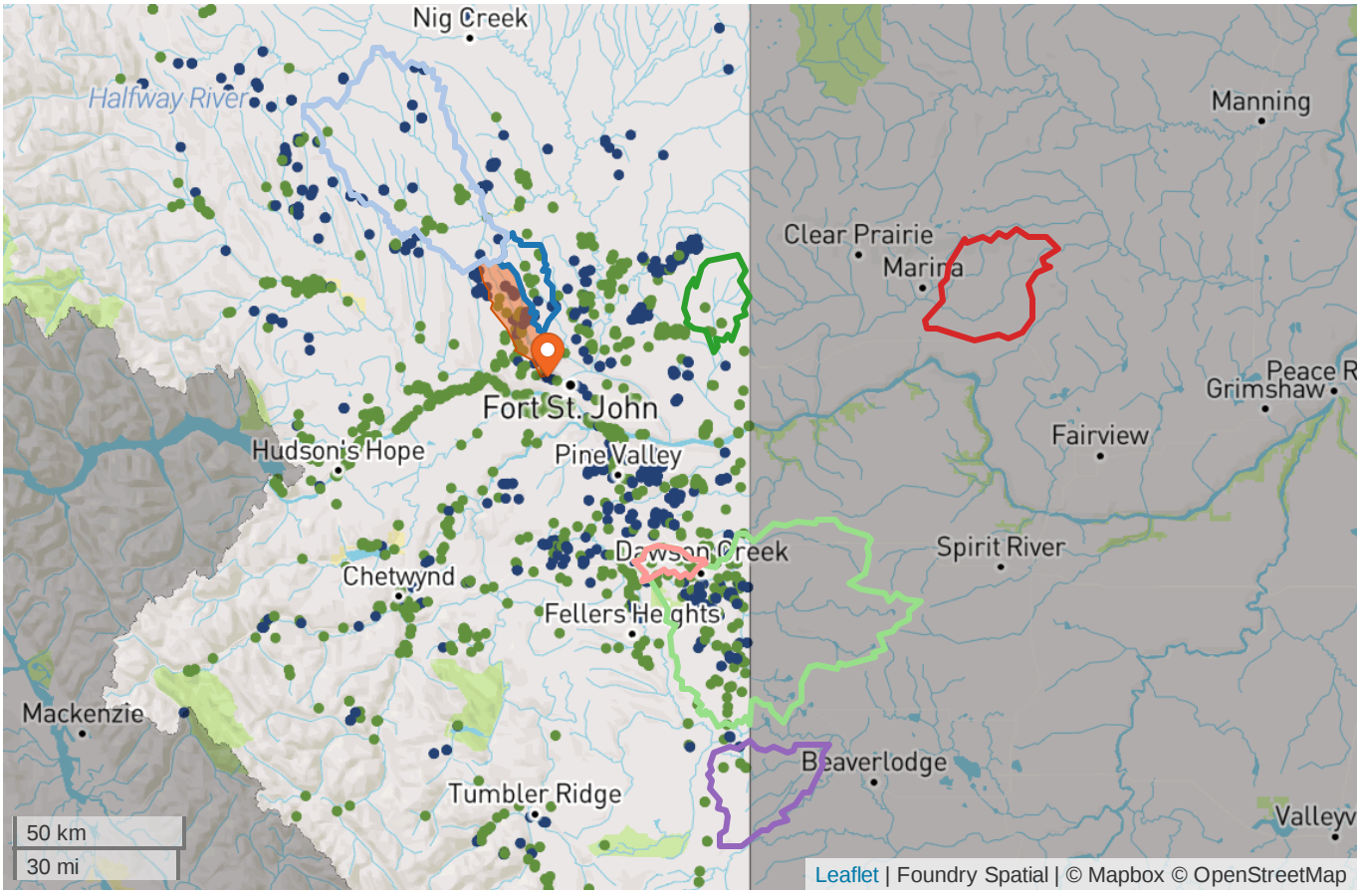
Active Applications

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 metrics[13]. 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 BC[14]. The location of the basins is shown on the map below.

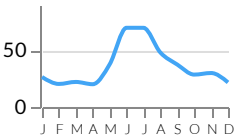
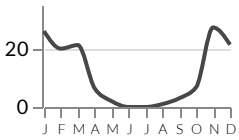
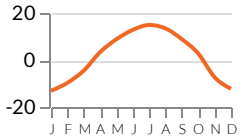


Legend

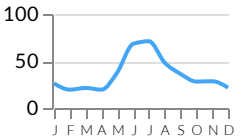
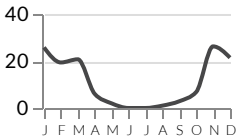
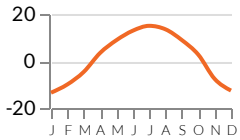
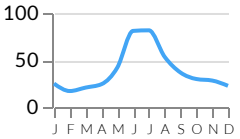
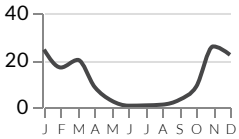
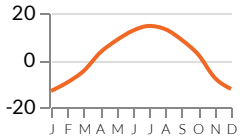
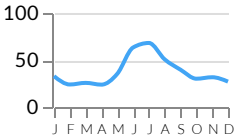
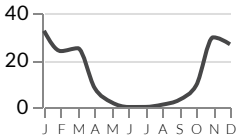
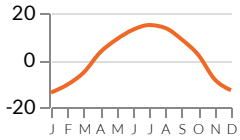
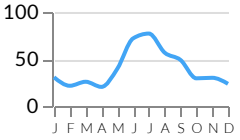
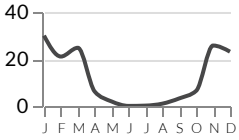
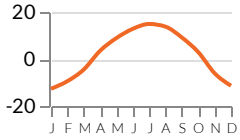
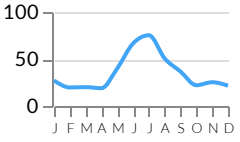
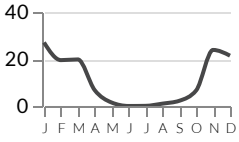
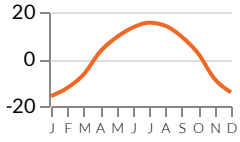
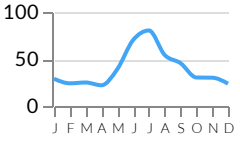
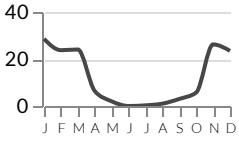
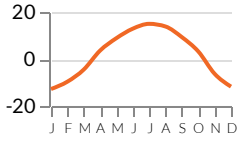
Query Watershed	07FC002	07FC003
07FD004	07FD007	07FD013
07FD015	07GD002	

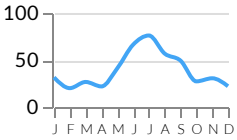
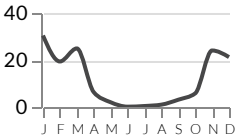
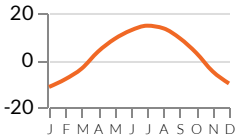
The watersheds shown on the map above have been identified as the most similar to the watershed described in this report. The table below shows key characteristics of these watersheds in relation to the watershed described in this report.

