Upper Bulkley Fish and Aquatic Review:
Stream Flow, Surface Water Licenses and Groundwater Wells

FEBRUARY 28, 2018

Prepared by Eclipse Geomatics Ltd.
Smithers, BC

Last Saved on 2018-06-07 9:24:00 AM
Filename: UBR_water_v14.docx

Acknowledgements

This report was generously funded by the Department of Fisheries and Oceans Contract F1480-160021. Special thanks to Lana Miller, Mark Beere, Kenny Rabnett, and Barry Watson for their assistance and time taken to answer questions.

Table of Contents

1. EXECUTIVE SUMMARY

Stream discharge and water extraction have been identified as key salmon habitat state indicators under the Wild Salmon Policy (DFO 2005). This report provides an overview of current surface water license use, ground water allocation, and long-term stream discharge within the Upper Bulkley Watershed and associated sub-watersheds.

Reliable hydrologic flow information provides the basis for accurate water volume estimation and allocation. The majority of hydrometric flow information in BC is provided by Water Survey of Canada (WSC) monitoring sites.

Currently within the Upper Bulkley watershed only two WSC sites are active. Six additional WSC sites have been in use intermittently over the past 53 years. Reactivating retired sites or installing additional hydrometric stations in several of the main tributaries of the Upper Bulkley would provide valuable additional hydrological data required to determine how climate change is affecting stream flow volumes.

In BC, the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRO) authorizes water licences and approvals which allow people to divert, use or store surface water or groundwater, or to make changes in and about a stream. Water licences are generally long-term agreements and are associated with a single to a Point of Diversion (POD) while approvals authorize holders to use water for a maximum of 24 months and are not tied to a single POD within a watershed.

Within the Upper Bulkley watershed 93 surface water licenses are registered to 67 PODs and 24 short-term approvals were issued as of April 2017. The sum of existing annual surface water allocations (824,000 m^3/year) for the Upper Bulkley currently makes up 1.09% of the potential annual allocation. Therefore, according to the 30 year average values provided by the Northwest Monitoring Tool, total surface water allocations for each month are well within acceptable levels and do not impact the environmental flows required to sustain aquatic health.

Although over half of the water licenses (55 licenses) in the Upper Bulkley are allocated to domestic use, 74.8% of the allocation volume is directed towards conservation/storage and 15.5% towards irrigation. Removing the non-consumptive uses such as conservation and storage from the allocation totals highlights the use of irrigation (62.7%) as one of the key uses of surface water licenses in the Upper Bulkley watershed.

The 24 short term approvals comprised 21.4% of the total surface water allocation for the Upper Bulkley in 2017. These short term approvals are recorded manually and not included within the surface water licensing system.

When comparing the proportion of stream volume a sub-watershed contributes to the Upper Bulkley watershed with the proportion of how much surface water has been allocated from the stream, Aitken Creek, Byman Creek, Maxan Creek, and Richfield Creek all have surface water allocations greater than their contributing average annual runoff volume.

According to the groundwater WELLS database, 217 ground water wells exist within the Upper Bulkley (GeoBC 2017). Of the 217 groundwater wells, 102 of the wells registered do not have a clear well use or well use is unknown. A recommendation of this report is to carry out a further investigation of the groundwater wells classified as other or unknown within the Upper Bulkley to determine if these wells are still active.

2. INTRODUCTION

Stream discharge and water extraction have been identified as key salmon habitat state indicators under the Wild Salmon Policy (DFO 2005). This report provides an overview of current surface water license use, ground water allocation, and long-term stream discharge within the Upper Bulkley Watershed.

The objectives of this report include:

1. An overview of surface water discharge, stream volume, environmental flows and surface water allocation within the Upper Bulkley watershed.

2. An overview of existing ground water wells and licenses within the various sub-watersheds of the Upper Bulkley.

3. A map reference identifying the location and unique water license ID of existing surface and ground water licenses within each sub-watershed.

4. A tool to allow environmental flows and allocations to be adjusted dynamically for each sub-watershed.

3. METHODS

This report is an in-house review of existing information as it relates to water quantity within the Upper Bulkley Watershed, defined as the Bulkley River Watershed upstream of the confluence of the Bulkley and Morice Rivers (Figure 1).

Surface Water Discharge

Static annual flow information presented was derived from the Northwest Water Tool (NWWT 2016). This information was converted from PDF to Excel format to create a more interactive dataset which allows alternate allocation thresholds to be specified for the sub-watersheds within the Upper Bulkley. The annual runoff volume and allocation information derived from the NWWT for the Upper Bulkley and included in this report captures all flow and allocation information relevant to the entire study area. Flow information for the Upper Bulkley Watershed was further characterized by sub-watershed.

Sub-Watershed Boundary Derivation

Annual runoff volume and allocation information derived from the NWWT for each sub-watershed and included in this report are based on the Freshwater Atlas Assessment Watershed boundaries.

This report methodology as it applies to the Bulkley River Units BR1 to BR9 applies a different set of sub-watershed boundaries than the Freshwater Assessment watersheds.

For the purposes of this report the Bulkley River Units BR1 to BR9 are an aggregation of smaller first and second order creeks that run directly into the Bulkley River and are not included in any of the named sub-watersheds. The delineation of these project specific boundaries does not necessarily follow the Freshwater Assessment watershed boundaries. In addition, the NWWT does not have the ability to produce aggregate reports based on more than one sub-watershed.

To accommodate the spatial difference in how sub-watersheds are defined within this project as compared to the NWWT, an additional category (Main Stem Bulkley River) is included in the summary table to accommodate flows along the Bulkley River not captured within the sub-watershed reports produced by the NWWT.

Surface Water Allocation

In BC, the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRO) authorizes water licences and approvals which allow people to divert, use or store surface water or groundwater, or to make changes in and about a stream. Water licences are generally long-term agreements and are associated with a single to a Point of Diversion (POD) while short-term approvals authorize holders to use water for a maximum of 24 months and are not tied to a single POD within a watershed. Surface water allocation information was obtained from the NWWT, and includes both water licenses and water approvals; however, spatial analysis was only completed for the surface water licenses, as the short-term approvals are not related to a specific location such as a POD.

Surface water licenses listed in the NWWT were corroborated with spatial water license data obtained from GeoBC (GeoBC 2017). The spatial data allowed for a more detailed analysis of use and volume of water licenses as the data contained a wider range of attribute information not available in the NWWT reports.

To examine the distribution of surface water licenses and groundwater wells throughout the Upper Bulkley watershed, a GIS exercise was carried out where each surface water license and groundwater well was assigned to a corresponding sub-watershed boundary. This resulted in no water licenses and ground wells assigned to the Main Stem Bulkley River.

In addition to summarizing existing water license use, current water license use provided by GeoBC (2017) is compared with historical license use information for the Upper Bulkley Watershed (Nijman 1986, Brockelhurst 1996).

Groundwater Water Wells

The new Water Sustainability Act (WSA) of 2016 considers the likelihood of hydraulic connections between surface water and ground water when reviewing a water license. The new WSA legislates the requirement to obtain a license for groundwater wells which have a non-domestic purpose. This new licensing regime now provides a record of how

much water each licensed ground water well can legally use. Recognizing the hydraulic connection between surface and ground water, this report also provides a summary of all existing ground water wells registered in the BC wells database within the Upper Bulkley watershed. Determining the distance of the identified groundwater wells from surface water features was outside the scope of this report.

4. INFORMATION SOURCES

4.1. Northwest Water Tool

This project utilizes the Northwest Water Tool (NWWT) to obtain surface water volume, stream discharge, environmental flows and surface water allocation thresholds.

The Northwest Water Tool presents long term (30 year) average values for stream flow as well as current and short term water license information based on a spatial watershed query. The tool leverages the BC Freshwater Atlas (Gray 2009) to communicate the results of detailed hydrology modeling (Chapman 2012). Environmental flow needs of the watershed are estimated using a concept adapted from the Alberta Desktop Method for Determining Environmental Flows (Locke and Paul 2011).

4.2. Surface Water License Information

To carry out a more detailed review of the surface water license data by purpose, quantity and volume this project incorporates spatial water license and point of diversion (POD) data from GeoBC (2017). This data contains a geographical point reference for each water license as well as more detailed attributes including POD number, purpose, licensee, and allocation volume.

4.3. Water Survey of Canada Hydrometric Sites

Reliable hydrologic flow information provides the basis for accurate water volume estimation and allocation. The majority of hydrometric flow information in BC is provided by Water Survey of Canada (WSC) monitoring sites.

Currently within the Upper Bulkley watershed only two WSC sites are active. Six additional WSC sites have been in use intermittently over the past 53 years. Figure 1 below shows the locations of WSC stations within the Upper Bulkley watershed. Tables 1 and 2 describe each active WSC site, its location and period of activity as well as the parameters measured. The details for the discontinued sites are described in Appendix A.

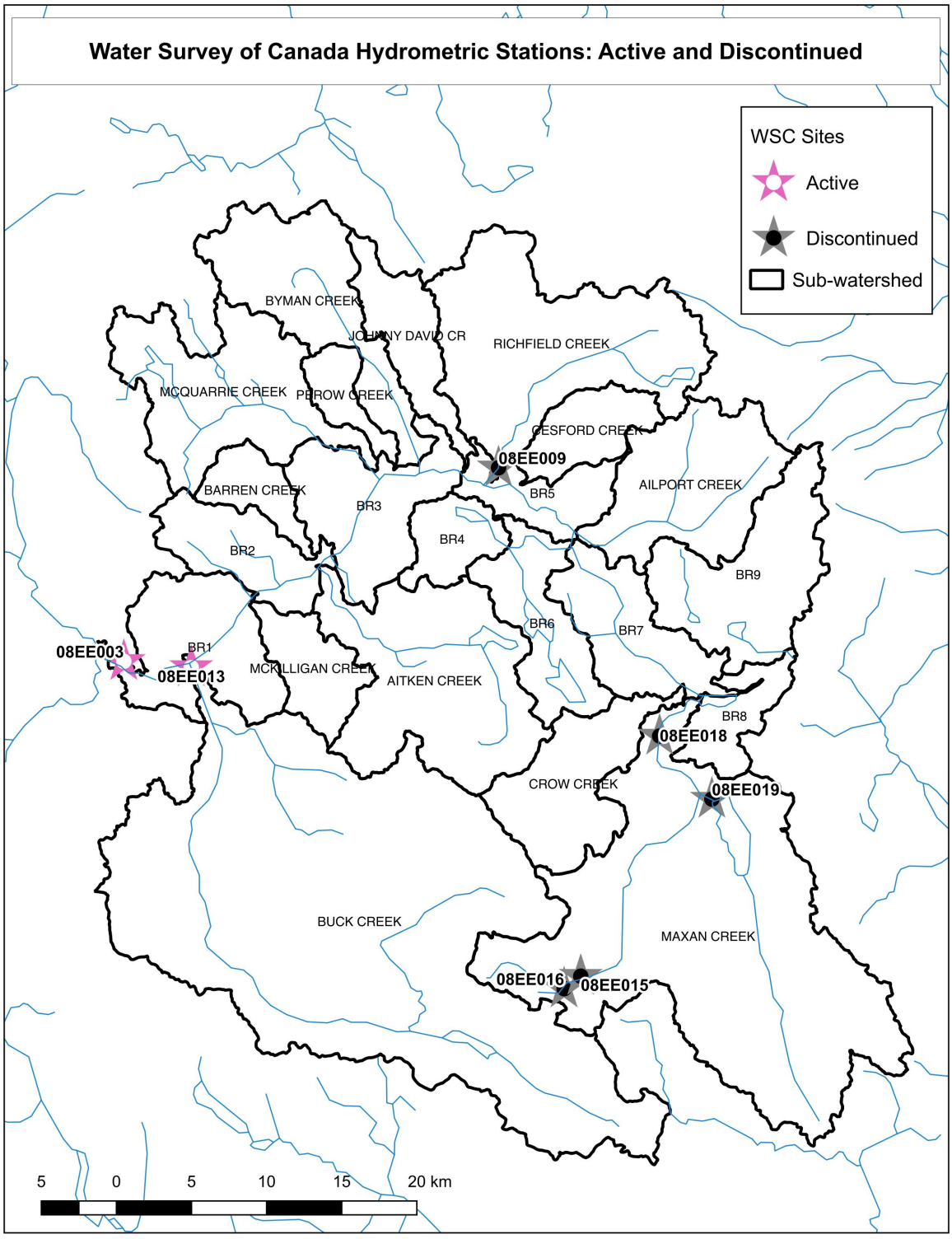

Figure 1: Water Survey of Canada Hydrometric Stations Within the Upper Bulkley Watershed

The Bulkley River Near Houston WSC station (08EE003) is the primary gauge relevant to the Upper Bulkley Watershed, recording flow during three distinct time periods including 1930 to 1951, 1971, and 1980 - present. As of 2011 the gauge measures water level as well as flow.

Table 1. Bulkley River Near Houston WSC Site 08EE003

WSC Site No.	**08EE003**		
Location:	**Bulkley River Near Houston**		
Service Dates	**Type**	**Operational Schedule**	**Gauge Type**
1930 - 1951	Flow	Seasonal/Miscellaneous	Manual
1971 - 1971	Flow	Continuous	Manual
1980 - 2009	Flow	Seasonal	Manual
2010 - 2010	Flow	Continuous	Recorder
2011 - 2017	Flow & Level	Continuous	Recorder

The second active gauge is situated at the mouth of Buck Creek (08EE013). This gauge has been recording flow since 1973. Stream level readings were added in 2011.

Table 2. Buck Creek at the Mouth WSC Site 08EE013[1]

WSC Site No.	**08EE013**		
Location:	**Buck Creek at the Mouth**		
Service Dates	**Type**	**Operational Schedule**	**Gauge Type**
1973 - 2010	Flow	Continuous	Recorder
2011 - 2017	Flow & Level	Continuous	Recorder

4.4. Groundwater Wells

In February 2016 BC released the new Water Sustainability Act (WSA). This new legislation requires a license for any groundwater use that is not considered domestic, although licensing of domestic wells is encouraged. These groundwater licenses are tracked in the BC WELLS database maintained by GeoBC (2017). This report draws from the WELLS database to provide groundwater well summaries by sub-watershed.

5. RESULTS

Water use summaries are presented for the Upper Bulkley watershed as well as each relevant sub-watershed including Ailport, Aitken, Barren, Buck, Byman, Crow, Maxan, McKilligan, Perow, Richfield, and Bulkey River face units BR 1 through BR9 (Figure 2). The following summaries are provided:

- Average stream runoff volume, environmental flow, and potential and existing surface water allocations;
- Surface water license allocations by use;
- Short term surface water approvals by volume and use;
- A comparison of current surface water allocation with historical allocation data from 1986, 1996, and 1998 (for Upper Bulkley watershed only); and
- Groundwater Well Summary.

5.1. Upper Bulkley Watershed

5.1.1. Average Runoff Volume, Environmental Needs and Allocations

The average (30 year) annual runoff volume for the Upper Bulkley is 505,562,000 m^3/year. Environmental flows (429,728,000 m^3/year) are calculated as a minimum of 85% of average runoff volume. Potential allocations (75,834,000 m^3/year) are derived from the remaining 15% of the average runoff volume (Table 3 and Figure 3).

Within the Upper Bulkley watershed 93[1] surface water licenses are registered to 67 PODs and 24 short-term approvals were issued as of April 2017. The sum of existing annual surface water allocations (824,000 m^3/year) for the Upper Bulkley is currently 1.09% of the potential annual allocation.

According to the long-term average values provided by the NWWT, total surface water allocations for each month are well within acceptable levels and do not impact the environmental flows required (Figure 4).

[1]These totals vary slightly from the total number of licenses from the NWWT (99) as our numbers take into account the situation where a license is listed twice due to the license tied to more than one POD but the quantity at each POD is unknown. (Max licensed demand for purpose/multiple PODs/qty at each POD unknown).