Query Watershed

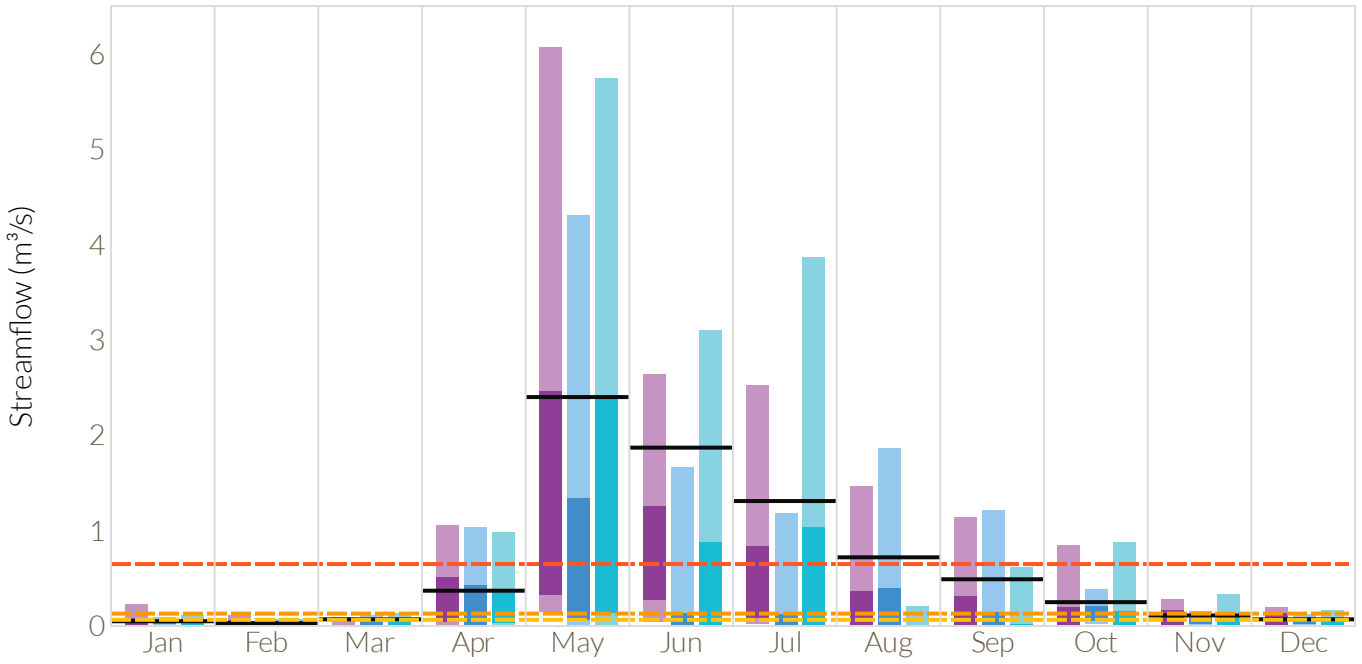
Watershed	Location (lat, long)	Area (km^2)	Elevation (m: min, mean, max)	Precipitation (mm/mo)	Precip. as snow (mm/mo)	Temperature (°C)
Charlie Lake	56.293, -120.957	296	634, 770, 864			

Candidate Watershed(s)

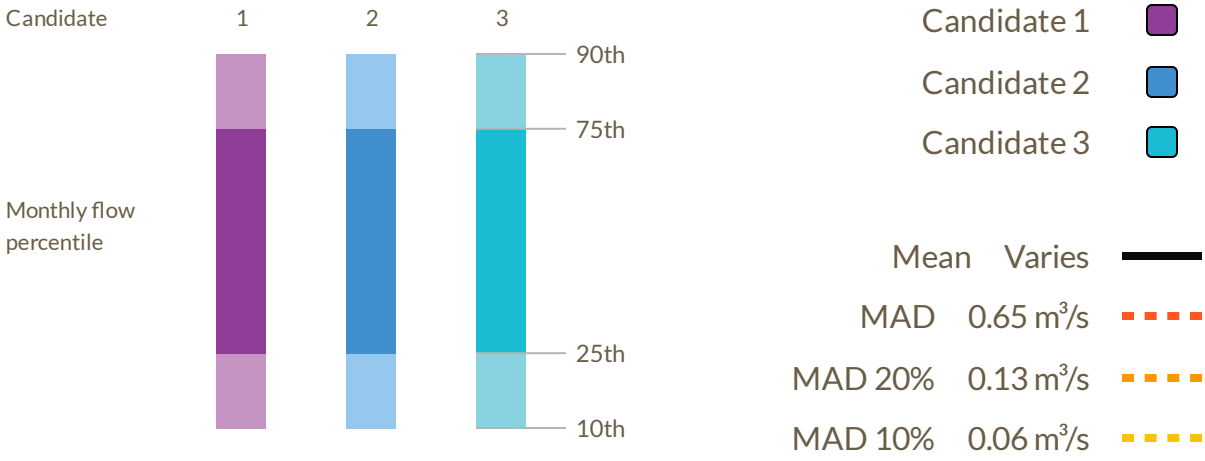
Watershed	Location (lat, long)	Area (km^2)	Elevation (m: min, mean, max)	Precipitation (mm/mo)	Precip. as snow (mm/mo)	Temperature (°C)
07FC002 St. John Creek Near Montney	56.429, -120.924	212	662, 750, 819			
07FC003 Blueberry River Below Aitken Creek	56.678, -121.221	1,774	658, 822, 1,021			
07FD004 Alces River At 22nd Base Line	56.339, -120.160	319	644, 763, 951			
07FD007 Pouce Coupe River Below Henderson Creek	55.862, -120.032	2,871	529, 778, 968			
07FD013 Eureka River Near Worsley	56.453, -119.134	755	614, 704, 981			
07FD015 Dawson Creek Above South Dawson Creek	55.761, -120.263	120	639, 739, 847			

Watershed	Location (lat, long)	Area (km^2)	Elevation (m: min, mean, max)	Precipitation (mm/mo)	Precip. as snow (mm/mo)	Temperature (°C)
07GD002 Beavertail Creek Near Hythe	55.316, -119.643	678	735, 861, 1,032			

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 report[15]. 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

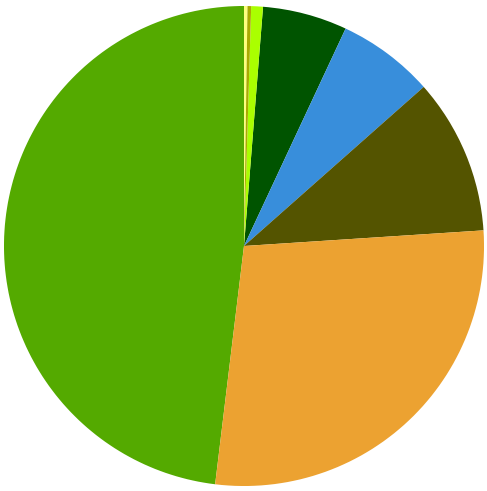
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
90th	0.09	0.07	0.11	1.04	4.30	1.66	1.18	1.86	1.21	0.39	0.16	0.12
75th	0.07	0.04	0.04	0.43	1.34	0.13	0.13	0.39	0.14	0.21	0.08	0.09
Mean	0.05	0.03	0.07	0.37	2.40	1.87	1.31	0.72	0.49	0.25	0.11	0.07
25th	0.02	0.01	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.06	0.03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

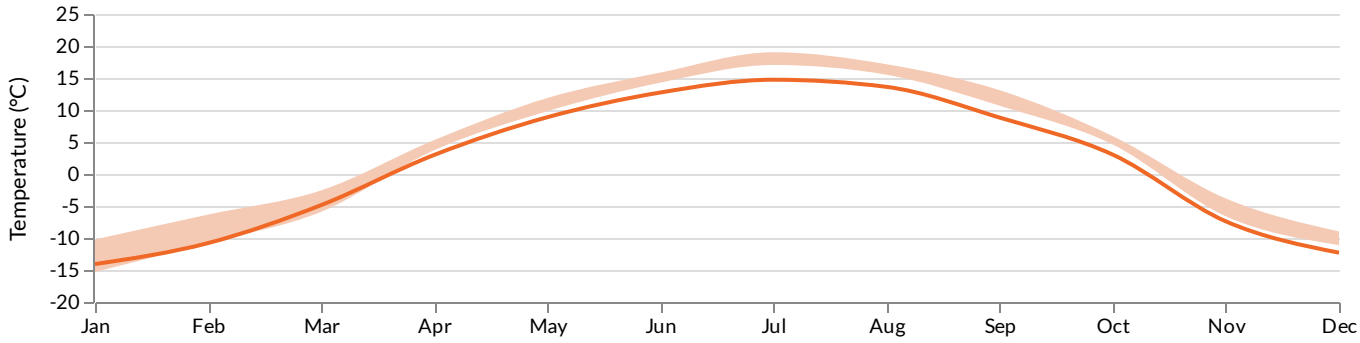
The landcover[16] characteristics influence hydrologic processes in a watershed[17]. The chart below shows the landcover makeup of the Charlie Lake watershed. These components were incorporated in the hydrologic model that produces the water supply estimates in this report, primarily influencing the 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.

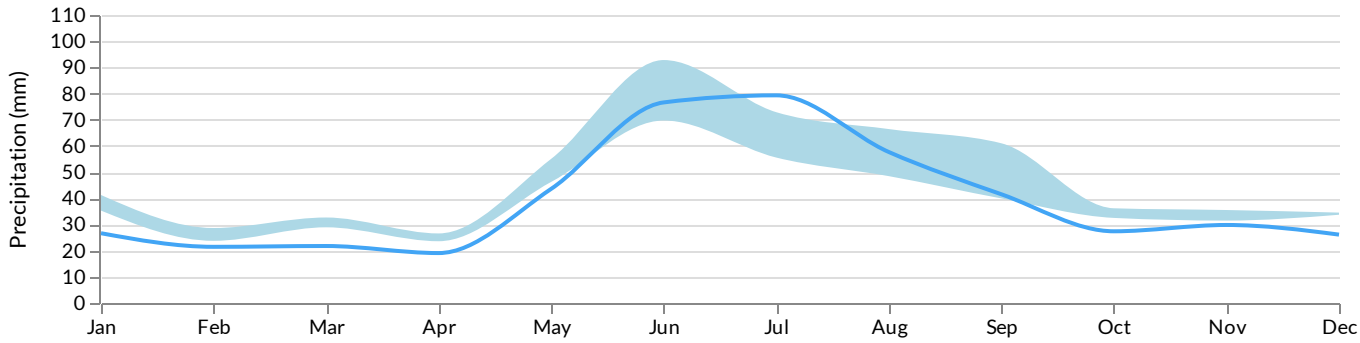


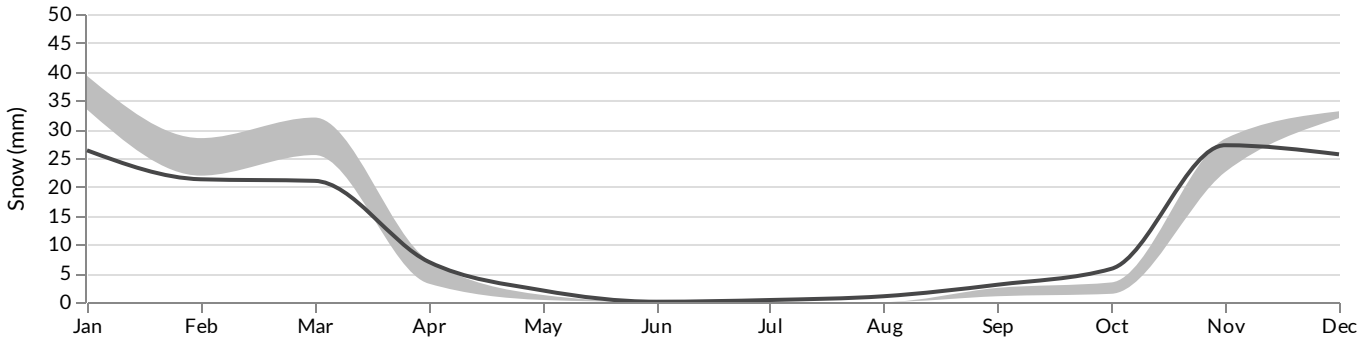
Type	Area (km²)	% of Watershed
Barren	0.0	0.0%
Coniferous	16.8	5.7%
Cropland	82.6	27.9%
Deciduous	142.5	48.1%
Developed	0.0	0.0%
Grassland	0.7	0.2%
Herb	0.0	0.0%
Mixed	31.0	10.5%
Shrub	2.3	0.8%
Snow / Glacier	0.0	0.0%
Water	19.2	6.5%
Wetland	0.7	0.2%

Climate

The climate of the Charlie Lake watershed has been characterized using gridded climate models[18]. 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.





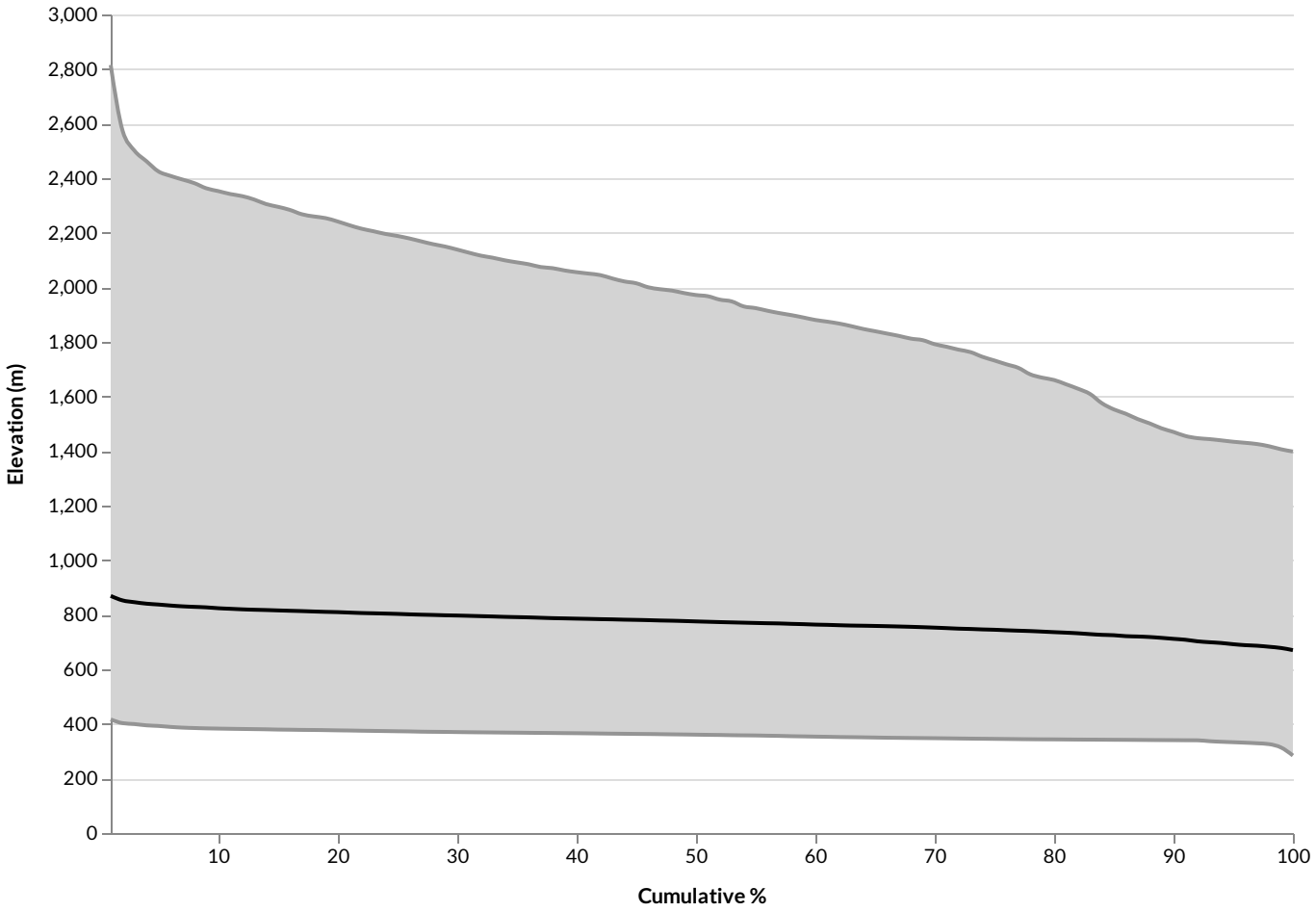


Normal / Historical Average

Projected Average for the 2050s

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 licences[21] 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 May 07, 2023 from https://catalogue.data.gov.bc.ca/dataset/water-approval-points