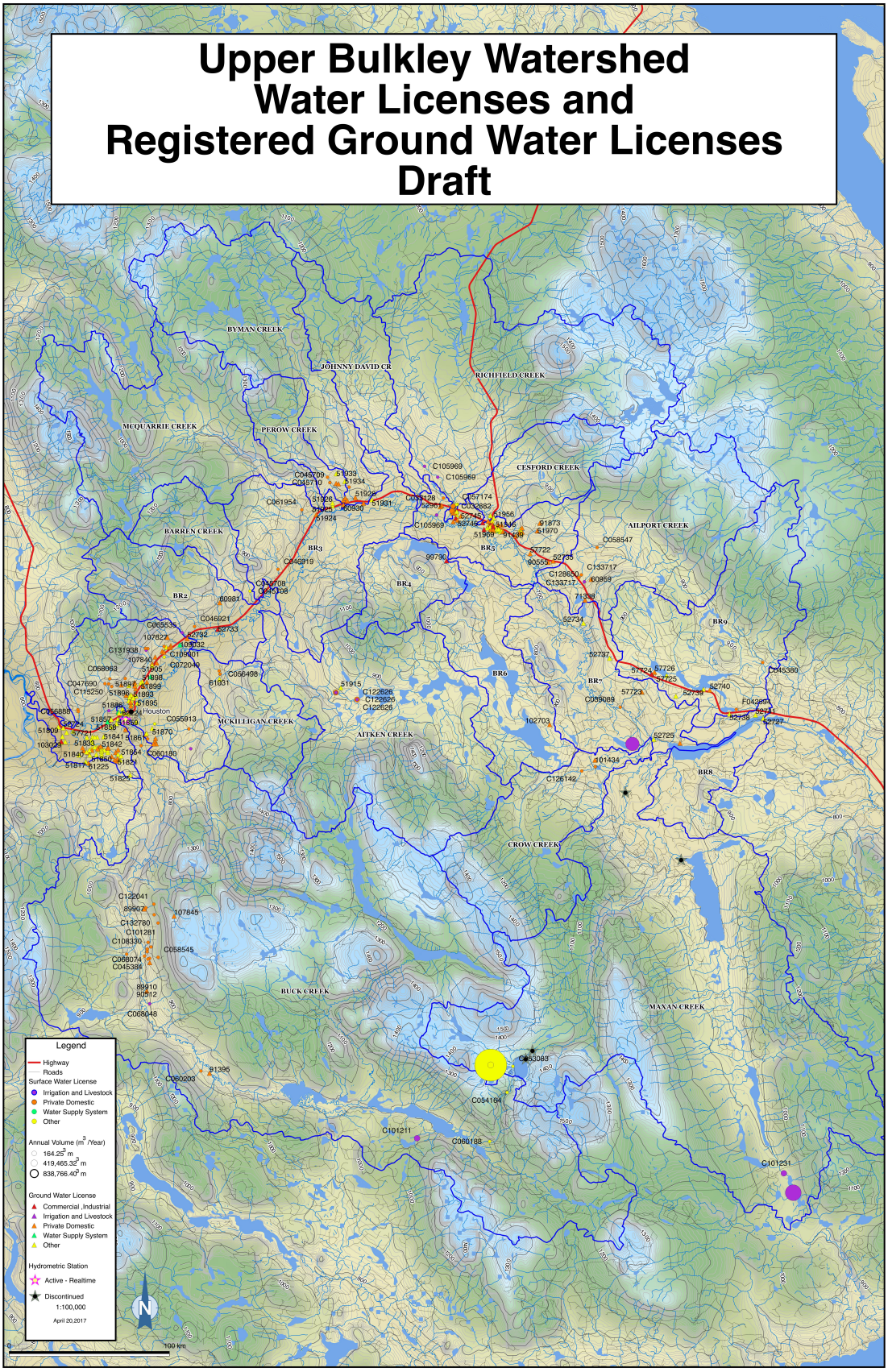

Figure 2. Water Licenses and Groundwater Wells within the Upper Bulkley Watershed

Table 3. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Upper Bulkley Watershed (10^3 m^3).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	5.2	4.8	5.7	14.8	58.7	50.9	23.0	10.2	10.6	15.5	11.7	8.4	220
AVG Discharge (m^3/s)	4.5	4.5	4.9	13.2	50.5	45.2	19.8	8.7	9.4	13.3	10.4	7.2	192
AVG Runoff Volume (10^3m^3)	12,060.8	10,958.3	13,200.2	34,146.0	135,152.2	117,171.6	52,971.6	23,426.8	24,472.8	35,684.4	26,995.4	19,321.9	505,562
Environmental Flows (10^3m^3)	10,251.7	9,314.6	11,220.2	29,024.1	114,879.4	99,595.9	45,025.9	19,912.8	20,801.9	30,331.7	22,946.1	16,423.6	429,728
Potential Allocation (10^3m^3)	1,809.1	1,643.7	1,980.0	5,121.9	20,272.8	17,575.7	7,945.7	3,514.0	3,670.9	5,352.7	4,049.3	2,898.3	75,834
Existing Allocation (10^3m^3)	69.5	63.2	69.9	71.9	69.5	67.2	69.5	69.5	67.2	69.5	67.2	69.5	824
Remaining Allocation (10^3m^3)	1,739.6	1,580.5	1,910.1	5,050.0	20,203.3	17,508.5	7,876.2	3,444.5	3,603.7	5,283.2	3,982.1	2,828.8	75,011

A few notes on how the NW Water Tool calculates surface water allocation:

- Existing annual allocations displayed in the NWWT are distributed equally across 12 months except for irrigation licenses which have their allocation distributed across June, July, August and September[2].
- The surface water allocation data was obtained from DataBC in April 2017.
- Short term approvals are included in the NWWT existing allocation calculations. These approvals are renewed on an annual basis, are not considered water licenses and therefore are not included in the GeoBC POD data files. (Watson 2017).
- Storage and conservation water license use are not included in the NWWT allocation calculations.

[2] Personal communication with Ben Kerr from Foundry Spatial on Dec 1, 2017.

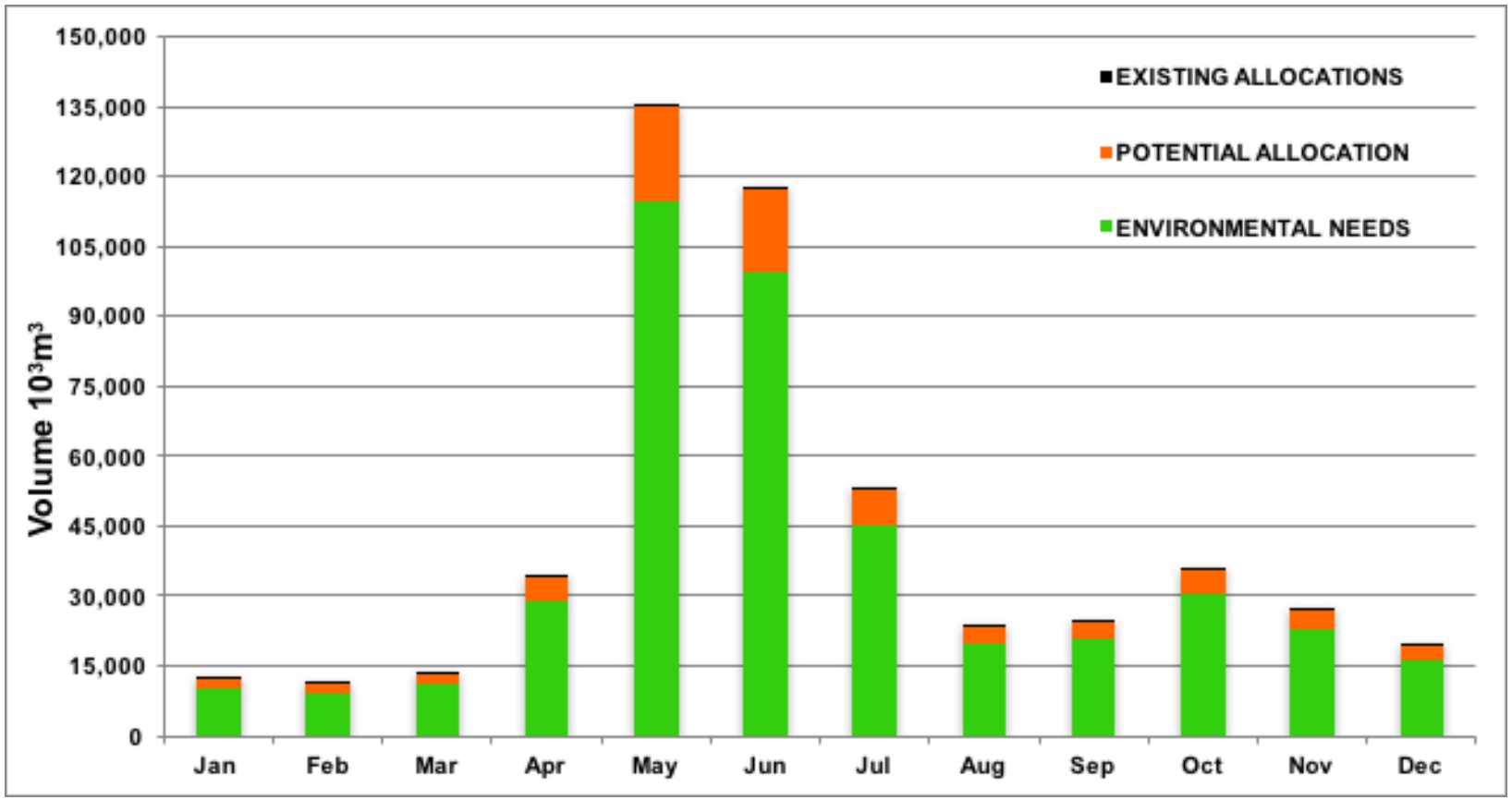

Figure 3. Environmental Needs, Potential and Existing Surface Water Allocations by Month for the Upper Bulkley Watershed

5.1.2. Surface Water License Allocation Use

Table 4 below provides a breakdown of surface water license allocation within the Upper Bulkley Watershed by use. Water use approvals are not included as they are not licenses and not categorized in the same way. Domestic water licenses (55 licenses) comprise 2.5% of the allocation, irrigation (10 licenses) comprise 15.8 % of the total water allocation, and 74.8% of the allocation is designated to 11 licenses for conservation and storage purposes. The remaining 6.5% of the allocation is directed toward the six land improvement licenses.

Table 4. Surface Water License Allocation in the Upper Bulkley by Purpose

Purpose	Number of Licenses	Total Quantity (m^3/year)	Proportion Allocation (%)
Conservation/ Storage	11	1,925,622.6	74.8%
Domestic	55	64,870.2	2.5%
Irrigation	10	407,404.2	15.8%
Land Improve	6	167,378.7	6.5%
Livestock	10	9,890.4	0.4%
Pond and Aquaculture	1	0.0	0.0%
Totals	**93**	**2,575,166.0**	**100%**

The total allocation of 2,575,166 m^3/year in Table 4 above is significantly higher than the totals provided by the NWWT (Table 3) because Table 4 includes conservation and storage uses. The conservation and storage allocations are removed from the NWWT allocation totals because the WSA considers these uses non-consumptive.

Although over half of the water licenses in the Upper Bulkley are allocated to domestic use, 90% of the allocation volume is directed towards conservation/storage and irrigation (Figure 4).

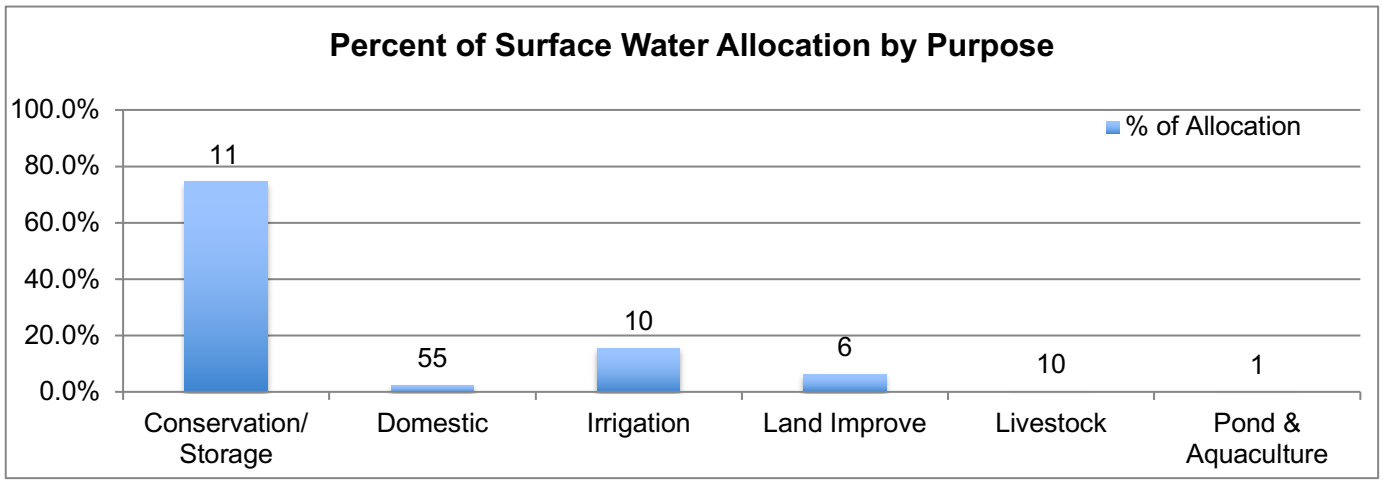

Figure 4. Percent of Surface Water Allocation by Purpose

It is useful to have a better understanding of conservation and storage allocation licenses within the Upper Bulkley in the event these types of allocations may be utilized more frequently as mitigation measures due to climate change.

The conservation and storage use licenses in the Upper Bulkley include:

- One license (C101223) on the Bulkley River issued to Department of Fisheries and Oceans for conservation construction works,
- One license on the Bulkley River for conservation storage issued to Ducks Unlimited (C062045), and
- Three licenses issued to Ministry of Environment (C101211, C101212, C101231) on Buck and Maxan Creeks for conservation storage.
- Five licenses (C046921, C068063, C072049, C115249, and F044094) fall under the stream storage: non-power purpose, and are situated along the mainstem Bulkley River and issued to local residents.
- The remaining stream storage license (C107980) is issued to GoldCorp Canada Ltd. (Equity mine site) and is situated at Maxan Creek. This license allocation of 838,766 m^3/year is 43.6 % of the total conservation/storage allocation in Table 4 and 32.6% of the total allocation within the Upper Bulkley.

Of the six licenses issued for land improvement purposes:

- Four are issued to GoldCorp Canada Ltd. (C53083, C054164, C060188, C107980) and
- The remaining two licenses (C045708, C101281) are issued to local residents.

The single pond and aquaculture license is tied to three points of diversion situated on McCracken, Hoffman, and Hogarth Springs.

Removing the non-consumptive uses such as conservation and storage from the allocation totals highlights the use of irrigation (62.7%) as one of the key uses of surface water licenses in the Upper Bulkley watershed.

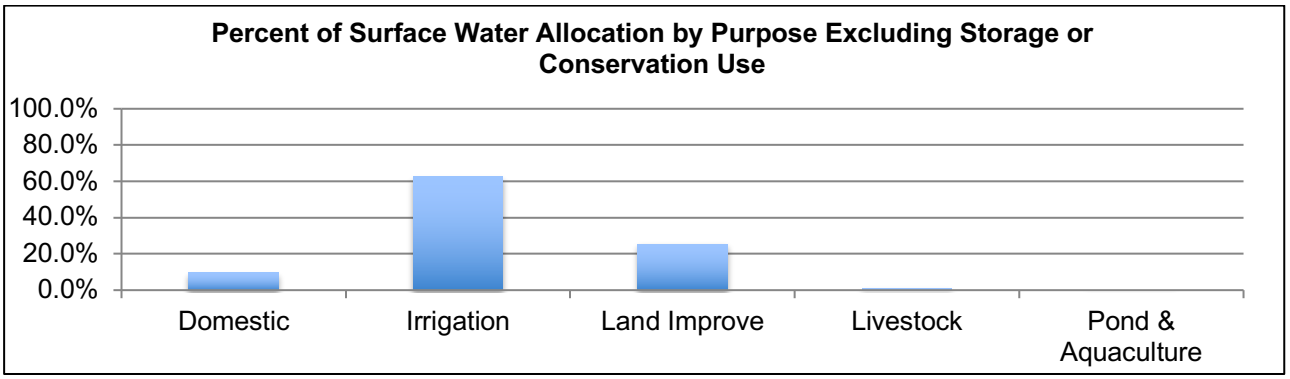

Figure 5. Percent of Surface Water Allocation by Purpose Excluding Storage or Conservation Use

5.1.3. Surface Water Allocation Comparisons with Historical Data

Over the past 30 years there have been three key reports prepared which provide overviews of water quantity and quality in the Upper Bulkley. The first report, prepared in 1986 by Nijman, is the Skeena-Nass Area Bulkley River Basin Water Quality Assessment and Objectives Report (Nijman 1986). In 1996, Remington prepared the Review and Assessment of Water Quality in the Skeena River Watershed, British Columbia. The third report, prepared by Brocklehurst in 1998, is entitled Historical data review on the Upper Bulkley River Watershed. All three reports provide summaries of surface water licenses.

Reach	Licensed Withdrawals		
	m^3/s	m^3/d	m^3/y
Source to Morice R.	0.00061	52.36	19 084
Morice R. to gauge at Quick	0.07213	3 117.00	187 680
Quick gauge to Telkwa R.	0.02602	1 128.10	80 572
Telkwa R. to Canyon Cr.	0.12012	5 649.63	634 250
Canyon Cr. to Skeena R.	0.0	0.0	0.0

Figure 6. Licensed Water Withdrawals from the Bulkley River: A Summary by Reach. Taken from Nijman (1986) Table 2

A summary of water license by volume in 1986 (Nijman 1986) as seen in Figure 6 indicates the total water license withdrawals in 1986 from the Source to Morice River was 19,084 m^3/year. Within the Source to Morice Reach catchment area, Nijman recorded three domestic licenses and one industrial license. The industrial license consists of one license with two withdrawals.