20. OGC Short term Approvals imported May 07, 2023 from https://data-bcogc.opendata.arcgis.com/datasets/fcc52c0cfb3e4bffb20518880ec36fd0_0

21. Water Rights Licences imported May 07, 2023 from https://catalogue.data.gov.bc.ca/dataset/water-rights-licences-public

22. Water Rights Applications imported May 07, 2023 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 m^3. Winter allocations from the lake are currently 2,242,282.91 m^3. Remaining potential allocation is -427,934.61 m^3

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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Water Survey of Canada (2019). HYDAT. Retrieved from https://collaboration.cmc.ec.gc.ca/cmc/hydrometrics/www/

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%

INTEGRATED SUSTAINABILITY

Appendix 2 – BC Environmental Flow Needs Policy

Ministry of Forests, Lands, Natural Resource Operations and Rural Development
Ministry of Environment and Climate Change Strategy

NAME OF POLICY:	Environmental Flow Needs Policy
APPLICATION:	Review of applications for a water authorization administered by Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) or the Oil and Gas Commission (OGC), and for certain amendments of existing authorizations.
ISSUANCE:	Executive Director, Water Protection and Sustainability Branch, Ministry of Environment and Climate Change Strategy, and Director, Water Management Branch, Ministry of Forests, Lands, Natural Resource Operations and Rural Development.
IMPLEMENTATION:	Water authorization program personnel in FLNRORD and the OGC. External consultants
LEGISLATIVE REFERENCES:	*Water Sustainability Act* (Ch. 15, S.B.C. 2014) Water Sustainability Regulation (B.C. Reg. 36/2016).
RELATED POLICIES:	Water Authorization Assessment and Processing Guide (May 17, 2019) EFN Policy Implementation Guide [under development]
RELATIONSHIP TO PREVIOUS POLICIES:	This policy updates the Environmental Flow Needs Policy effective February 29, 2016.
POLICY AMENDMENT PROCESS:	To amend this policy a request must be made in writing to the Executive Director, Water Protection and Sustainability Branch, Ministry of Environment and Climate Change Strategy and the Director, Water Management Branch, Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

[redacted]

[redacted]

Ted Zimmerman
Executive Director
Water Protection and Sustainability Branch
Ministry of Environment and Climate Change Strategy

Date: January 11, 2022

Ted White
Director and Comptroller of Water Rights
Water Management Branch
Ministry of Forests, Lands, Natural Resource Operations and Rural Development

Date: January 11, 2022

APPROVED AMENDMENTS:		
Effective date	Approval date	Description/Summary of Changes:
March 1, 2014	January 2014	New policy
June 15, 2015	June 15, 2015	Administrative changes; additional detail for greater clarity
February 29, 2016	February 16, 2016	Administrative changes to align the policy with the Water Sustainability Act and its regulations
February 11, 2022	January 11, 2022	Updated to distinguish between EFN risk assessment, formal EFN determination, supplemental analysis, and risk management; reorganize content and amalgamate similar content; add new definitions.

TABLE OF CONTENTS

1. POLICY STATEMENT

This policy describes a recommended procedure for evaluating the likelihood that an application for a water authorization, if granted, would affect the environmental flow needs (EFN) – defined as the volume and timing of water flow required for the proper functioning of the aquatic ecosystem of the stream – of the proposed water source. It also recommends additional analytical activities for applications identified as medium or high risk and provides examples of risk management measures. Completion of a EFN risk assessment and supplemental activities does not constitute EFN risk management.

2. REASON FOR POLICY

Water Sustainability Act (WSA) s. 15 requires that the decision maker – except where exempted – consider the EFN of a stream when deciding on an application for a water authorization and for certain amendments of existing authorizations. In situations where a water allocation decision would likely have a negative impact on EFN the decision maker may refuse the application or specify conditions for water use.

This policy recommends that decision makers implement a risk-based approach in considering EFN. Such an approach can streamline the application review and decision-making process and ensure that applications posing a greater risk to EFN receive greater scrutiny. It can also help authorization-holders understand the rationale for any authorization terms and conditions designed to protect stream health.

The policy presents a screening tool that can be used to assess the likelihood that an application, if granted, will affect the EFN of the proposed water source. It is intended to be applied where there is limited site-specific hydrological and/or biological data. The trade-off for its simplicity however, is that the screening tool provides a conservative risk estimate. Where a scientifically credible EFN study(s) relevant to the proposed water source already exists, it may provide more accurate information about potential impacts on EFN.

This policy does not apply to all ‘streams’ as defined in the WSA. It applies to the technical review and determination of applications to divert and use water from flowing sources (i.e., rivers, creeks, lakes, ponds, springs), or aquifers that are reasonably likely to be hydraulically connected to such sources. It is not applicable to proposed diversions from hydraulically isolated lakes, ponds, springs, ravines, gulches, wetlands or glaciers. Water program staff are advised to consult an expert for advice on how to consider EFN when evaluating applications to divert and use water from such sources.

This policy applies to applications for authorization amendments if the proposed amendment has the potential to affect the EFN of the water source e.g., if a change of works changes the point of diversion from the water source or the amendment will result in a change in the volume or timing of flow in the water source.

Note that this policy does not include a methodology for *determining* the EFN of a stream – that is, the volume and timing of water flow required for the proper functioning of the aquatic ecosystem of the stream. Hatfield *et al.* (2003) describes methods for determining instream flow thresholds to protect aquatic habitat. The companion document Lewis *et al.* (2004) describes detailed methods for assessing the potential impacts of water diversion and use on aquatic ecosystems.

3. DEFINITIONS

Relevant terms defined under WSA s. 1 *[definitions]* are:

> **"environmental flow needs"**, in relation to a stream, means the volume and timing of water flow required for the proper functioning of the aquatic ecosystem of the stream.

Other terms used in this document are defined as follows:

> **Point of interest (POI)** – The location within the watershed of interest (WOI) at which flow modifications by the proposed water use will likely have little or no effect on environmental flows, aquatic organisms, or downstream water rights. An EFN risk assessment (and a formal EFN determination) will typically consider flows at this location. The POI will typically be different from the proposed Point of Diversion (POD).
>
> **Stream** – The EFN Policy uses the term 'stream' more narrowly than as defined in the WSA. Specifically, the EFN Policy applies to the technical review and determination of new applications to divert and use water from flowing sources (i.e., rivers, creeks, lakes, ponds, springs) or from aquifers that are reasonably likely to be hydraulically connected to such sources.
>
> **Watershed of interest (WOI)** is the area to be considered in an EFN risk assessment. This area typically extends upstream from the point of diversion (POD) proposed in an application and downstream from the EFN point of interest (POI).

WSA s. 14 provides the comptroller and the water manager with powers respecting an application for a water licence. These include but are not limited to:

- Refusing an application;
- Requiring additional plans or other information; or
- Issuing one or more conditional or final licences 'subject to the prescribed terms and conditions and on the terms and conditions the decision maker considers advisable.'

WSA s. 15 (1) states that, except in relation to an application exempted under the regulations, the decision maker must consider the environmental flow needs of a stream in deciding an application in relation to the stream or an aquifer the decision maker considers is reasonably likely to be hydraulically connected to that stream.

WSA s. 15 (2) authorizes the decision maker to direct applicants 'to provide to the decision maker the information and reports of assessments the decision maker directs' for the purpose of determining the EFN of the applicable stream.

WSA s. 15 (4) specifies that 'Despite subsection (1), a decision maker may take into account the environmental flow needs of any stream the decision maker considers may be affected by granting the application.'

4. PROCEDURES

It is recommended that during the technical review of an application to divert and use water from a stream (as defined above), or aquifer reasonably likely to be hydraulically connected to a stream, the reviewer initially conduct an EFN risk assessment to determine the potential risk to the EFN of the proposed source, should the application be granted.

Section 5.1 describes the recommended EFN risk assessment methodology. This methodology uses information about aquatic ecosystem values within a watershed of interest (WOI), long-term mean annual discharge (lt MAD) and mean monthly discharge (MMD) at the point of interest (POI), and cumulative monthly withdrawals above the POI to characterize the EFN risk associated with an application as: 1 (low); 2 (medium); or 3 (high), and to identify applications that require 'special consideration.'

Section 5.2 describes supplemental analytical activities that decision makers may wish to specify for each risk level to better understand potential impacts to EFN. Such additional analysis may be completed prior to a decision on the application or specified in authorization terms and conditions. Where a scientifically credible EFN study(s) relevant to the proposed source already exists, additional analysis may not be necessary. Section 5.2 also provides examples of risk management measures that could be included in authorization terms and conditions at the discretion of the decision maker.

The screening tool and supplemental analytical activities complement existing practices for gathering information on water availability, such as a background scan for water restrictions and water development plan requirements. The EFN Policy does not limit the discretion of the decision maker to ask an applicant for additional relevant information.

4.1 Environmental Flow Needs Risk Assessment Framework

Figure 1 illustrates the steps in the Environmental Flow Needs Risk Assessment Framework. It is recommended that this framework be used to assess EFN risk for each of the months during which the applicant proposes to divert and use water.

Data inputs to this framework are described below. Note that the generic quantitative thresholds identified in the framework were developed at a provincial level. Regions may choose to develop and use their own scientifically defensible thresholds that reflect regional and/or site-specific hydrological and ecological sensitivities.

Decision makers are advised to check the quality of the hydrological data and other information used in the EFN risk assessment process (e.g., whether or not data collection met Resources Information Standards Council (RISC) standards) and to document any concerns.

Species Sensitivity

The EFN risk assessment process considers the presence or absence of fish and 'sensitive species or ecosystems' (as described below) for each of the months during which the applicant proposes to divert and use water. A key question is 'does the watershed of interest include aquatic values that might be affected by water withdrawals?'

With respect to fish, it is recommended that for the purpose of EFN risk assessment, the watershed of interest be considered fish-bearing by default. Confirmation of fish absence should reflect regional expertise or be demonstrated by qualified individuals using approved methods and standards.

For the purpose of EFN risk assessment 'sensitive species or ecosystems' may include, but are not limited to:

- Species designated as 'threatened' or 'endangered' under the provincial *Wildlife Act* or the federal *Species at Risk Act (*see *BC Conservation Data Centre* for a current list*)*;
- Regionally important aquatic species that may include red or blue-listed species or populations that are considered vulnerable in B.C. because they are rare and/ or have limited distributions; or
- Species or habitats important for ecosystem function.

It is recommended in addition that for the purpose of EFN risk assessment the following be interpreted as indicating the presence of sensitive species or ecosystems:

- Sensitive stream designation under the WSA and Water Sustainability Regulation;
- Presence of a Wildlife Management Area with a flow-related objective(s);
- A site-specific report identifying species or aquatic habitat with flow related concerns. (Such reports may be found in Cross-Linked Information Resources (CLIR) or EcoCat Ecological Reports Catalogue); and
- Cultural sensitivities e.g., ceremonial sites; culturally important aquatic species.

Flow Sensitivity

EFN risk assessment considers the sensitivity of the proposed water source to water withdrawals for each month during which the applicant proposes to divert and use water. A key question in EFN risk assessment is: 'How sensitive is the stream to changes in flow?'

Ptolemy & Lewis (2002), in a review of habitat-flow studies completed in British Columbia, found that flows of 20% lt MAD or more (based on natural streamflow) are

required to conserve adequate summer and winter rearing flows for juvenile fish and to maintain insect production in riffle habitats.

For EFN risk assessment, flow sensitivity is based on long-term mean monthly discharge (lt MMD) as a percentage of long-term mean annual discharge (lt MAD) at the Point of Interest, and is represented by the equation:

(lt MMD/lt MAD) x 100%

The EFN Risk Assessment Framework assumes that mean monthly discharge:

- Greater than 20% lt MAD represent *low* flow sensitivity;
- Between 10 and 20% lt MAD represent *moderate* flow sensitivity; and
- Less than 10% of lt MAD represent *high* flow sensitivity.

The EFN risk assessment methodology distinguishes between flow-sensitive streams that are 'moderately' and 'highly' flow sensitive.

In applying the EFN Risk Assessment Framework regions may make scientifically defensible adjustments to these flow sensitivity parameters to better reflect regional conditions. For example, although lt MAD for many streams on the east side of Vancouver Island is greater than $10m^3/s$ these streams are highly flow sensitive in summer.

In addition, in some regions monthly means (lt MMD) may mask significant variability in the timing of the freshet and the start and end of low flow periods. Where this is known to be the case, regions may choose to select – for key portions of the year – time intervals (e.g., weekly; 15^{th} to 14^{th} of each month) that will likely generate more representative hydrometric statistics.

Where existing and/or proposed consumptive water use modifies natural streamflow patterns, regions will likely need to adjust measured discharge data before they can generate appropriate lt MAD and lt MMD statistics for use in implementing the EFN Risk Assessment Framework.

Stream Size

The EFN Risk Assessment Framework categorizes stream size according to lt MAD. The categories are:

- Small: less than $10m^3/s$ lt MAD
- Medium-Large: equal to or greater than $10m^3/s$ lt MAD

'Stream size' is assumed to be the same throughout the year, with the exception – for medium-large streams – of ice-covered months. The period during which a stream is ice-covered is considered more ecologically sensitive than the period with open water

conditions.[1] For months in which the proposed water source is ice-covered, it is recommended that EFN risk assessment consider the source to be 'small' – regardless of its actual lt MAD.

Stream size parameters can be adjusted to regional differences. For example, in regions with an abundance of streams with lt MAD smaller than $10m^3/s$ it may be appropriate to define a 'small' stream – for the purpose of EFN risk assessment – as one in which lt MAD is less than 5 m^3/s or even $1m^3/s$.

Cumulative Withdrawals

The last step in the EFN risk assessment considers cumulative withdrawals – including withdrawals from hydraulically-connected aquifers – above the Point of Interest (POI). Cumulative withdrawals includes existing authorized demand and demand proposed in the application – as a percent of flow for each of the months (or other time interval used in the risk assessment) weeks or days) during which the applicant proposes to divert and use water. This can be represented as the equation:

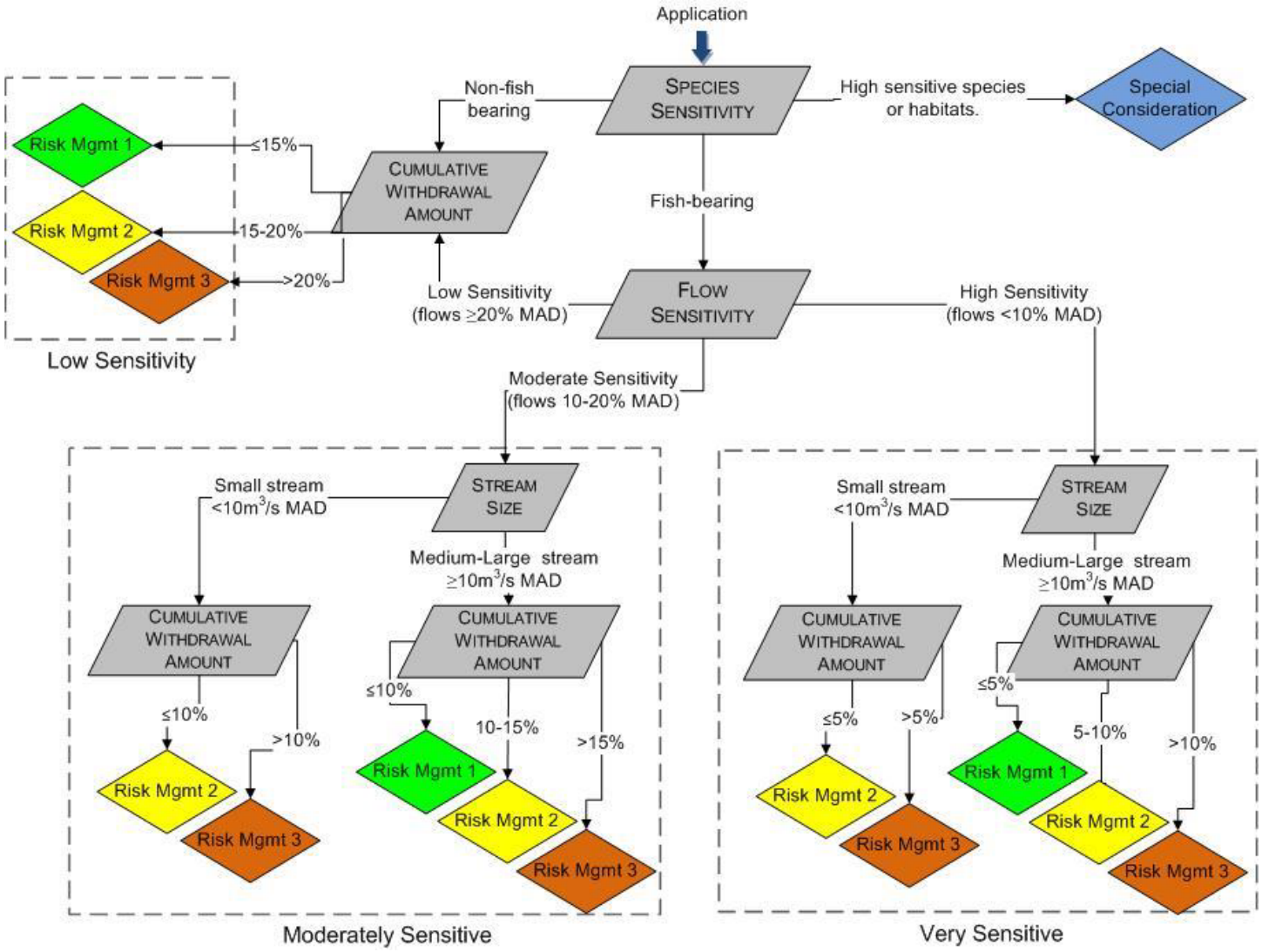
((Authorized diversion + Proposed Diversion)/MMD) x 100%.

The final step in the EFN Risk Assessment Framework uses the result of this equation to identify the EFN risk level associated with the application. In general, the greater the percent of flow, the greater the risk. The percent thresholds specified in the EFN Risk Assessment Framework vary, however, depending on stream sensitivity and size. More conservative thresholds apply to streams that are smaller and/or to naturally flow sensitive periods.

In highly flow sensitive streams (i.e., those with MMD significantly less than 10% of lt MAD during the proposed period of diversion and use) it is recommended that the EFN risk assessment consider information about instantaneous or peak daily demand, where available. For example, whether or not water diversion and use are constant throughout the month or concentrated during smaller time periods will potentially influence the likelihood of impacts on EFN during those time periods.

[1] Hatfield (2012)

Figure 1. Environmental Flow Needs (EFN) Risk Assessment Framework



4.2 Supplemental Analysis and Risk Management Measures

The EFN risk assessment process identifies low risk (Level 1) applications that, if granted, are unlikely to affect EFN and medium (Level 2) and high risk (Level 3) applications for which more information may be needed before a decision can be made. The risk levels identified through the EFN risk assessment process may vary from month to month during the period of diversion and use proposed in the application.

A finding of medium or high risk related to potential impacts on EFN does not mean that an application is automatically refused; it does suggest the need for additional information, analysis and/or risk management. Supplemental analytical activities can increase understanding of the potential influence of proposed water diversion and use on EFN and inform the selection of appropriate risk management measures.

Table 1 provides examples of supplemental analytical activities and risk management measures relevant to each risk level. The decision maker has the discretionary authority to implement additional or alternative supplemental analytical activities and/or measures.

The analytical activities and risk management measures identified in this section may be implemented by government or may be required of the applicant (prior to a decision on an application) or licensee (as authorization terms and conditions) at the discretion of the statutory decision maker. The choice of analytical activities and risk management measures may be based on the quantity of water to be withdrawn, whether the application is for a licence or use approval, or other factors.

Special Consideration

If 'sensitive species or habitats' (as defined in this policy) are present within the watershed of interest it is recommended that the review of the application, consider information about these sensitive values in addition to information relevant to the identified risk level. This may involve development or review of an existing regional fish periodicity table.

Risk Level 1

Where the EFN risk assessment process results in Risk Level 1, for that specific flow period (i.e., monthly) there is sufficient water available to provide for EFN as well as for proposed water diversion and use.

While Level 1 does not mean 'no risk' (i.e., lower risk of negatively influencing EFN), it indicates that supplementary information may not be required, unless the presence of sensitive species or habitats suggests the need for Special Considerations (Figure 1 and see above).

Risk Level 2
Risk Level 2 means that the aquatic environment is flow-limited for the proposed withdrawal period or that cumulative water withdrawals are greater than a specified threshold of concern.

A result of Risk Level 2 suggests that more information may be required prior to a decision to grant or decline an application, or that the authorization (if granted) may include terms and conditions to minimize potential impacts to EFN.

Risk Level 3
Risk Level 3 means that the aquatic environment may be severely flow-limited for the proposed period of withdrawal, or cumulative water withdrawals would be greater than a specified threshold of concern, that varies depending on flow sensitivity.

A result of Risk Level 3 suggests that more extensive analysis of the potential impacts of the proposed application on EFN may be appropriate prior to the decision to grant or decline the application; and/or the inclusion of comprehensive terms and conditions in the authorization (if granted).

Table 1. Supplemental measures to assess potential impacts on EFN and examples of risk management measures in authorization terms and conditions

Special Considerations (Reflecting presence of sensitive species or ecosystems, cultural sensitivities, etc.; see description of 'Species Sensitivity' above.)
Supplemental measures *to assess potential effects on high value species or habitats:* • Create and/or apply a fish periodicity table that is relevant to the WOI and identifies minimum flows for different life phases of species of significance (e.g., Lewis *et al.* 2004)
Level 1
Supplemental measures *to assess potential effects on EFN:* • Review relevant available information related to the WOI (e.g., water and fish reports on EcoCat) 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)
Level 2
In addition to Level 1 measures: ***Supplemental measures*** *to assess potential effects on EFN:* • 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 EFN:*

- Issue seasonal licence, 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 specified periods,
- Require authorization-holder to monitor flows and limit withdrawals when flows drop below a certain level

Level 3

In addition to Level 1 and Level 2 measures:

Supplemental measures *to assess potential effects on EFN:*

- 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 EFN:

- Issue limited licence term (e.g., five years), allowing for review and potential adjustment

5. APPENDICES

5.1 References

DFO. 2013. *Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada*. DFO Can. Sci. Advis. Rep. 2013/017.

Hatfield, T. 2012. *BC Ministry of Environment Winter Flows Project*. *Final Report.* Consultant's report prepared for the Ministry of Environment, British Columbia by Ecofish Research Ltd., April 2012.

Hatfield, T., A. Lewis, D. Ohlson and M. Bradford. 2003. *Development of instream flow thresholds as guidelines for reviewing proposed water uses*. Report prepared for British Columbia Ministry of Sustainable Resource Management, and British Columbia Ministry of Water, Land, and Air Protection, Victoria, BC.