Remington (1996) also provides a summary of surface water licenses as seen in Figure 7. Remington reports a total of 71 active water licenses consisting of 59 domestic/stock watering licenses, 11 irrigation licenses, and one work camp license. A total annual withdrawal of 791,388 m^3/year was reported.

Input streams

Domestic/stock watering

GD	m3/d	m3/s
(56 licences)		
45000	204.6	2.37E-03

Irrigation*

AF	m3/d	m3/s
(11 licences)		
407	8367.1	9.68E-02

Bulkley River

Domestic/stock watering

GD	m3/d	m3/s
(3 licences)		
1500	6.8	7.87E-05

Work camp

License	Licensee	GD	m3/d	m3/s
C107980	Equity Silver Mines Ltd. (Also 14 434 m3/d storage) (Lu Creek/Lake)	20000	90.9	1.05E-03

* Irrigation licences have been converted from acre-feet to m3/s by assuming 2 months of operation, 12 hours/day in the summer.

Figure 7. Taken from Remington (1996) Page 139 Table 7.3 License Water Withdrawals Upper Bulkley River to Morice River Confluence

Brockelhurst (1998) also reviewed water allocation licenses within the Upper Bulkley and recorded 125 licenses issued within the Upper Bulkley. Brockelhurst recognizes in her report that some of the licenses for ponds and conservation (stored water) may not have been active.

Type of License	No. of Licenses Issued	Amount Allocated		Comments
		AF	GD	
Conservation-Construction	2		0.00	1AN
Conservation-Stored Water	14	4,633.00		considered non-consumptive
Domestic	68		52,400.00	
Irrigation	13	1,099.00		
Land Improvement	6	0.50	100,500.00	3@0TF
Ponds	4			all @ 0TF
Stockwatering	7		4,100.00	
Storage	9	10,753.63		
Water Delivery	1		20,000.00	
Waterworks (Dist. of Houston) (this license comes out of Matthew Lake)	1		30,758.43	109,500,000 GY
Total	**125**	**16,486.13**	**207,758.43**	

Figure 8. Summary of Water Licenses on the Upper Bulkley. Taken from Brockelhurst (1998) Table 5

Table 5. Total Annual Water Allocation within the Upper Bulkley Watershed from 1986 to 2016

Reporting Year	Total Annual Water Allocation (m^3/year)
1986	19,084
1996	791,388
1998	287,054
2016	824,000

The difference in total annual water allocation reported between 1986 and 2016 is quite significant and warrants a further examination of the data to determine a reason for the large increase in water allocations over the past 30 years, in particular from 1986 to 1996 (Table 5).

Improvements in licensing regulation and registration processes between 1986 to 2017 appear to have led to a significant improvement in the management of existing licenses. Current spatial data indicates licensing information with registration dates but also with priority dates - the date the water license use was initiated. This 'priority date' within the current data can provide more insight into how water license allocation has changed over time.

According to the priority date within the water licensing data, an additional 66 water licenses were active between the years 1969 to 1986 in addition to the three licenses identified by Nijman (1986). This would result in a total of 69 surface water licenses in 1986. The GIS data shows that there was not a large increase in surface water licenses between 1986 and 1996 as suggested by Nijman's and Remington's reports, but that the license registration documentation was most likely incomplete in 1986.

The majority of the increase in water licenses occurred between 1970 to 1989 (Table 6). During the period from 1970 – 1979 thirty new licenses were issued, and another 34 licenses issued from 1980 – 1989. This increase in water license use could be reflective of a population increase in in the area led by the construction of the Northwood Pulp and Timber mill constructed in 1970 (Remington, 1996).

Table 6. Number of Water Licenses Issued by Priority Date

Priority Year	**No. of Licenses**
1966 - 1969	13
1970 - 1979	30
1980 - 1989	34
1990 - 1999	9
2000 - present	7
Total	**93**

5.1.4. Short Term Approvals

Short Term Approvals are legislated by Section 10 of the Water Sustainability Act. They are not considered water licenses but do provide short term water allocations for a 12 month or 24 month term, mostly to seasonal use activities such as road maintenance (Frontcounter BC, 2017). These approvals are not renewable and new applications are processed by the regional office of the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRO) each spring. Although this process results in a new set of short term approvals every year, typically the approvals are requested by the same applicants on an annual basis. For example, in the Upper Bulkley the majority of the short term approvals are assigned to the Lakes District Maintenance for road maintenance. Canfor also applies for Short Term Approvals on an annual basis. In April 2017 Canfor was assigned one short term approval with six points of diversion situated on McQuarry Creek, Byman Creek, Peacock Creek, two on Buck Creek and two PODs on two additional unnamed streams.

The total annual volume as of April 2017 for 24 short-term approvals as per the NWWT is 176,473 m^3/year. This value changes annually, particularly in the spring when the annual short term approvals are processed by FLNRO staff.

5.1.5. Groundwater Well Summary

The 2016 Water Sustainability Act requires registration for groundwater wells with a non-domestic purpose. The new act also encourages voluntary domestic groundwater well registration. According to the groundwater WELLS database, 217 ground water wells exist within the Upper Bulkley (Table 7; GeoBC 2017). Of the 217 groundwater wells, 102 of the wells registered do not have a clear well use or well use is unknown. A recommendation of this report is to carry out a further investigation of the groundwater wells classified as other or unknown within the Upper Bulkley to determine if these wells are still active.

Table 7. Summary of Ground Water Well use within the Upper Bulkley Watershed

Groundwater Well Use	No. of Wells
Commercial and Industrial	11
Private Domestic	97
Water Supply System	6
Observation Well Count	1
Other	3
Unknown Well Use	99
Total	**217**

5.1.6. Average Runoff Volumes by Sub-watershed

Table 8 provides a breakdown of average runoff volumes and allocations within the Upper Bulkley by sub-watershed. Refer to Figure 2 and Section 3 for sub-watershed boundary definitions. The following sections further discuss water allocations and flows for each sub-watershed.

Table 8. Sub-basin characterization and water allocation

Sub-watershed	Area (km^2)	Sub-Watershed Annual Runoff Volume (10^3 m^3)	Proportion of Average Runoff Volume (%)	Existing Allocation (10^3 m^3/year)	Proportion of Water License Allocation (%)	No. of Surface Water Licenses	No. of Groundwater wells	Comments
Ailport Creek	97.13	26,241.00	5.19%	29.0	3.52%	6	2	Moderate irrigation
Aitken Creek	148.66	33,020.00	6.53%	250.00	30.34%	4	1	Heavy Irrigation
Barren Creek	25.81	4,739.00	0.94%	2.00	0.24%	2	0	light domestic
Buck Creek	566.77	139,095.00	27.51%	31.00	3.76%	31	13	Heavy domestic
Byman Creek	94.04	23,107.00	4.57%	57.00	6.92%	1	4	Short-term approvals
Cesford Creek	36.7	9,351.00	1.85%	0.00	0.00%	0	0	No water licenses or wells
Crow Creek	73.96	15,425.00	3.05%	1.00	0.12%	2	1	Light Domestic
Johnny David Creek	43.73	9,812.00	1.94%	0.00	0.00%	0	0	No water licenses or wells
Maxan Creek	370.73	82,896.00	16.40%	166.00	20.15%	5	0	Conservation/storage/land improvement (GoldCorp/Equity Silver)
McKilligan Creek	38.2	7,342.00	1.45%	1.00	0.12%	1	1	Light Domestic
McQuarrie Creek	114.62	26,090.00	5.16%	57.00	6.92%	0	0	No water licenses or wells
Perow Creek	20.63	4,101.00	0.81%	4.00	0.49%	3	4	Light Domestic
Richfield Creek	161.81	41,729.50	8.25%	125.70	15.25%	3	3	Heavy Irrigation
BR1	78.47	7,299.00	1.44%	25.80	3.13%	23	96	Heavy Domestic and Irrigation
BR2	51.21	5,451.00	1.08%	2.40	0.29%	3	4	Domestic and Irrigation
BR3	75.84	3,009.40	0.60%	2.40	0.29%	2	2	Light Domestic
BR4	30.07	3,498.00	0.69%	0.30	0.04%	0	1	Light Industrial
BR5	36.87	2,720.00	0.54%	0.40	0.05%	2	55	Heavy Private Domestic/Unknown Groundwater Wells
BR6	59.21	5,218.00	1.03%	0.00	0.00%	0	1	Light domestic
BR7	64.63	3,813.00	0.75%	2.40	0.29%	2	5	Light domestic
BR8	32.23	5,025.20	0.99%	0.00	0.00%	0	2	Light domestic
BR9	93.77	21,627.20	4.28%	2.40	0.29%	2	7	Light domestic
Main Stem Bulkley River		24,952.70	4.94%	64.20	7.79%			

5.2. Ailport Creek

Ailport Creek comprises 5.2% of the average annual runoff volume of the Upper Bulkley and 3.5 % of the total existing surface water allocation (Table 8). Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Ailport Creek are presented in Table 9 and Figure 9. The existing annual surface water allocation (29,000 m^3) within the sub-watershed consists of two domestic, two irrigation, and two livestock licenses (Figure 10, Tables 9 and 10). Of the allocation within the Ailport sub-watershed, 85.7% is directed towards irrigation purposes. Two domestic ground water wells are registered within this sub-watershed.

Table 9. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Ailport Creek Sub-watershed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	7.20	5.50	6.60	17.10	71.30	65.10	30.50	12.80	13.00	16.90	14.60	10.00	271
AVG Discharge (m^3/s)	0.30	0.40	0.20	0.60	2.60	2.40	1.10	0.50	0.50	0.60	0.50	0.40	10
AVG Runoff Volume (10^3m^3)	697.90	533.30	642.50	1,656.50	6,910.90	6,315.90	2,959.00	1,238.50	1,258.20	1,643.20	1,411.60	973.70	26,241
Environmental Needs (10^3m^3)	593.22	453.31	546.13	1,408.03	5,874.27	5,368.52	2,515.15	1,052.73	1,069.47	1,396.72	1,199.86	827.65	22,305
Potential Allocation (10^3m^3)	104.69	80.00	96.38	248.48	1,036.64	947.39	443.85	185.78	188.73	246.48	211.74	146.06	3,936
Existing Allocation (10^3m^3)	2.40	2.20	2.40	2.60	2.40	2.30	2.40	2.40	2.30	2.40	2.30	2.40	29
Remaining Allocation (10^3m^3)	102.29	77.80	93.98	245.88	1,034.24	945.09	441.45	183.38	186.43	244.08	209.44	143.66	3,908

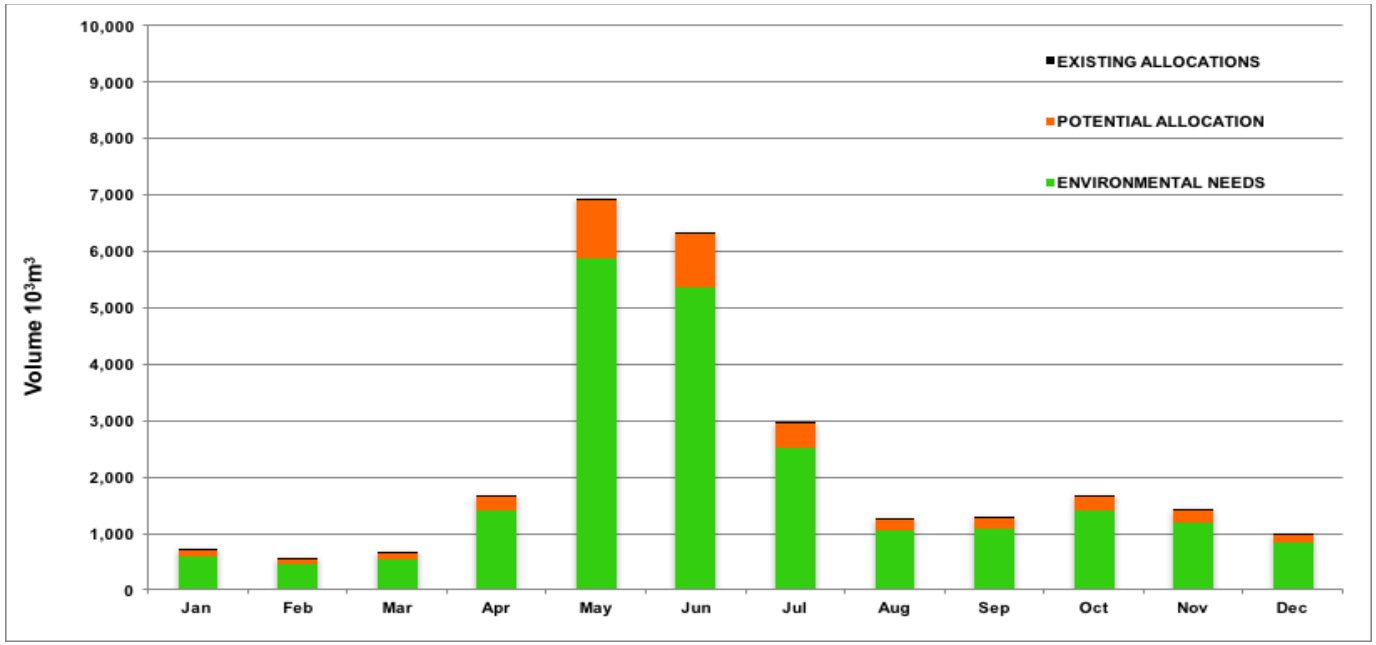

Figure 9. Environmental Needs, Potential and Existing Surface Water Allocations for the Ailport Creek Sub-watershed

Table 10. Surface Water Allocations within Ailport Sub-watershed

Purpose	Number of Licenses	Total Quantity (m^3/year)	Proportion of Allocation (%)
Conservation/ Storage	0	0.00	0.00%
Domestic	2	3,318.58	11.65%
Irrigation	2	24,408.61	85.67%
Land Improve	0	0.00	0.00%
Livestock	2	764.25	2.68%
Pond & Aquaculture	0	0.00	0.00%
Totals	**6**	**28,491.44**	**100.00%**

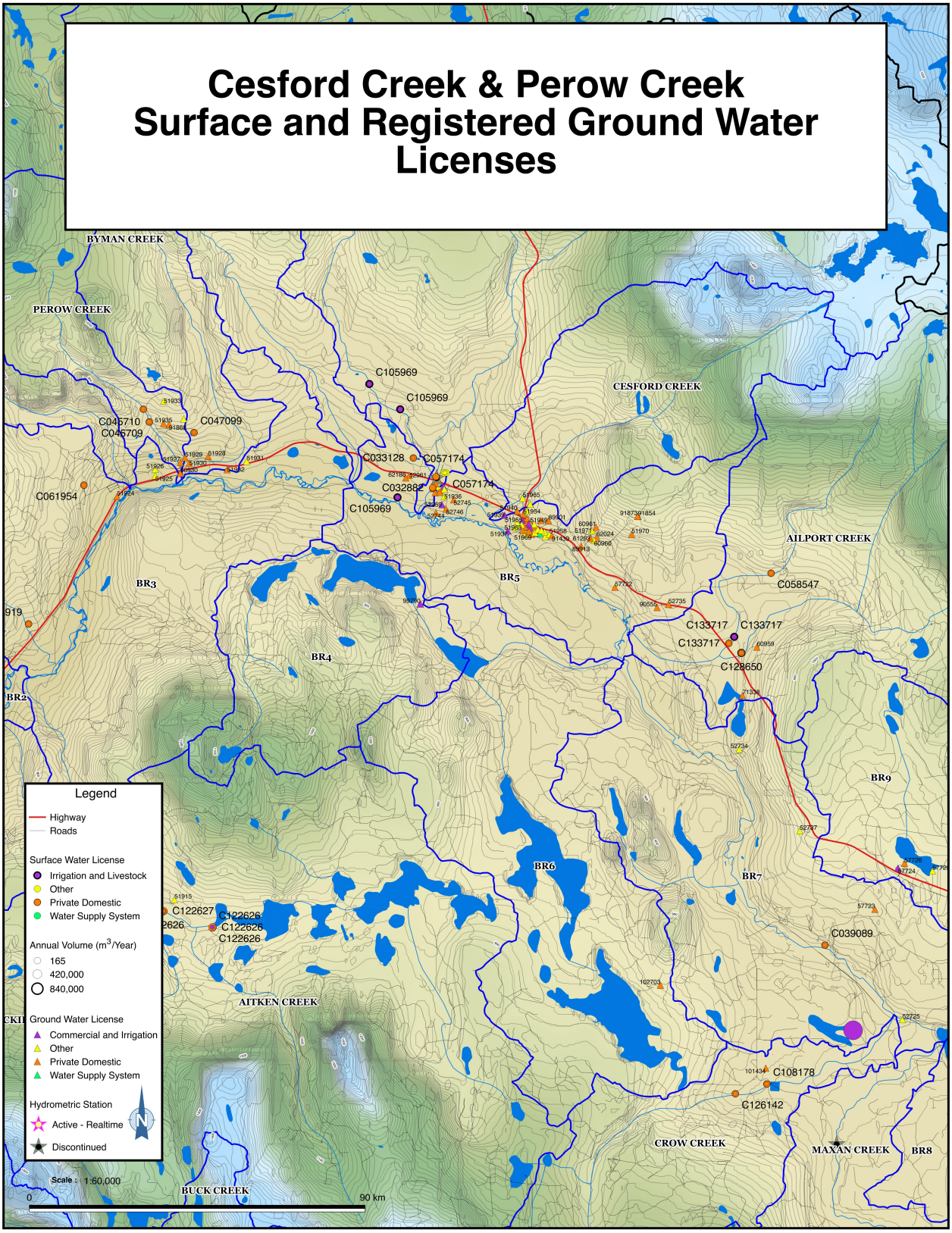

Figure 10. Surface Water Licenses and Groundwater Wells near Cesford and Perow Creek Watersheds

5.3. Aitken Creek

Aitken Creek comprises 6.5% of the average annual runoff volume of the Upper Bulkley and 30.3 % of the total existing surface water allocation (Table 8). Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Aitken Creek are presented in Table 11 and Figure 11. The water licenses within the sub-watershed consist of one domestic, two irrigation, and one livestock water license (Table 12, Figure 10). Approximately 99% of the surface water allocation within Aitken sub-watershed is directed towards irrigation purposes. One ground water well with an unknown use is registered within Aitken Creek.