Hatfield, T., A. Lewis, and S. Babakaiff. 2007. *Guidelines for the collection and analysis of fish and fish habitat data for the purpose of assessing impacts from small hydropower projects in British Columbia*.

Lewis, A., T. Hatfield, B. Chilibeck, and C. Roberts. 2004. *Assessment methods for aquatic habitat and instream flow characteristics in support of applications to dam, divert, or extract water from streams in British Columbia*. Prepared for Ministry of Water, Land & Air Protection and Ministry of Sustainable Resource Management.

Resource Inventory Standards Committee (RISC), 2001. *Reconnaissance (1:20,000) fish and fish habitat inventory standards and procedures - version 2.0*. Prepared by B.C. Fisheries Information Services Branch. 170 pages.

5.2 Background on the EFN Risk Screening Approach

The EFN risk screening approach described in this policy is derived from methods currently used in B.C. and other jurisdictions, scientific literature, and expert opinion. The principles considered in developing the EFN risk assessment process include:

- Key aspects of the natural flow regime can be maintained by restricting hydrologic alterations to within a percentage-based range around natural (flow regime) or historic flow variability (DFO, 2013);
- Smaller streams are more sensitive than larger streams to water withdrawals;
- Use of mean annual discharge for characterizing flow sensitivity is already used in B.C. (e.g., B.C. Modified Tennant method, described in Hatfield *et al.* 2003) and is supported by other B.C. studies; and
- Hydrology information using natural or naturalized flow regime data is used as a proxy for biological performance because historic flows are typically easier to measure or synthesize than ecological metrics like fish abundance.

INTEGRATED SUSTAINABILITY

Appendix 3 - POD B Site Visit for Hydrology Assessmet

INTEGRATED SUSTAINABILITY

Memo

To:	Daris Gillis and Kari Bondaroff
Cc:	
From:	Ryan Parisien
Date:	August 2nd, 2023
Project #:	VP22-PRD-02-00
Priority:	Normal
Subject:	POD B Site Visit for Hydrology Assessment

1 INTRODUCTION

The Peace River Regional District (PRRD) is considering installing a public tank loader facility (facility) to comply with the Northern Health Authority's health standards for potable water in the Electoral Area C (Area). An overall feasibility study has been conducted for Charlie Lake previously by Integrated Sustainability in 2022, and the characteristics of location B were identified as optimal for the facility. Integrated Sustainability has since conducted an onsite investigation on July 18th, 2023 to obtain data for the water quality, substrate type, topographic, and bathymetric qualities of the location, and whether it would be suitable for the facility.

The purpose of this memo is to provide an overview for the topographic suitability of location B including shore geometry, substrate characterization, and water level profiling. Additionally sample data has been discussed and briefly analyzed. Data collected will be used to assess the rate of water diversion that could be requested under a potential water license. It will also be used to evaluate allowable water diversion with respect to the lake's Environmental Flow Needs (EFN). The shore characteristics and topographic information would be considered in any future designs of a potable water filling station. If the location is selected, the data collected is sufficient to begin preliminary designs of the facility.

2 LOCATION B GENERAL CHARACHTERISTICS

The location consists of a single service building, being around 27 m in length and 11 m in width. The street address of the site is 13074 Lakeshore Drive and is owned by PRRD. The land ownership type is Municipal as listed in the ParcelMap BC database and would allow for easy acquisition and development of the site by PRRD. The location can service

around 45.03% of the populated area within a ten-minute drive in the district, being the highest percentage of the three available POD locations previously studied. The site currently has an intake pipe installed, which is buried in some sections and exposed in others. Images were taken of this pipe and are listed as Figures G through I, Appendix A.

The site has an oval shaped gravel lot for maneuvering trailers carrying potable water tanks, and a dispensation system that was observed to be functional. The building which houses former pumping and treatment equipment is in good condition and could likely be repurposed for a new potable water filling station. The inside of the building was not examined during this site visit, and conditions inside are unknown. The closest available water quality station is operated by the B.C. Lake Monitoring Network and is listed as: Charlie Lake Deep Station (0400390). The station is approximately 0.6 Km linear distance from POD location B and has two depths of measurement during sampling events. There is another station located northwards from the POD, also run by the B.C. Lake Monitoring Network. It is listed as: Charlie Lake North Arm Deep Station (E207459). This station has only historic data and is not actively monitored.

3 TOPOGRAPHIC SURVEY

A topographic survey was performed using a Wingtra One UAV, and included QA/QC, ground control, water line, and points of other significant features captured with portable RTK GNSS. The main purpose of the topographic survey was to gain an understanding of the surface layout to predict the costs, difficulty, and logistics of constructing the facility. The land slopes from the East to West side of the site. Measured from a single averaged profile, the slope starts at 698.0 m and drops to 693.5 m over a 65 m run. This results in a grade of 6.9% and an overall slope angle of 4°, although there is a flat spot in the middle of this profile from the gravel lot shown in Figure 3, Appendix A. The grade measured from the back of the service building to the edge of the shore is slightly steeper, at around 12.5% with a slope of 7°. The grade is gentle and consistent and should not pose significant challenges in designing or constructing an intake.

The shore has an average 1.5 m drop off to the beach, which extends another 1.0 m out to the water line. The beach mainly consists of small to medium cobbles, around 10-30 cm in size. This is intermixed on the shore with gravels ranging in size from 1.0 to 10.0 cm. The cobbles overlay a substrate consisting mainly of medium to coarse sand, accounting for around 95% of the volume. The other 5% consist of fine grain silt and mud. The percentage of fine sediments increases mildly with depth. The gravel found on the beach was not observed in the shallow lake sediments. The shore has been previously managed for erosion using pieces of rebar reinforced concrete ranging in size from 0.5 to 3 m. The shoreline geometry, substrate material, and erosion control measures can be seen in Figures I through K, Appendix A.

Topographic data collected includes an Orthophoto, Digital Terrain Model (DTM), Digital Surface Model (DSM), and RTK GNSS points of various features of interest. The DTM represents a model of the land surface without any above ground objects such as vegetation, vehicles, or structures. It shows the true geometry of the terrain, and thus is

ideal to use for future CAD designs. The DSM captures everything present at the time of the survey and will display at a higher resolution than the DTM due to the interpolation algorithms used. The DSM and Orthophoto have a resolution of 1.6 cm/pixel, whereas the DTM resolution is 8 cm/pixel. Elevation values from the aerial survey were corrected from height to elevation using the HTv2.0 geoid model. This was done to increase accuracy using a regional elevation model and remain consistent across data streams. Should PRRD request, the output files can be converted to other elevation or height models. The accuracy of the spatial products is 2 cm horizontally and 3 cm vertically. These digital products will be made available to the client as a digital download for use in future projects.

4 BATHYMETRY SURVEY

Bathymetry data was collected using a Sonarmite 200 KHz single frequency echosounder mounted to an Unmanned Surface Vessel (USV). The extent of the surveyed area covered 125 x 125 m. The point data was interpolated to a 3D DTM using the inverse distance weighting method to generate a surface capable of use in future intake design models. The waterline was found to be at an elevation of 691.85 m within 1.1 cm of accuracy on the day of measurement (June 18th, 2023). The lowest bathymetry point recorded was 688.10 m, yielding a maximum depth of 3.75 m in the surveyed lake area. This location begins around 120m offshore, at a compass bearing of 53.5° and continues past the survey area shown in Figure B, Appendix A. The interpolated bathymetry survey has an overall resolution of 62 cm/pixel and is also tied to the HTv2.0 geoid model.

In this location the lake is generally shallow, with a smooth and gradual slope. Some gravel bars and patches of thick lacustrine vegetation were observed closer to shore. The density and surface proximity of the vegetation was sufficient to foul the props of the USV, and thus the area was avoided. The average grade of the profile towards the deepest section is 2.7%, or 1.5°. The grade is relatively shallow, and the type of intake used will have to be carefully considered if this location is selected to ensure proper submersion. A copy of the bathymetry surface will be made available to the client if they wish to use in future designs.