Table 11. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Aitken Creek Sub-watershed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	4.8	5.1	6.1	15.7	59.3	51.1	22.5	9.6	10.3	16.4	12.4	8.7	222
AVG Discharge ($m^{3/s}$)	0.3	0.3	0.3	0.9	3.3	2.9	1.2	0.5	0.6	0.9	0.7	0.5	12
AVG Runoff Volume (10^3m^3)	716.0	762.3	910.4	2,334.8	8,821.8	7,589.5	3,339.3	1,431.4	1,531.0	2,439.1	1,847.4	1,296.9	33,020
Environmental Needs (10^3m^3)	608.6	648.0	773.8	1,984.6	7,498.5	6,451.1	2,838.4	1,216.7	1,301.4	2,073.3	1,570.3	1,102.4	28,067
Potential Allocation (10^3m^3)	107.4	114.3	136.6	350.2	1,323.3	1,138.4	500.9	214.7	229.7	365.9	277.1	194.5	4,953
Existing Allocation (10^3m^3)	21.2	19.3	21.2	20.5	21.2	20.5	21.2	21.2	20.5	21.2	20.5	21.2	250
Remaining Allocation (10^3m^3)	86.2	95.1	115.4	329.7	1,302.1	1,117.9	479.7	193.5	209.2	344.7	256.6	173.4	4,704

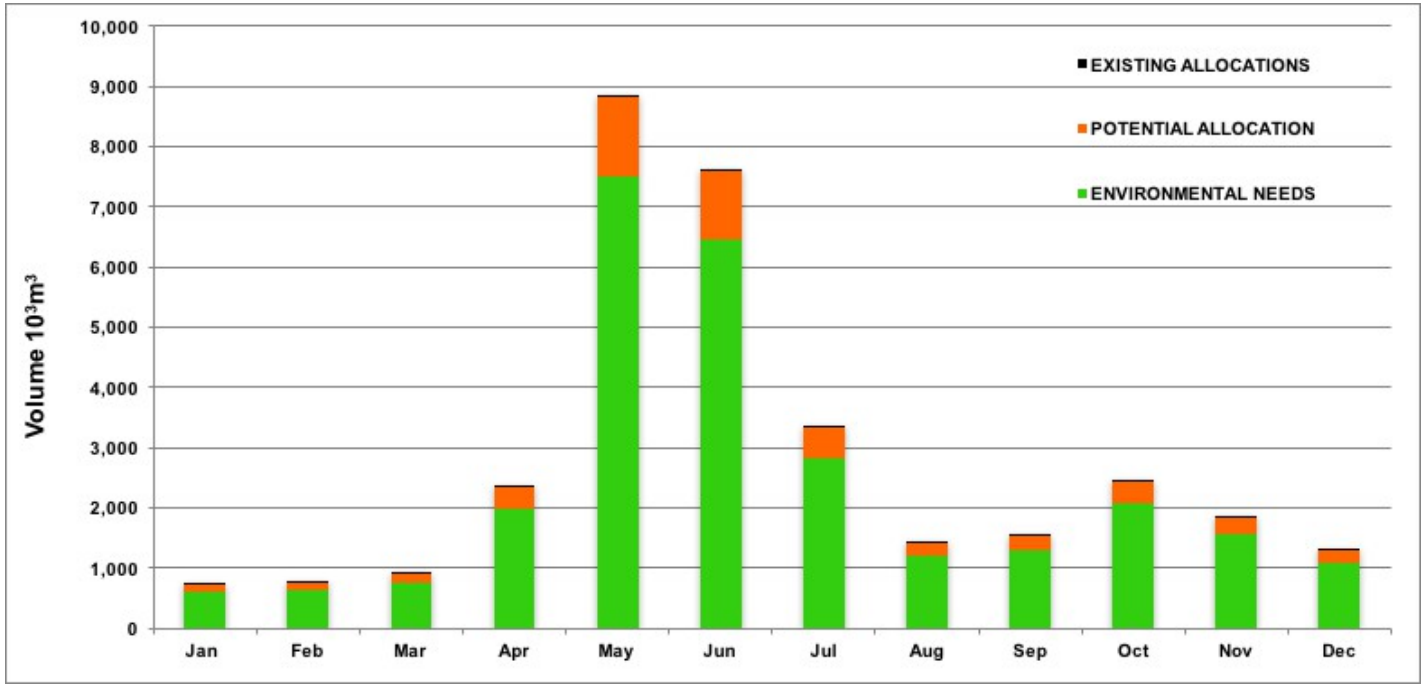

Figure 11. Environmental Needs, Potential and Existing Surface Water Allocations for the Aitken Creek Sub-watershed

Table 12. Surface Water Allocations in Aitken Sub-watershed

Purpose	Number of Licenses	Total Quantity (m^3/year)	Proportion of Allocation (%)
Conservation/ Storage	0	0.00	0.00%
Domestic	1	829.65	0.33%
Irrigation	2	246,696.00	99.00%
Land Improve	0	0.00	0.00%
Livestock	1	1,659.29	0.67%
Pond & Aquaculture	0	0.00	0.00%
Totals	**4**	**249,184.94**	**100.00%**

.

5.4. Barren Creek

Barren Creek comprises 0.9 % of the average annual runoff volume of the Upper Bulkley and 0.2 % of the total existing surface water allocation (Table 8). Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Barren Creek are presented in Table 13 and Figure 12. The one domestic water license and one land improvement license within the sub-watershed have a minimal impact on the overall water allocations for the Bulkley River (Table 14). Approximately 66.7 % of the allocation within Barren Creek is directed towards domestic use and 33.3 % towards land improvement. No ground water wells are recorded within Barren Creek.

Table 13. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Barren Creek Sub-watershed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	3.50	4.40	5.20	13.00	48.80	42.40	18.30	8.30	7.70	14.10	10.90	7.00	184
AVG Discharge ($m^{3/s}$)	-	-	0.10	0.10	0.50	0.40	0.20	0.10	0.10	0.10	0.10	0.10	2
AVG Runoff Volume (10^3m^3)	89.90	114.20	134.00	335.20	1,259.00	1,095.10	472.20	214.70	199.80	364.40	280.30	180.40	4,739
Environmental Needs (10^3m^3)	76.42	97.07	113.90	284.92	1,070.15	930.84	401.37	182.50	169.83	309.74	238.26	153.34	4,028
Potential Allocation (10^3m^3)	13.49	17.13	20.10	50.28	188.85	164.27	70.83	32.21	29.97	54.66	42.05	27.06	711
Existing Allocation (10^3m^3)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	2
Remaining Allocation (10^3m^3)	13.29	16.93	19.90	50.08	188.65	164.07	70.63	32.01	29.77	54.46	41.85	26.86	708

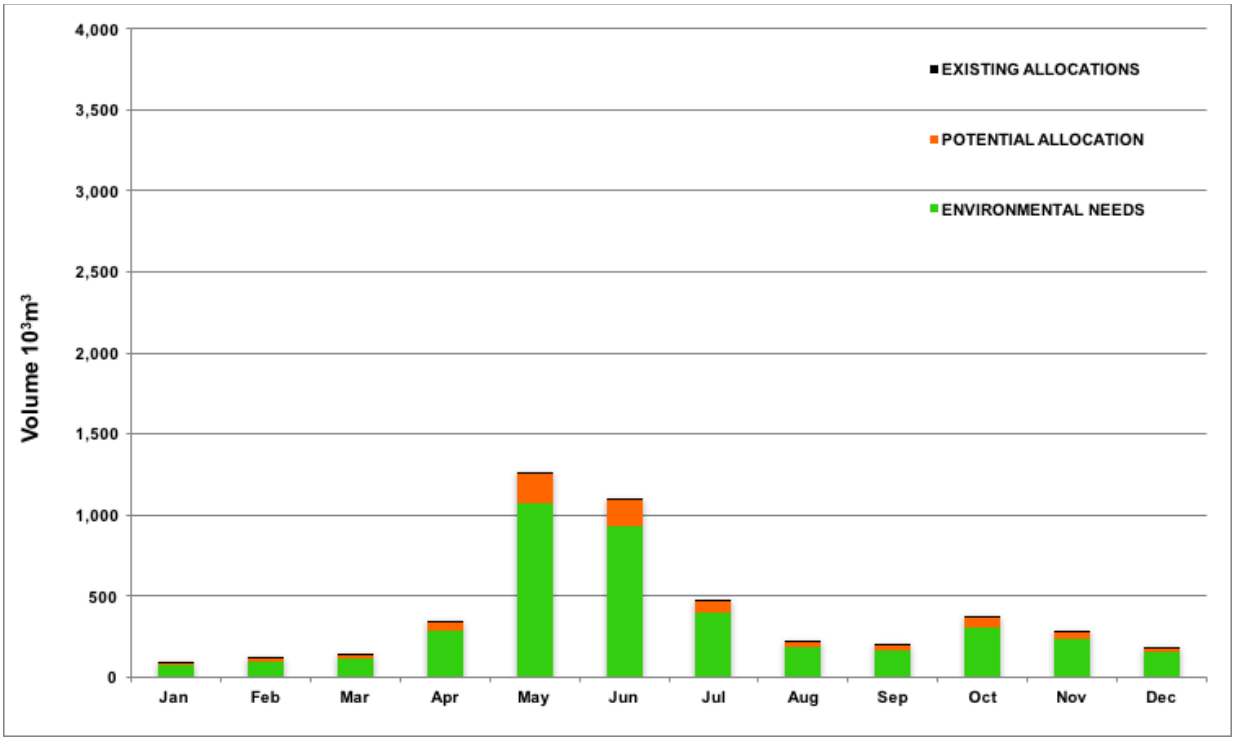

Figure 12. Environmental Needs, Potential and Existing Surface Water Allocations for the Barren Creek Sub-watershed

Table 14. Surface Water Allocations in Barren Creek Sub-watershed

Purpose	Number of Licenses	Total Quantity (m^3/year)	Proportion of Allocation (%)
Conservation/ Storage	0	0.00	0.00%
Domestic	1	1,659.29	66.67%
Irrigation	0	0.00	0.00%
Land Improvement	1	829.65	33.33%
Livestock	0	0.00	0.00%
Pond & Aquaculture	0	0.00	0.00%
Totals	**2**	**2,488.94**	**100.00%**

5.5. Buck Creek

Buck Creek comprises 27.5 % of the average annual runoff volume and 3.8 % of the total existing surface water allocations within the Upper Bulkley (Table 8). Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Buck Creek are presented in Table 15 and Figure 13. Within Buck Creek are 31 surface water licenses and thirteen registered ground wells (Figure 14, Table 15).

Within Buck Creek watershed one conservation/storage license (considered non-consumptive) accounts for 84.37% of the allocation (Table 16). This license is issued to Ministry of Environment and is located on Sam Creek. The 24 domestic licenses account for 13.51% of the total allocation in Buck Creek and 86.4% of the total consumptive allocation in Buck Creek.

The thirteen ground water wells registered within Buck Creek sub-watershed including six domestic wells, one water supply system, and six wells with an unknown purpose (Table 17).

Table 15. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Buck Creek Sub-watershed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	4.40	4.20	5.30	15.70	65.70	58.30	29.00	14.70	13.00	16.60	10.80	7.70	245
AVG Discharge ($m^{3/s}$)	0.90	1.00	1.10	3.40	13.90	12.80	6.10	3.10	2.80	3.50	2.40	1.60	53
AVG Runoff Volume (10^3m^3)	2,472.20	2,371.00	3,020.40	8,877.60	37,219.70	33,054.80	16,459.10	8,305.40	7,366.80	9,428.50	6,129.20	4,390.50	139,095
Environmental Needs (10^3m^3)	2,101.37	2,015.35	2,567.34	7,545.96	31,636.75	28,096.58	13,990.24	7,059.59	6,261.78	8,014.23	5,209.82	3,731.93	118,231
Potential Allocation (10^3m^3)	370.83	355.65	453.06	1,331.64	5,582.96	4,958.22	2,468.87	1,245.81	1,105.02	1,414.28	919.38	658.58	20,864
Existing Allocation (10^3m^3)	2.50	2.30	2.60	3.50	2.50	2.40	2.50	2.50	2.40	2.50	2.40	2.50	31
Remaining Allocation (10^3m^3)	368.33	353.35	450.46	1,328.14	5,580.46	4,955.82	2,466.37	1,243.31	1,102.62	1,411.78	916.98	656.08	20,834

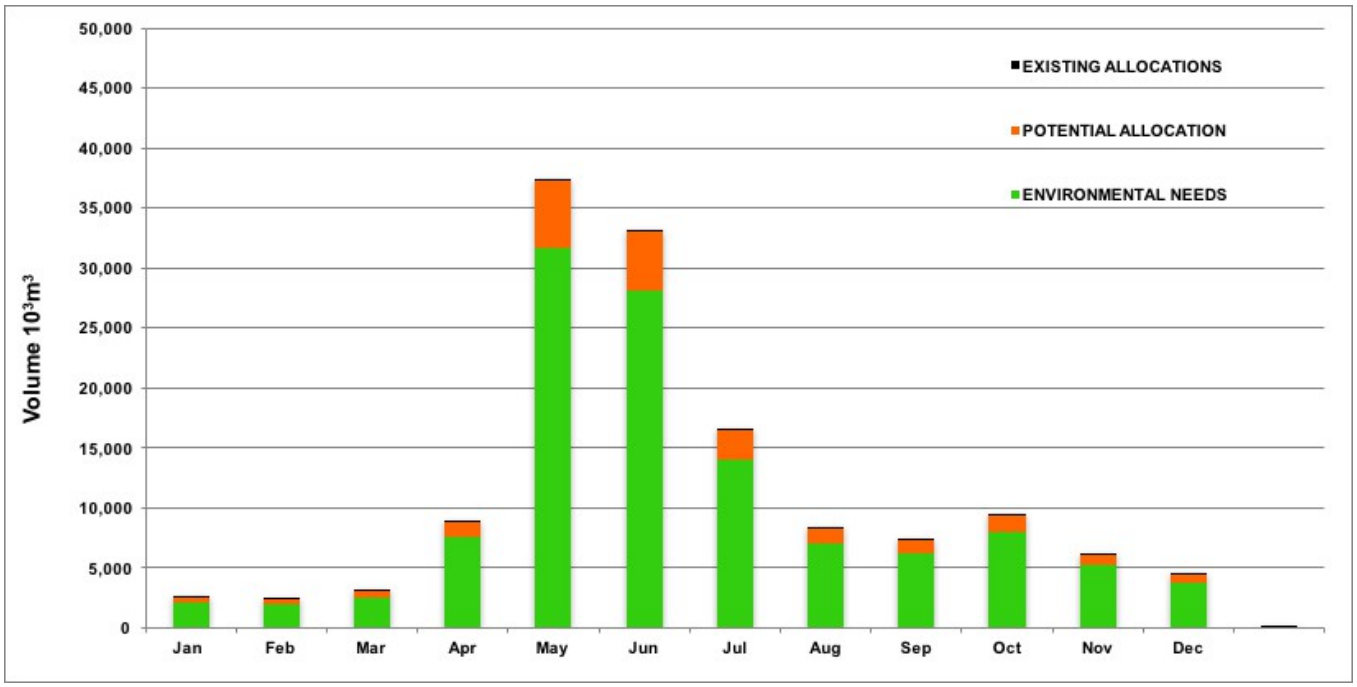

Figure 13. Environmental Needs, Potential and Existing Surface Water Allocations by month for the Buck Creek Sub-watershed