5 WATER QUALITY DATA

Water quality was analyzed in situ using a YSI multi-parameter sonde from three areas within 5 m of the POD shoreline. The results are summarized in Table A below:

Table A. Field Water Quality Readings

Water Level (m)	Shoreline Distance (m)	Water Temp (°C)	pH	EC (µS/cm)	DO (%)	ORP (mV)	TDS (g/L)
0.6	5	20.9	8.55	173	66.2	95.2	0.122

0.5	3	20.7	8.73	192	94.6	143.6	0.136
0.3	5	20.5	8.62	196	75.0	98.6	0.120

Table B. 2022 Summer Water Quality Readings from Monitoring Station (0400390)

Sample Depth (m)	Shoreline Distance (m)	Water Temp (°C)	pH	EC (µS/cm)	DO (%)	ORP (mV)	TDS (g/L)
7.0	600	18.1	8.38	173	93.1	N/A	0.071

The water temperature recorded was relatively warm. The probe's thermistor was checked for proper temperature compensation in the open air and read accurately compared to a handheld anemometer. It was also calibrated before use by the provider. Lab and in situ measurements coincide well, where the only discrepancy was the pH reading which was more than one unit higher in the field readings. This range is still within tolerance to consider both measurements valid due to large changes in pH at varying temperatures and analysis time after sample removal.

Test results were analyzed with respect to standards set in the Canadian Drinking Water Guidelines. Full test results are available in Appendix B. Results were good and typically low in most analytes with the only exception being manganese. The criteria require a maximum of 0.05 mg/L of manganese, while the lab sample contained 0.10 mg/L. While not of significant concern, further sampling should be conducted to determine an average manganese concentration. If manganese is of concern at the location, certain treatment and monitoring methods can be utilised. These may include water softeners, membrane filtration, or installation of a green sands filter, along with remote monitoring equipment at the intake and outlet to ensure the effectiveness of the filtration system.

6 FINAL NOTES

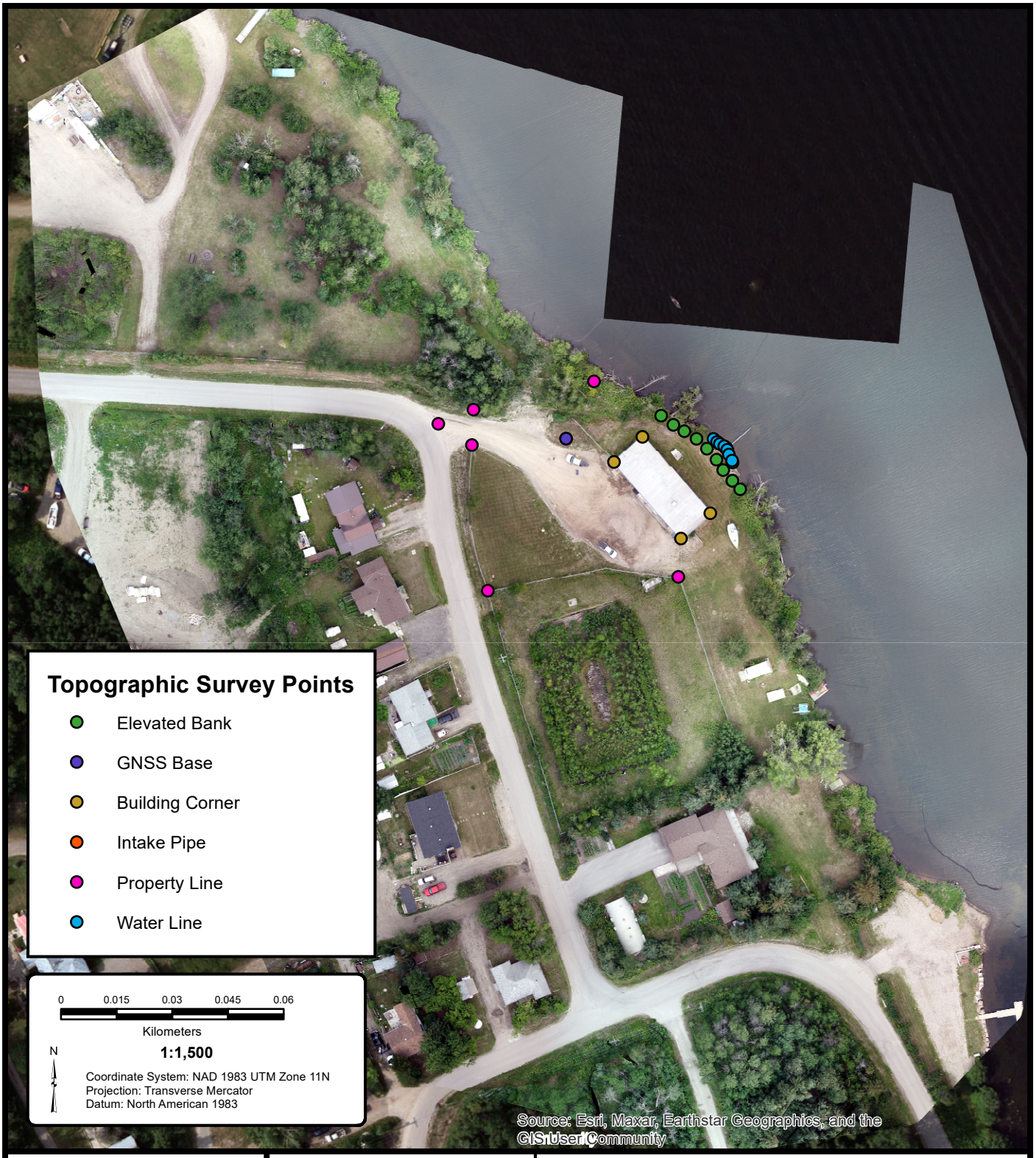
POD location B would make for a good location for a facility providing potable water to nearby residents. The overall quality of the water is good, and topography of the location suitable for such a facility. Given that there is an existing facility in place, some of the equipment may be still in serviceable condition and available for re-use. The structure on site is large and could accommodate a significant amount of filtration and process equipment. It likely also has a medium to high voltage grid connection to provide machinery with ample power. Two dispensation pumps and taps are already available at the site, and residents are familiar with its location and usage procedures.

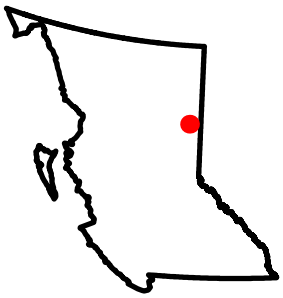
Upon discussion with several users while on site, a common issue noted was the size of the gravel lot, being somewhat small for maneuvering larger trailers and water tanks. It was suggested that this lot should be made larger. Additionally, users spoken to noted that

significant algae blooms had often caused issues with the previously installed treatment system. As such, blue-green algae should be closely monitored, and appropriate mitigation measures employed in the design of the system. Chlorophyll-a can be used as an indicator of potential cyanobacteria growth and is used for testing among the two other water quality stations in the lake. As the algae blooms seasonally, a longer-term testing program or in depth analysis of existing data would need to be considered at the POD to determine the severity and effect of algae on a potable water intake.

INTEGRATED SUSTAINABILITY

Appendix A – Figures and Images





PREPARED BY:

INTEGRATED SUSTAINABILITY

CLIENT:

PRRD

PEACE RIVER REGIONAL DISTRICT HYDROLOGY ASSESMENT OF CHARLIE LAKE SITE ORTHOPHOTO AND TOPO SURVEY

DRAWN BY:	CHECKED BY:	APPROVED BY:
R.PARISIEN	F.MADAENI	F.ADLI

PROJECT NO.	FIGURE NO.	REVISION:
CP22-PRD-02-00	1	0

NOTES: 25-JUL-23
Source: Data collected on July 18th, 2023 using a Wingtra One UAV. Elevations observe the Canadian HT_02 geoid model

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