Table 16. Surface Water Allocations in Buck Creek

Purpose	Number of Licenses	Total Quantity (m^3/year)	Proportion of Allocation (%)
Conservation/ Storage	1	155,418.48	84.37%
Domestic	24	24,881.04	13.51%
Irrigation	2	2,466.96	1.34%
Land Improve	3	616.74	0.33%
Livestock	1	829.65	0.45%
Pond & Aquaculture	0	0.00	0.00%
Totals	**31**	**184,212.87**	**100.00%**

Table 17. Groundwater Wells in Buck Creek

Groundwater Wells within Buck Creek	
Commercial and Industrial	0
Private Domestic	6
Water Supply System	1
Observation Well Count	0
Other	3
Unknown Well Use	3
Total	**13**

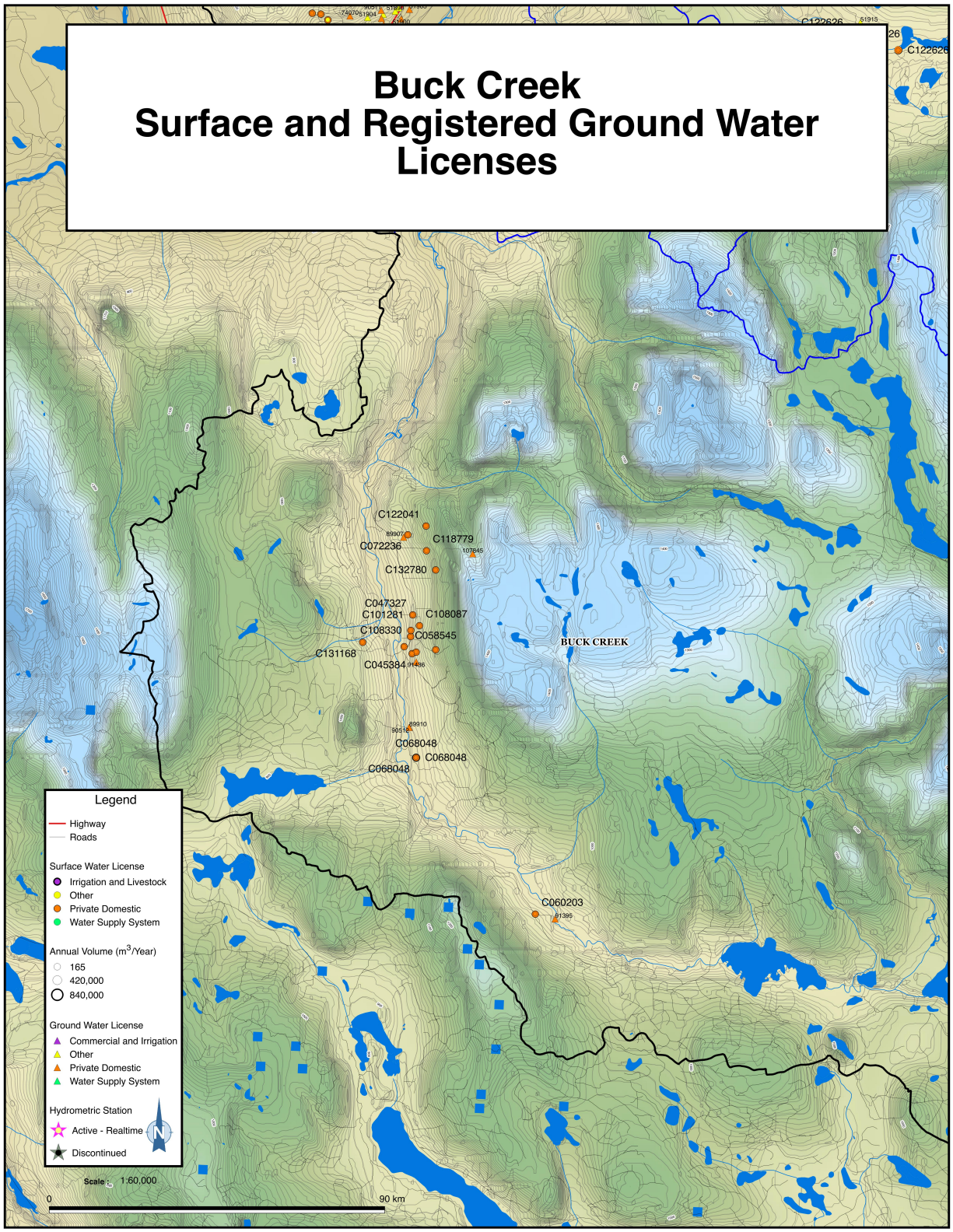

Figure 14. Surface Water Licenses and Groundwater Wells within Buck Creek Sub-watershed

4.6 Byman Creek

Byman Creek comprises 4.6 % of the average annual runoff volume and 7.0 % of the total existing surface water allocations within the Upper Bulkley (Table 8). Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Byman Creek are presented in Table 18 and Figure 15. The majority of the surface water allocations are short term approvals as only one domestic surface water license is registered in the sub-watershed situated on Hitchcock Spring with an annual allocation of 1,659.29 m^3/year (Table 19). Byman Creek has two short term approvals: the first approval of 300 m^3 from an unnamed stream to Lakes District Maintenance for road maintenance and dust; and a second approval of 56,825 m^3/year to Canfor for industrial uses. Four domestic use ground wells are registered in Byman Creek (Figure 10).

Table 18. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Byman Creek Sub-watershed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	5.10	5.00	6.00	15.60	65.40	59.90	27.70	13.40	12.30	18.00	12.30	8.30	249
AVG Discharge ($m^{3/s}$)	0.20	0.20	0.20	0.60	2.30	2.10	1.00	0.50	0.40	0.60	0.40	0.30	9
AVG Runoff Volume (10^3m^3)	476.70	461.00	557.40	1,450.10	6,067.60	5,556.30	2,567.10	1,244.10	1,144.10	1,669.70	1,141.90	771.30	23,107
Environmental Needs (10^3m^3)	405.20	391.85	473.79	1,232.59	5,157.46	4,722.86	2,182.04	1,057.49	972.49	1,419.25	970.62	655.61	19,641
Potential Allocation (10^3m^3)	71.51	69.15	83.61	217.52	910.14	833.45	385.07	186.62	171.62	250.46	171.29	115.70	3,466
Existing Allocation (10^3m^3)	4.80	4.40	4.90	4.90	4.80	4.70	4.80	4.80	4.70	4.80	4.70	4.80	57
Remaining Allocation (10^3m^3)	66.71	64.75	78.71	212.62	905.34	828.75	380.27	181.82	166.92	245.66	166.59	110.90	3,409

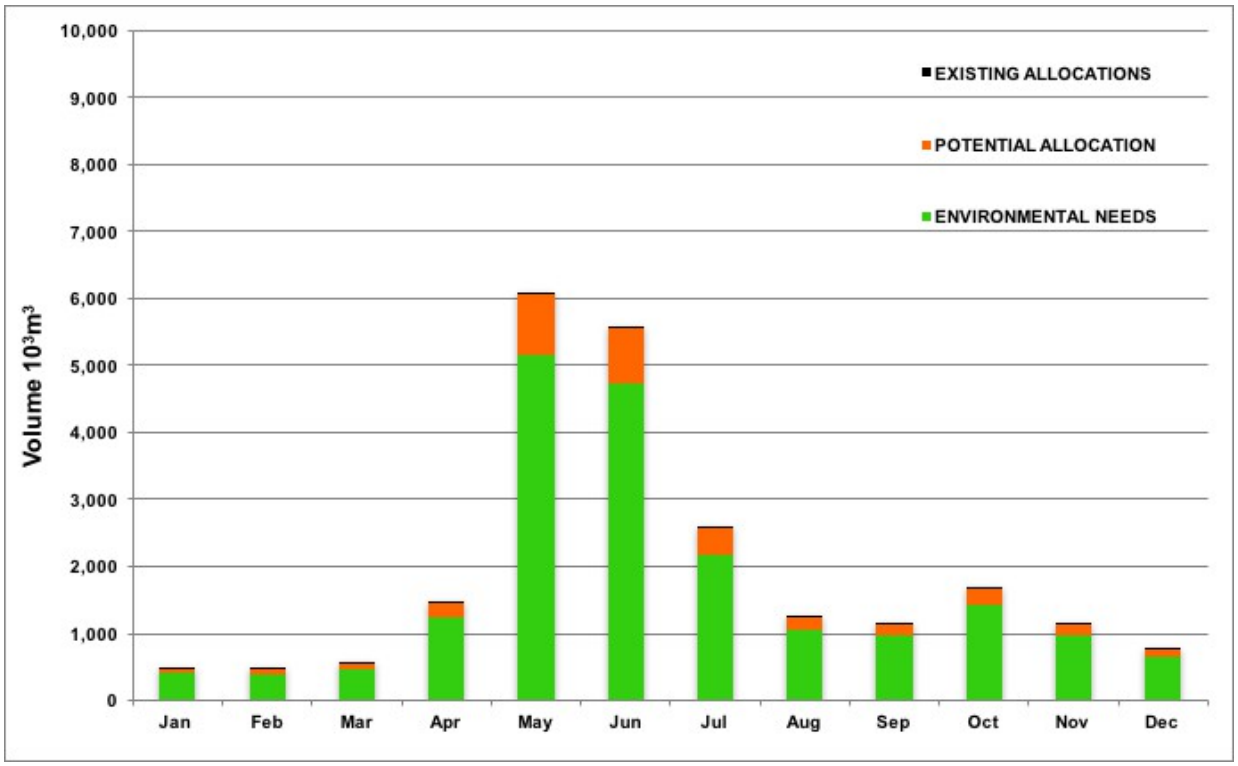

Figure 15. Environmental Needs, Potential and Existing Surface Water Allocations by month for Byman Creek

Table 19. Surface Water Allocations in Byman Creek

Purpose	Number of Licenses	Total Quantity (m^3/year)	Proportion of Allocation (%)
Conservation/ Storage	0	0.00	0.00%
Domestic	1	1,659.29	100.00%
Irrigation	0	0.00	0.00%
Land Improve	0	0.00	0.00%
Livestock	0	0.00	0.00%
Pond & Aquaculture	0	0.00	0.00%
Totals	**1**	**1,659.29**	**100.00%**

5.6. Cesford Creek

Cesford Creek comprises 1.9 % of the average annual runoff volume within the Upper Bulkley. There are no water licences issued or groundwater wells registered in the Cesford Creek sub-basin (Figure 10). Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Cesford Creek are presented in Table 20 and Figure 16.

Table 20. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Cesford Creek Sub-watershed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	7.60	5.80	6.80	16.40	66.20	60.20	27.80	11.30	11.90	16.10	14.70	10.10	255
AVG Discharge ($m^{3/s}$)	0.10	0.10	0.10	0.20	0.90	0.90	0.40	0.20	0.20	0.20	0.20	0.10	4
AVG Runoff Volume (10^3m^3)	280.20	211.10	247.90	600.30	2431.50	2207.90	1020.10	415.40	437.00	589.60	538.30	372.10	9,351
Environmental Needs (10^3m^3)	238.17	179.44	210.72	510.26	2066.78	1876.72	867.09	353.09	371.45	501.16	457.56	316.29	7,949
Potential Allocation (10^3m^3)	42.03	31.67	37.19	90.05	364.73	331.19	153.02	62.31	65.55	88.44	80.75	55.82	1,403
Existing Allocation (10^3m^3)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Remaining Allocation (10^3m^3)	42.03	31.67	37.19	90.05	364.73	331.19	153.02	62.31	65.55	88.44	80.75	55.82	1,403

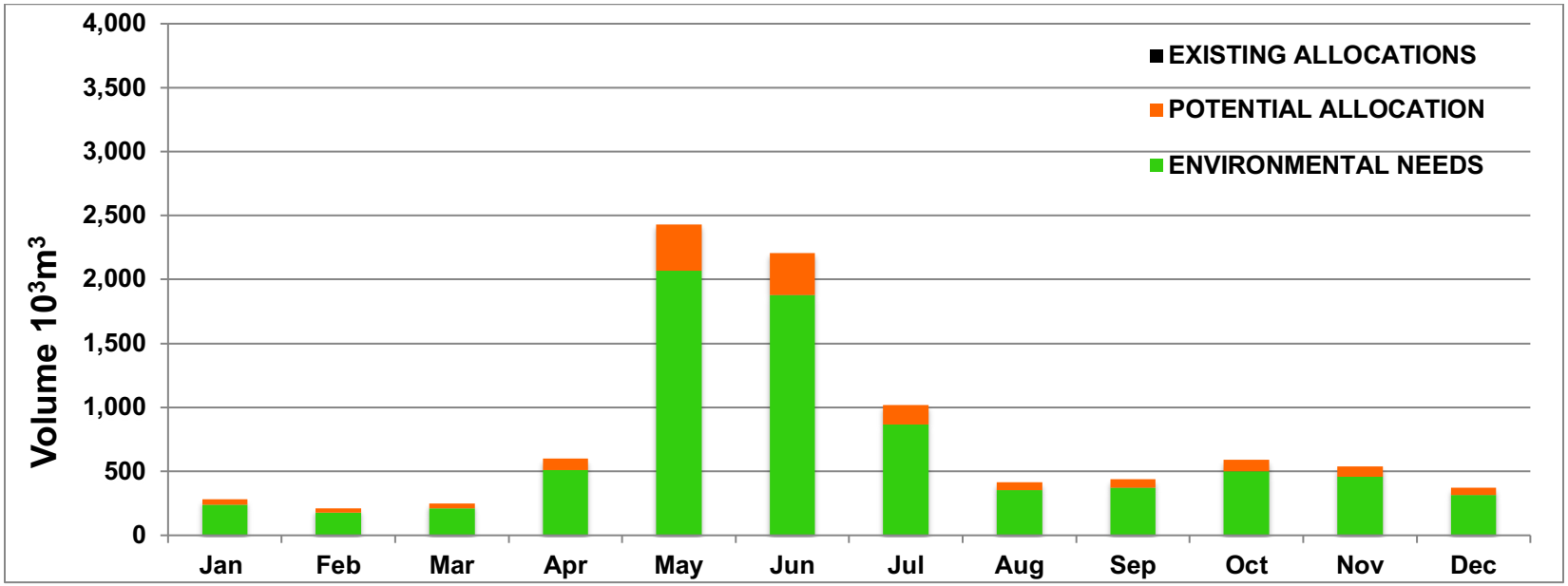

Figure 16. Environmental Needs, Potential and Existing Surface Water Allocations by month for Cesford Creek

5.7. Crow Creek

Crow Creek comprises 3.1 % of the average annual runoff volume and 0.1 % of the total existing surface water allocations within the Upper Bulkley. Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Crow Creek are presented in Table 21 and Figure 16. There are two domestic water licenses and one domestic ground water well registered within Crow Creek (Table 22, Figure 17).

Table 21. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Crow Creek Sub-watershed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	4.00	4.00	5.00	14.30	57.50	48.50	22.20	9.60	10.90	15.10	9.80	7.60	209
AVG Discharge ($m^{3/s}$)	0.10	0.10	0.10	0.40	1.60	1.40	0.60	0.30	0.30	0.40	0.30	0.20	6
AVG Runoff Volume (10^3m^3)	295.30	298.50	372.80	1,058.70	4,250.20	3,587.60	1,640.40	713.50	802.80	1,118.80	727.80	558.60	15,425
Environmental Needs (10^3m^3)	251.01	253.73	316.88	899.90	3,612.67	3,049.46	1,394.34	606.48	682.38	950.98	618.63	474.81	13,111
Potential Allocation (10^3m^3)	44.30	44.78	55.92	158.81	637.53	538.14	246.06	107.03	120.42	167.82	109.17	83.79	2,314
Existing Allocation (10^3m^3)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	1
Remaining Allocation (10^3m^3)	44.20	44.68	55.82	158.71	637.43	538.04	245.96	106.90	120.30	167.70	109.00	83.70	2,312

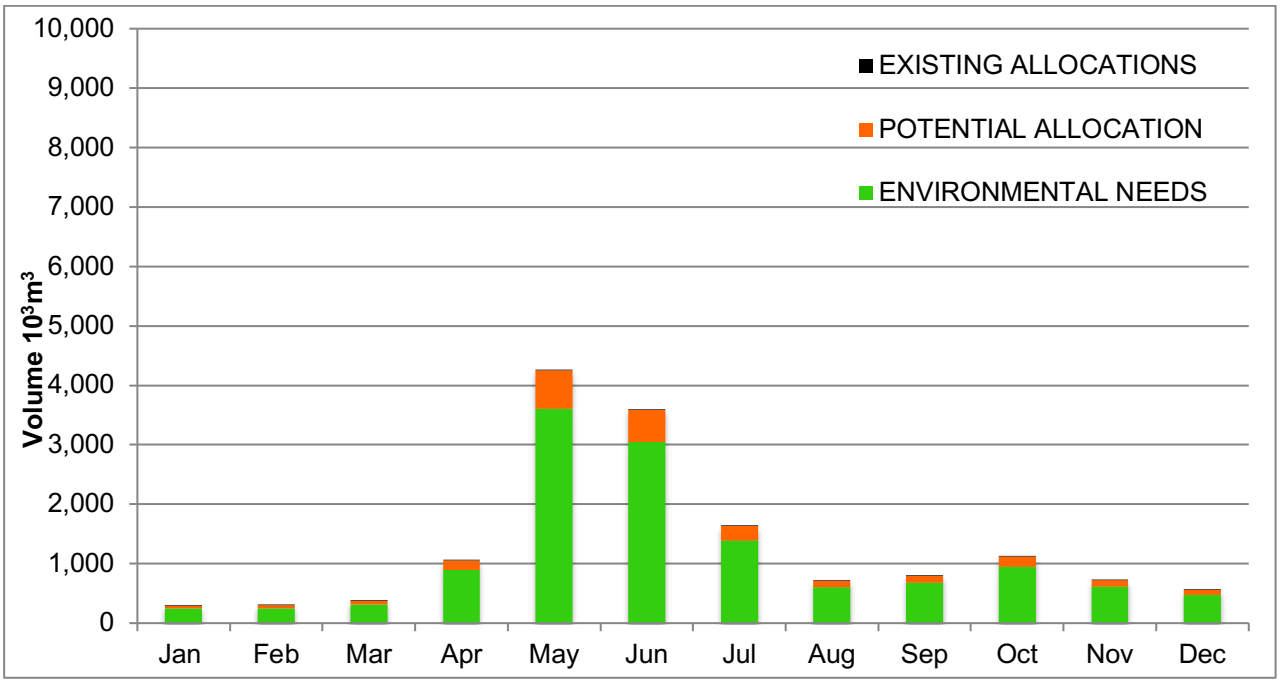

Figure 17. Environmental Needs, Potential and Existing Surface Water Allocations by month for Crow Creek

Table 22. Surface Water Allocations in Crow Creek

Purpose	Number of Licenses	Total Quantity (m^3/year)	Proportion of Allocation (%)
Conservation/ Storage	0	0.00	0.00%
Domestic	2	1,659.30	100.00%
Irrigation	0	0.00	0.00%
Land Improve	0	0.00	0.00%
Livestock	0	0.00	0.00%
Pond & Aquaculture	0	0.00	0.00%
Totals	**2**	**1,659.30**	**100.00%**

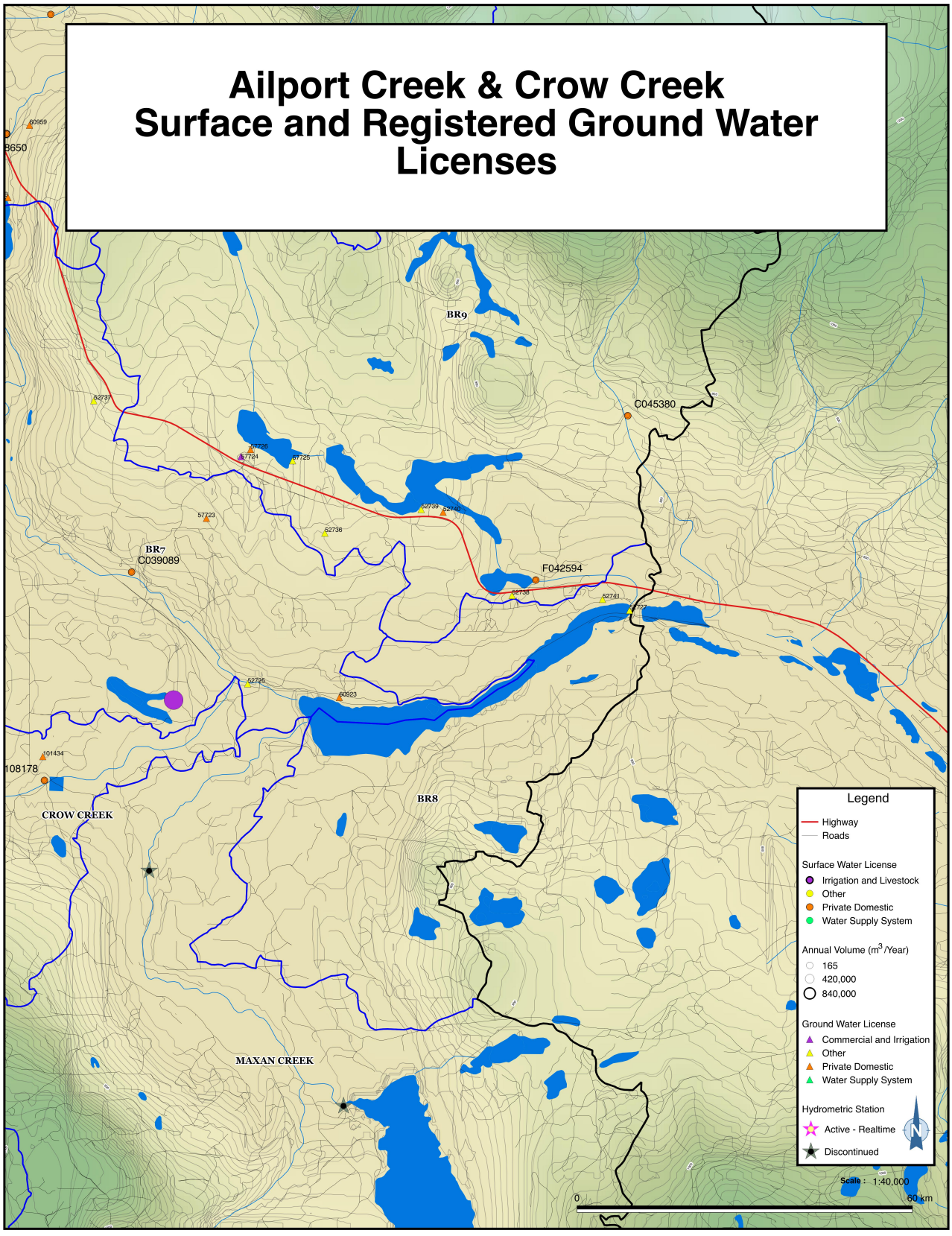

Figure 18. Surface Water Licenses and Groundwater Wells Near Crow Creek Sub-watershed

5.8. Johnny David Creek

Johnny David Creek comprises 1.9% of the average annual runoff volume within the Upper Bulkley (Table 8). No water licences were issued or groundwater wells present in this sub-basin (Figure 10). Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Johnny David Creek are presented in Table 23 and Figure 19.

Table 23. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Johnny David Creek Sub-watershed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	7.60	6.30	7.20	15.90	58.60	50.00	20.60	7.10	9.90	16.70	14.00	10.50	224
AVG Discharge ($m^{3/s}$)	0.10	0.10	0.10	0.30	1.00	0.80	0.30	0.10	0.20	0.30	0.20	0.20	4
AVG Runoff Volume (10^3m^3)	331.00	275.30	314.10	693.50	2,564.50	2,186.60	900.10	309.90	433.40	729.00	613.40	461.00	9,812
Environmental Needs (10^3m^3)	281.35	234.01	266.99	589.48	2,179.83	1,858.61	765.09	263.42	368.39	619.65	521.39	391.85	8,340
Potential Allocation (10^3m^3)	49.65	41.30	47.12	104.03	384.68	327.99	135.02	46.49	65.01	109.35	92.01	69.15	1,472
Existing Allocation (10^3m^3)	-	-	-	-	-	-	-	-	-	-	-	-	-
Remaining Allocation (10^3m^3)	49.65	41.30	47.12	104.03	384.68	327.99	135.02	46.49	65.01	109.35	92.01	69.15	1,472

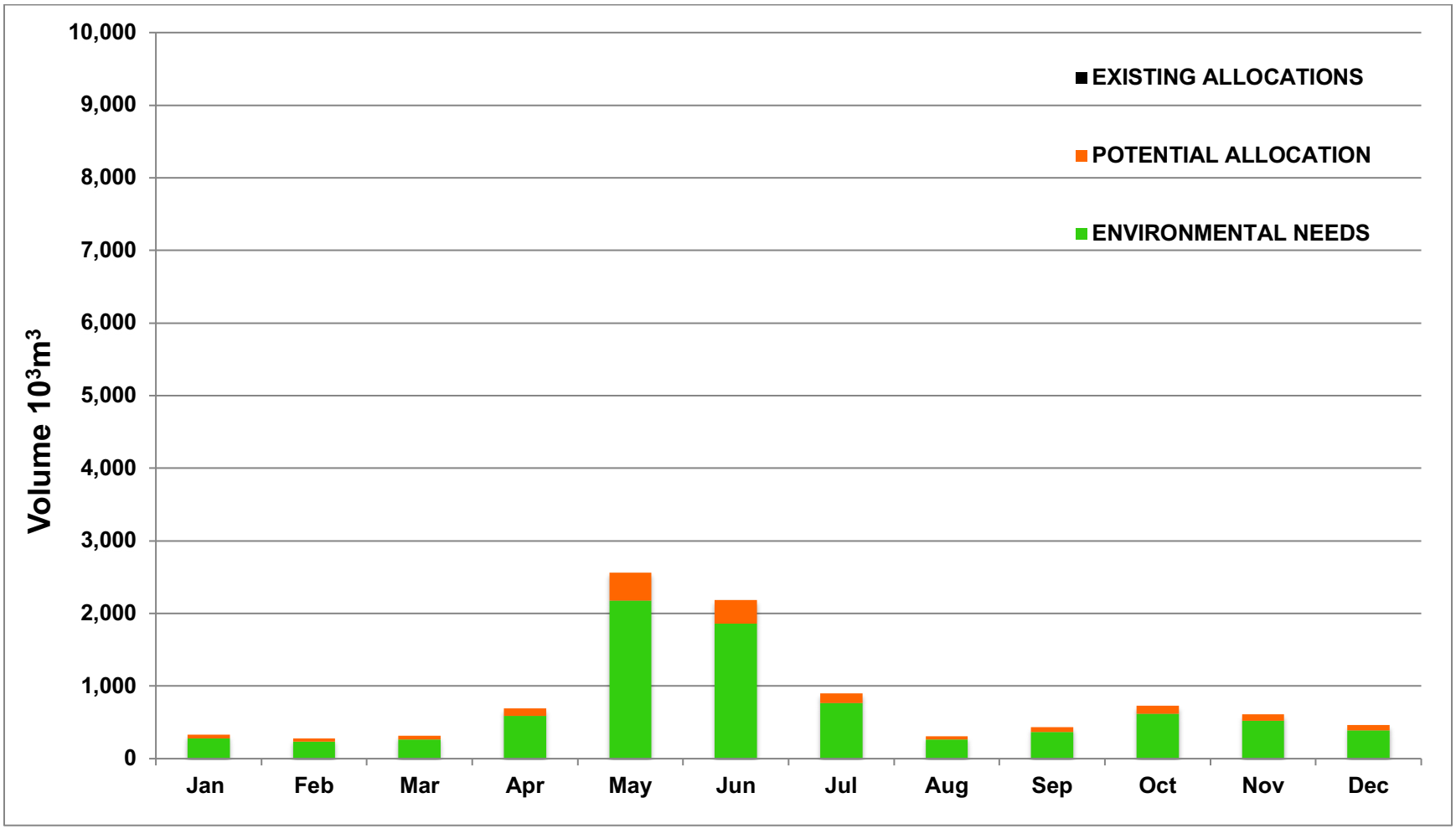

Figure 19. Environmental Needs, Potential and Existing Surface Water Allocations by month for Johnny David Creek

5.9. Maxan Creek

Maxan Creek comprises 16.4% of the average annual runoff volume and 20.1% of the total existing surface water allocations within the Upper Bulkley (Table 8). Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Maxan Creek are presented in Table 24 and Figure 20. The five water licenses in Maxan Creek are dedicated to conservation, storage, and land improvement (Figure 21, Table 25). There is also a short term approval of 300 m^3/year from Lou Lake to Lakes District Maintenance Inc.

Table 24. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Maxan Creek Sub-watershed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	5.00	4.40	5.50	15.30	62.10	51.80	23.00	9.60	11.50	15.70	11.30	8.40	224
AVG Discharge ($m^{3/s}$)	0.70	0.70	0.80	2.20	8.60	7.40	3.20	1.30	1.60	2.20	1.60	1.20	32
AVG Runoff Volume (10^3m^3)	1,870.50	1,638.40	2,036.10	5,668.00	23,027.60	19,206.30	8,526.20	3,541.80	4,272.20	5,808.60	4,172.70	3,127.90	82,896
Environmental Needs (10^3m^3)	1,589.93	1,392.64	1,730.69	4,817.80	19,573.46	16,325.36	7,247.27	3,010.53	3,631.37	4,937.31	3,546.80	2,658.72	70,462
Potential Allocation (10^3m^3)	280.58	245.76	305.42	850.20	3,454.14	2,880.95	1,278.93	531.27	640.83	871.29	625.91	469.19	12,434
Existing Allocation (10^3m^3)	14.10	12.80	14.10	13.90	14.10	13.60	14.10	14.10	13.60	14.10	13.60	14.10	166
Remaining Allocation (10^3m^3)	266.48	232.96	291.32	836.30	3,440.04	2,867.35	1,264.83	517.17	627.23	857.19	612.31	455.09	12,268

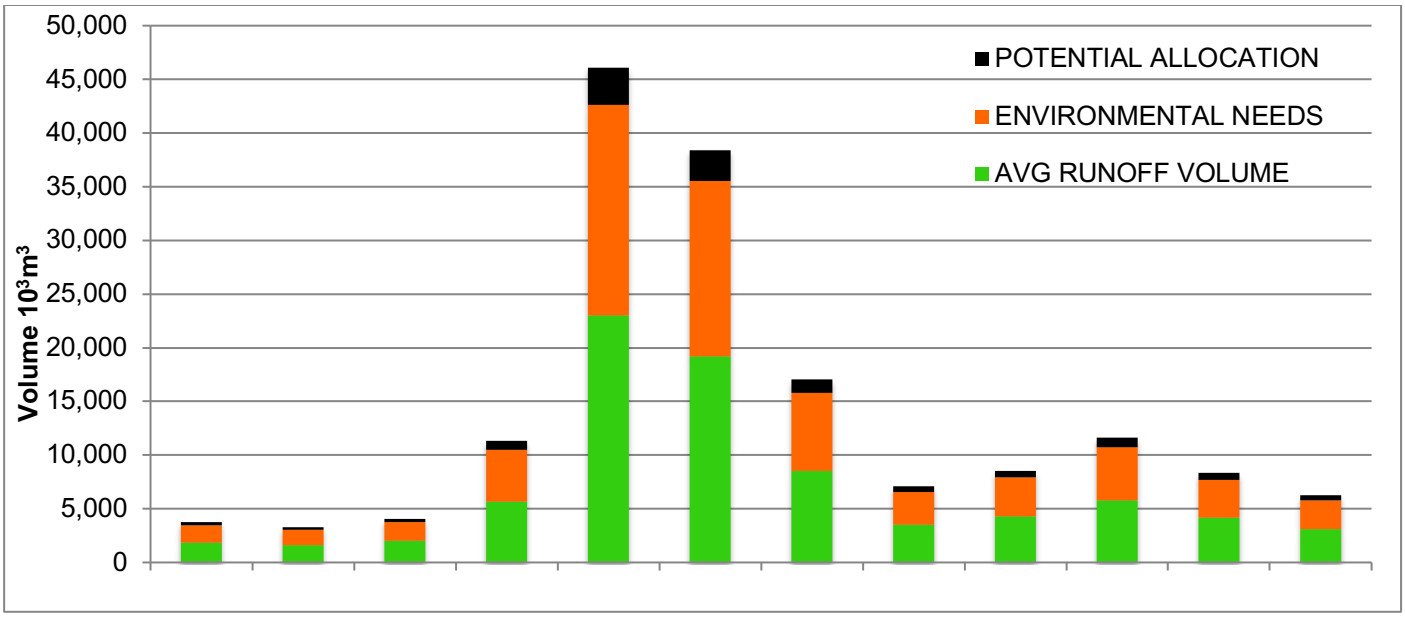

Figure 20. Environmental Needs, Potential and Existing Surface Water Allocations by month for Maxan Creek

BC Environment is the licensee for the two conservation licenses. GoldCorp Canada Ltd. Equity Division is the licensee for the two land improvement licenses at Lu Lake and Lu Cree, as well as the stream storage license at Lu Lake.

GoldCorp Canada Ltd. owned and operated the Equity Silver mine from 1990 – 1994. The main focus at Equity Silver is on treating acid rock drainage and managing the tailings dams to prevent any releases into the environment.

Table 25. Surface Water Allocations in Maxan Creek

Purpose	Number of Licenses	Total Quantity (m^3/year)	Proportion of Allocation (%)
Conservation/ Storage	3	1,409,867.64	89.47%
Domestic	0	0.00	0.00%
Irrigation	0	0.00	0.00%
Land Improve	2	165,932.29	10.53%
Livestock	0	0.00	0.00%
Pond & Aquaculture	0	0.00	0.00%
Totals	5	**1,575,799.93**	100.00%

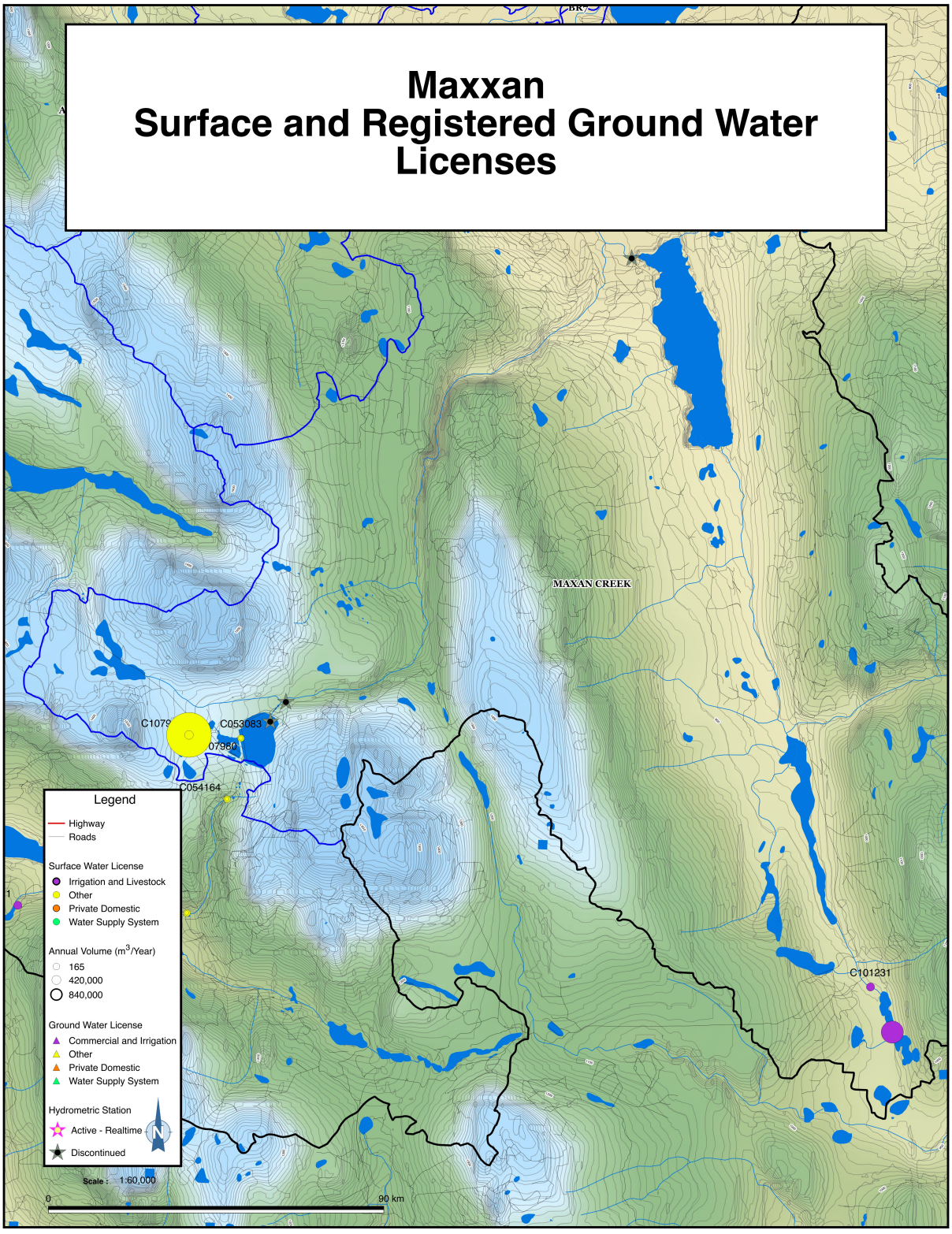

Figure 21. Surface Water Licenses and Groundwater Wells within Maxan Creek Headwaters

5.10. McKilligan Creek

McKilligan Creek comprises 1.5 % of the average annual runoff volume and 0.1 % of the total existing surface water allocations within the Upper Bulkley (Table 8). Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for McKilligan Creek are presented in Table 26 and Figure 22. There is one domestic water license situated on McKilligan Creek with an allocation of 1,659.29 m^3/year (Table 27, Figure 27).One ground water well is registered in this sub-watershed with an unknown use.

Table 26. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the McKilligan Creek Sub-watershed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	4.40	5.30	6.10	14.50	51.10	42.60	17.10	7.40	7.50	15.10	12.70	8.30	192
AVG Discharge ($m^{3/s}$)	0.10	0.10	0.10	0.20	0.70	0.60	0.20	0.10	0.10	0.20	0.20	0.10	3
AVG Runoff Volume (10^3m^3)	169.00	201.70	233.70	553.40	1,952.40	1,628.30	651.70	284.00	285.00	577.50	486.10	318.90	7,342
Environmental Needs (10^3m^3)	143.65	171.45	198.65	470.39	1,659.54	1,384.06	553.95	241.40	242.25	490.88	413.19	271.07	6,240
Potential Allocation (10^3m^3)	25.35	30.26	35.06	83.01	292.86	244.25	97.76	42.60	42.75	86.63	72.92	47.84	1,101
Existing Allocation (10^3m^3)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	1
Remaining Allocation (10^3m^3)	25.25	30.16	34.96	82.91	292.76	244.15	97.66	42.50	42.65	86.53	72.82	47.74	1,100

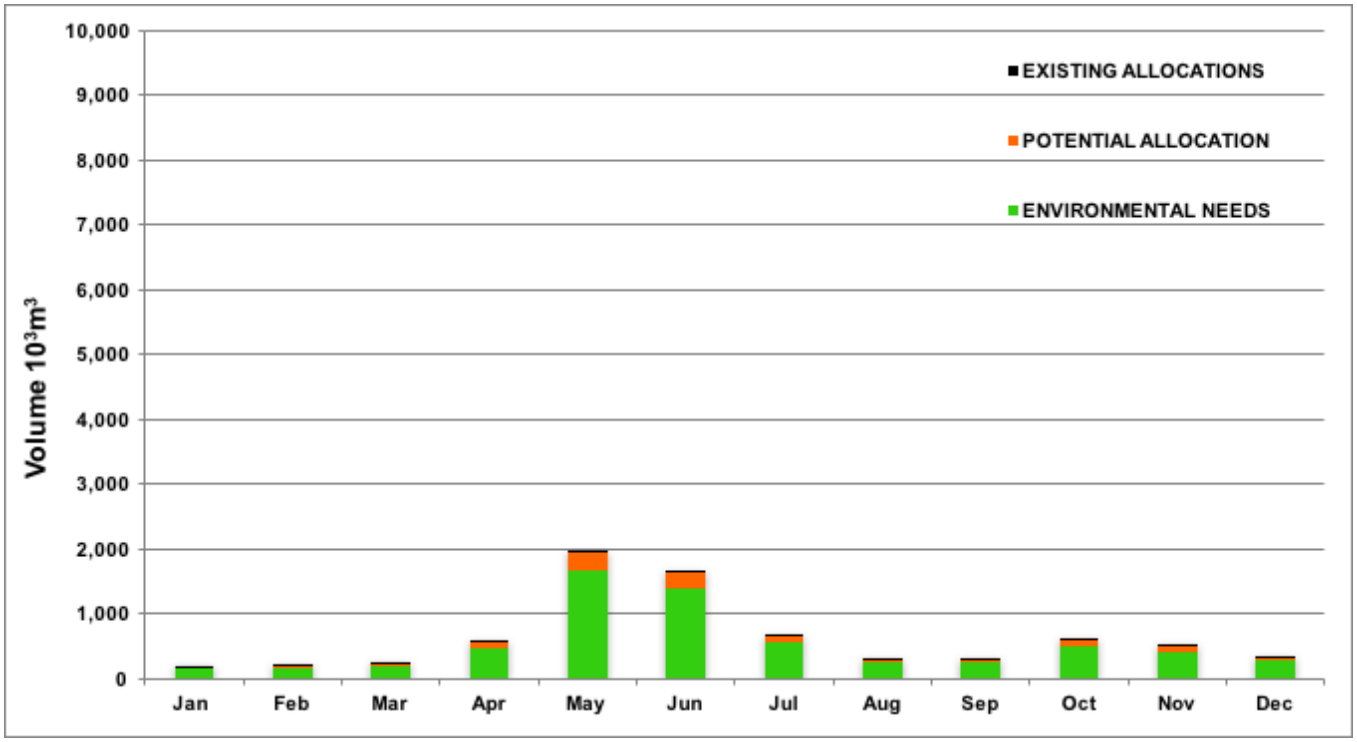

Figure 22. Environmental Needs, Potential and Existing Surface Water Allocations by month for McKilligan Creek

Table 27. Surface Water Allocations in McKilligan Creek

Purpose	Number of Licenses	Total Quantity (m^3/year)	Proportion of Allocation (%)
Conservation/ Storage	0	0.00	0.00%
Domestic	1	1,659.29	100.00%
Irrigation	0	0.00	0.00%
Land Improve	0	0.00	0.00%
Livestock	0	0.00	0.00%
Pond & Aquaculture	0	0.00	0.00%
Totals	**1**	**1,659.29**	**100.00%**

5.11. McQuarrie Creek

McQuarrie Creek comprises 5.2 % of the average annual runoff volume within the Upper Bulkley, and does not have and water licenses issued or groundwater well registered (Table 8, Figure 10). Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for McQuarrie Creek are presented in Table 25 and Figure 21.

Table 28. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the McQuarrie Creek Sub-watershed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	4.00	4.60	5.60	14.70	60.40	54.80	25.20	12.70	11.30	17.10	11.60	7.60	230
AVG Discharge ($m^{3/s}$)	0.20	0.20	0.20	0.60	2.60	2.40	1.10	0.50	0.50	0.70	0.50	0.30	10
AVG Runoff Volume (10^3m^3)	456.70	523.20	634.30	1,668.80	6,867.20	6,225.70	2,864.80	1,441.40	1,284.50	1,941.10	1,316.80	865.00	26,090
Environmental Needs (10^3m^3)	388.20	444.72	539.16	1,418.48	5,837.12	5,291.85	2,435.08	1,225.19	1,091.83	1,649.94	1,119.28	735.25	22,176
Potential Allocation (10^3m^3)	68.51	78.48	95.15	250.32	1,030.08	933.86	429.72	216.21	192.68	291.17	197.52	129.75	3,913
Existing Allocation (10^3m^3)	4.80	4.40	4.80	4.70	4.80	4.70	4.80	4.80	4.70	4.80	4.70	4.80	57
Remaining Allocation (10^3m^3)	63.71	74.08	90.35	245.62	1,025.28	929.16	424.92	211.41	187.98	286.37	192.82	124.95	3,857

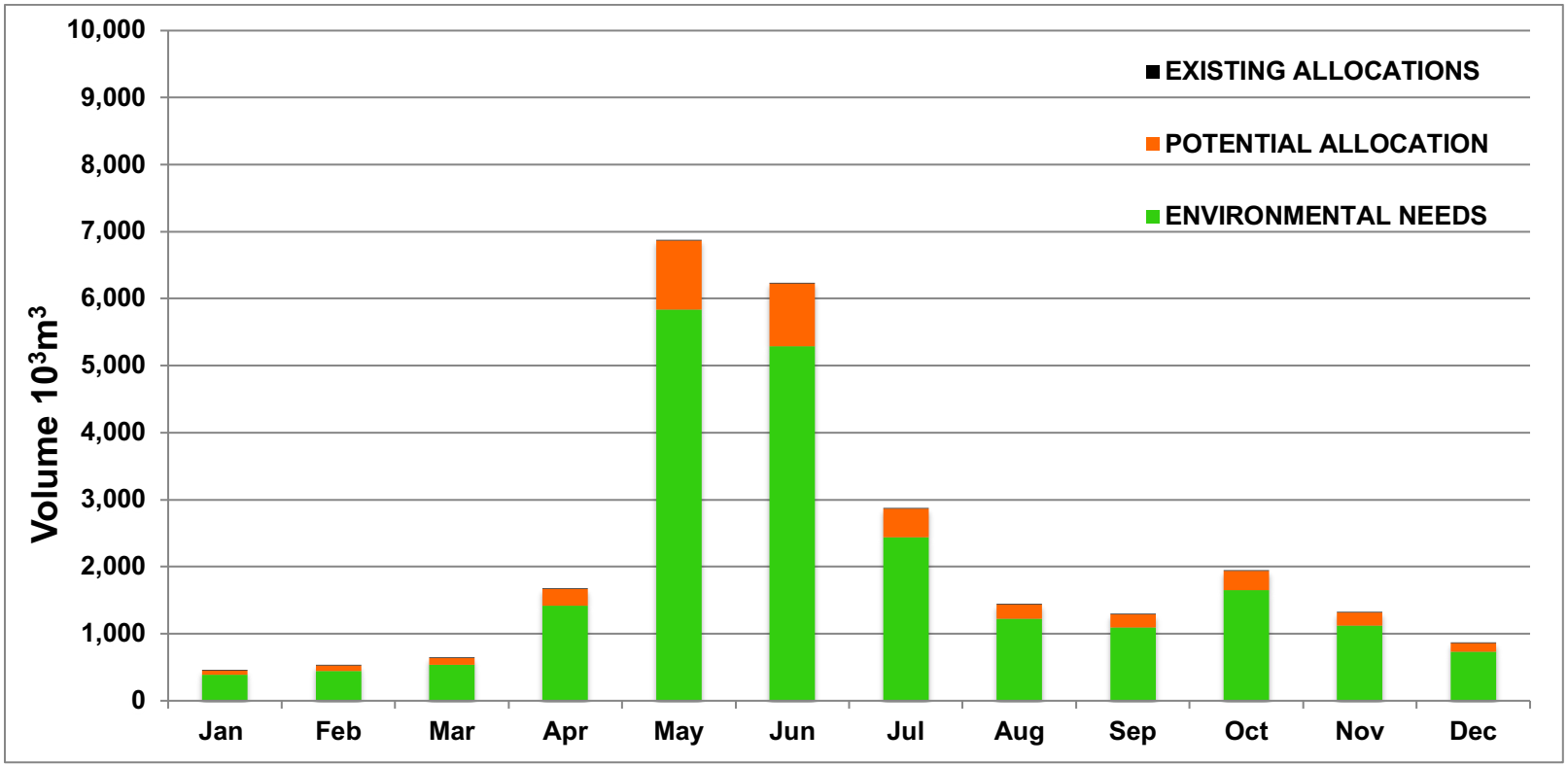

Figure 23. Environmental Needs, Potential and Existing Surface Water Allocations by month for McQuarrie Creek

5.12. Perow Creek

Perow Creek comprises 0.8 % of the average annual runoff volume and 0.5 % of the total existing surface water allocations within the Upper Bulkley (Table 8). Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Perow Creek are presented in Table 29 and Figure 24. Three domestic water licenses are situated on Perow Creek with a total allocation of 4,148.23 m^3/year (Table 30). Four private domestic ground wells are registered within this sub-watershed (Figure 27).

Table 29. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Perow Creek Sub-watershed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	5.10	5.10	5.90	13.70	52.20	45.50	19.40	7.90	8.70	15.30	11.80	8.30	199
AVG Discharge ($m^{3/s}$)	-	-	-	0.10	0.40	0.40	0.10	0.10	0.10	0.10	0.10	0.10	2
AVG Runoff Volume (10^3m^3)	105.10	104.70	121.00	283.10	1,076.90	937.60	400.50	163.60	178.70	314.50	243.30	172.00	4,101
Environmental Needs (10^3m^3)	89.34	89.00	102.85	240.64	915.37	796.96	340.43	139.06	151.90	267.33	206.81	146.20	3,486
Potential Allocation (10^3m^3)	15.77	15.71	18.15	42.47	161.54	140.64	60.08	24.54	26.81	47.18	36.50	25.80	615
Existing Allocation (10^3m^3)	0.40	0.30	0.40	0.30	0.40	0.30	0.40	0.40	0.30	0.40	0.30	0.40	4
Remaining Allocation (10^3m^3)	15.37	15.41	17.75	42.17	161.14	140.34	59.68	24.14	26.51	46.78	36.20	25.40	611

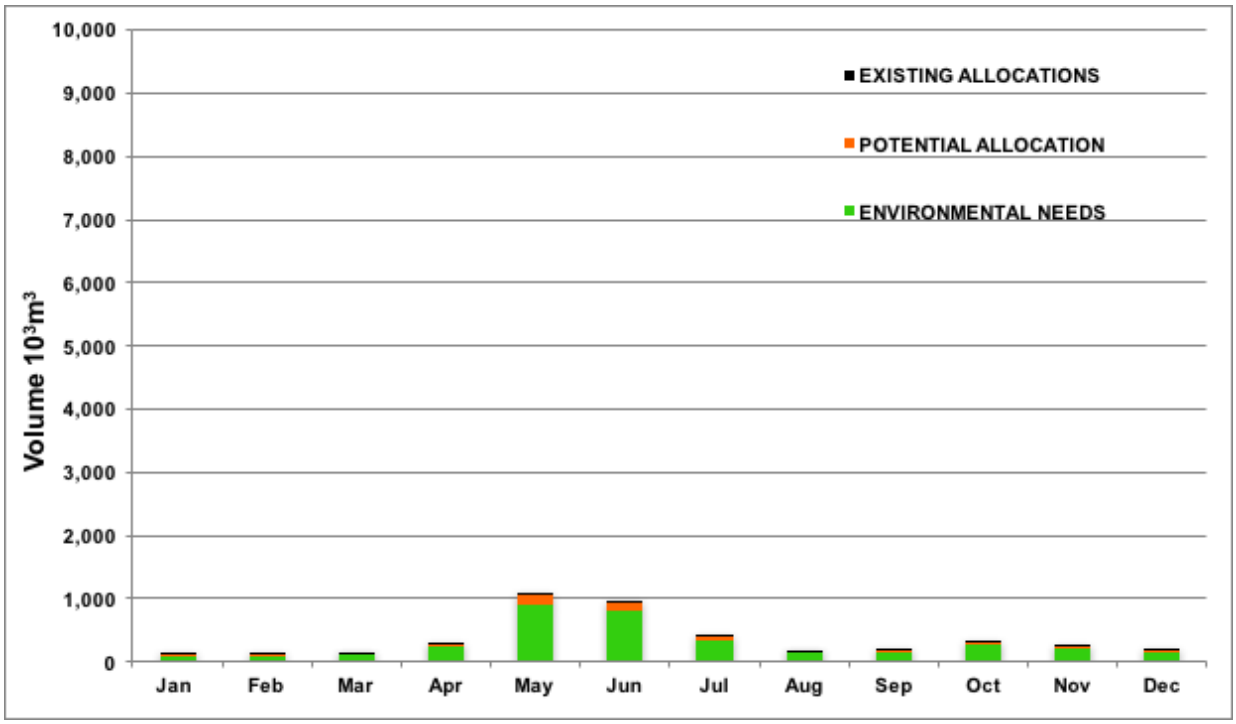

Figure 24. Environmental Needs, Potential and Existing Surface Water Allocations by month for Perow Creek

Table 30. Surface Water Allocations in Perow Creek

Purpose	Number of Licenses	Total Quantity (m^3/year)	Proportion of Allocation (%)
Conservation/ Storage	0	0.00	0.00%
Domestic	3	4,148.23	100.00%
Irrigation	0	0.00	0.00%
Land Improve	0	0.00	0.00%
Livestock	0	0.00	0.00%
Pond & Aquaculture	0	0.00	0.00%
Totals	**3**	**4,148.23**	**100.00%**

5.13. Richfield Creek

Richfield Creek comprises 8.3% of the average annual runoff volume and 15.3 % (125,836.94 m^3**)** of the total existing annual surface water allocations within the Upper Bulkley (Table 8). Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Richfield Creek are presented in Table 31 and Figure 25. The sub-watershed contains one irrigation license, one livestock license, and one pond/aquaculture license (Table 32, Figure 10).

The irrigation license on Richfield Creek has an allocation of 123,348.00 m^3/year (98.02% of the total allocation for Richfield Creek) and is most likely withdrawing most of the water during the growing season (June, July, August, and September). This one irrigation license is tied to two points of diversion along Richfield Creek and the quantity allocated at each POD is unknown.

The livestock license is also tied to two points of diversion but in this case the allocation at each POD is known. Both PODs are situated on Robert Hatch Creek and are licensed to draw 1,659.29 m^3/year and 829.65 m^3/year. The Licensee for the irrigation and livestock licenses is Hatch Creek Ranch Ltd. The priority dates for these licenses dates back to 1967.

The pond/aquaculture license is related to three Points of Diversion situated on Hogarth Spring, Hoffman Spring, and McCracken Spring. The total license allocation is 0 m^3 per year as pond/aquaculture licenses are considered non-consumptive. The license has a 1980 priority date.

Two private domestic ground wells and one ground well with unknown use are registered within Richfield Creek.

Table 31. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Richfield Creek Sub-watershed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	7.60	4.90	5.90	15.10	66.00	63.00	31.50	14.00	12.70	15.70	12.90	8.70	258.00
AVG Discharge (m^3/s	0.50	0.30	0.40	0.90	4.00	3.90	1.90	0.80	0.80	0.90	0.80	0.50	15.70
AVG Runoff Volume ($10^3/m^3$)	1,232.10	788.00	949.40	2,443.00	10,671.50	10,195.70	5,090.70	2,264.20	2,057.50	2,543.60	2,091.40	1,402.40	41,729.50
Environmental Needs ($10^3/m^3$)	1,047.29	669.80	806.99	2,076.55	9,070.78	8,666.35	4,327.10	1,924.57	1,748.88	2,162.06	1,777.69	1,192.04	35,470.08
Potential Allocation ($10^3/m^3$)	184.82	118.20	142.41	366.45	1,600.73	1,529.36	763.61	339.63	308.63	381.54	313.71	210.36	6,259.43
Existing Allocation ($10^3/m^3$)	0.20	0.20	0.20	0.20	0.20	37.20	37.20	37.20	12.50	0.20	0.20	0.20	125.70
Remaining Allocation ($10^3/m^3$)	184.62	118.00	142.21	366.25	1,600.53	1,492.16	726.41	302.43	296.13	381.34	313.51	210.16	6,133.73

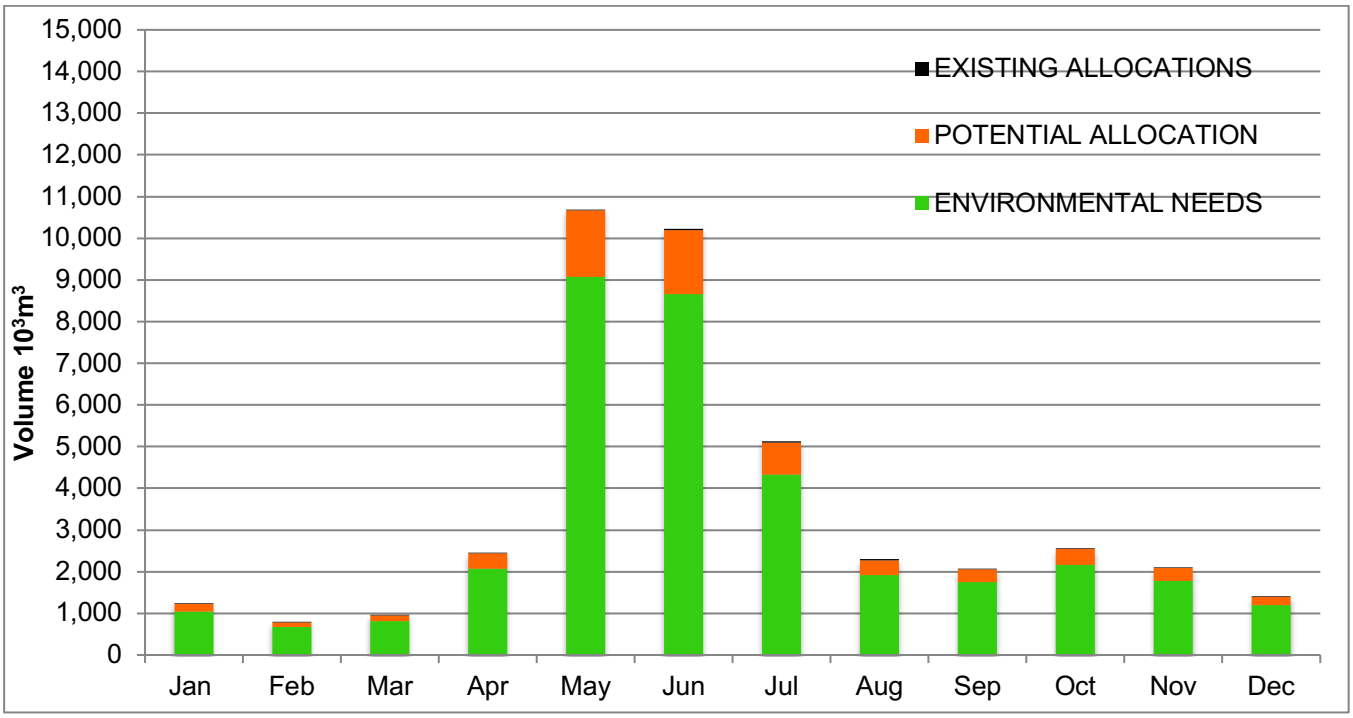

Figure 25. Environmental Needs, Potential and Existing Surface Water Allocations by month for Richfield Creek

Table 32. Surface Water Allocations in Richfield Creek

Purpose	Number of Licenses	Total Quantity (m^3/year)	Proportion of Allocation (%)
Conservation/ Storage	0	0.00	0.00%
Domestic	0	0.00	0.00%
Irrigation	1	123,348.00	98.02%
Land Improve	0	0.00	0.00%
Livestock	1	2,488.94	1.98%
Pond & Aquaculture	1	0.00	0.00%
Totals	**3**	**125,836.94**	**100.00%**

5.14. Bulkley River Unit 1 Sub-watersheds (BR1)

The Bulkley River Unit 1 sub-watersheds (BR1) is an amalgamation of 17 first- and-second order Freshwater Atlas Assessment watersheds along the Bulkley River east of Houston (Figure 27).

BR1 contains 1.4% of the average annual runoff volume and 3.1 % of the total existing annual surface water allocations within the Upper Bulkley (Table 8). Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Bulkley River Unit 1 Sub-watershed are presented in Table 33 and Figure 26.

With 23 surface water licenses registered within this watershed unit, the BR1 has the second highest number of licenses within the Upper Bulkley watershed. The surface water licenses include thirteen domestic, three irrigation, two livestock, four conservation and one storage water license (Table 34).

A total of 96 ground water wells are recorded within the BR1 (Table 35). Of these wells, 40% (38) are assigned to private domestic use and 54% (51) of these wells have an unknown use. It is not clear from the data as to whether these wells are still functioning. Approximately 44.2 % of the groundwater wells registered within the Upper Bulkley watershed are situated within the BR1 sub-watershed unit.

Table 33. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Bulkley River Unit 1 Sub-watersheds

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	54.20	97.00	71.40	145.30	432.10	314.10	85.40	31.40	46.80	148.60	146.30	100.90	1,673.50
AVG Discharge ($m^{3/s}$)	0.00	0.00	0.00	0.10	0.50	0.50	0.00	0.00	0.00	0.10	0.10	0.00	1.30
AVG Runoff Volume (10^3m^3)	215.10	263.20	293.30	620.20	1,925.40	1,463.30	459.00	175.10	227.60	637.80	607.70	411.20	7,298.90
Environmental Needs (10^3m^3)	182.80	223.50	249.20	527.10	1,636.50	1,243.90	390.20	148.90	193.60	542.10	516.40	349.40	6,203.60
Potential Allocation (10^3m^3)	32.20	39.30	43.90	92.90	289.00	219.60	69.00	25.70	34.20	95.50	91.10	61.70	1,094.10
Existing Allocation (10^3m^3)	2.20	2.00	2.20	2.10	2.20	2.10	2.20	2.20	2.10	2.20	2.10	2.20	25.80
Remaining Allocation (10^3m^3)	29.90	37.40	41.70	90.60	286.70	217.50	66.70	24.10	32.00	93.30	89.00	59.40	1,068.30

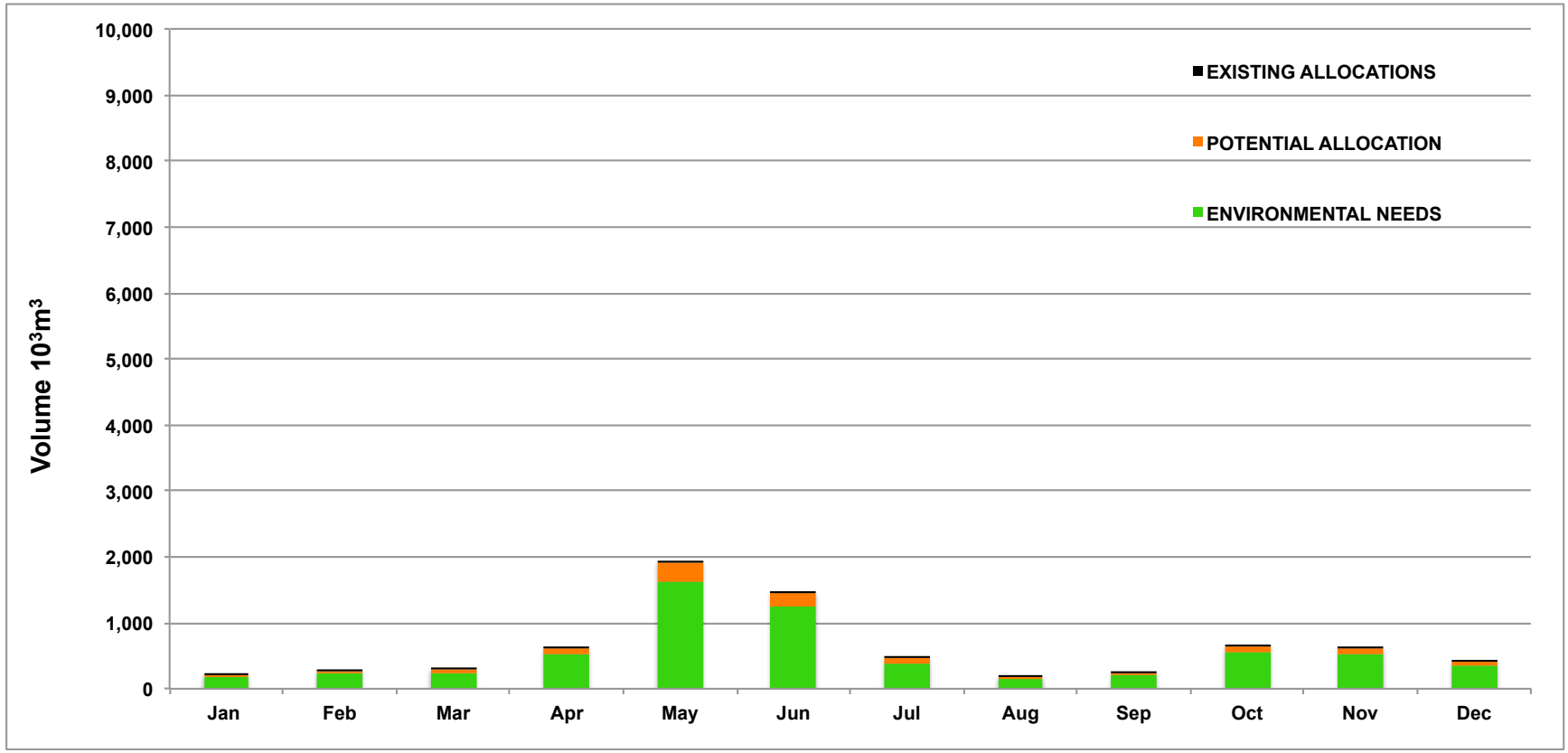

Figure 26. Environmental Needs, Potential and Existing Surface Water Allocations by month for Bulkley River Unit 1 sub-watersheds (BR1)

Table 34. Surface Water Allocations in Bulkley River Unit 1 Sub-watersheds

Purpose	Number of Licenses	Total Quantity (m^3/year)	Proportion of Allocation (%)
Conservation/ Storage	5	4,600.88	14.15%
Domestic	13	14,933.67	45.94%
Irrigation	3	10,484.58	32.25%
Land Improve	0	0.00	0.00%
Livestock	2	2,488.94	7.66%
Pond & Aquaculture	0	0.00	0.00%
Totals	**23**	**32,508.07**	**100.00%**

The 13 domestic water licenses draw 45.9% of the allocation within the BR1 sub-watershed unit whereas the three irrigation licenses draw 32.25% of the allocation.

Table 35. Ground Water Wells within Bulkley River Sub-watersheds Unit 1

Groundwater Wells within BR1	
Commercial and Industrial	1
Private Domestic	38
Water Supply System	4
Observation Well Count	1
Other	1
Unknown Well Use	51
Total	96

Although 51 wells with an unknown use are identified within the Bulkley River Unit 1 sub-watersheds, it is not clear from the data if these unknown wells are still active.

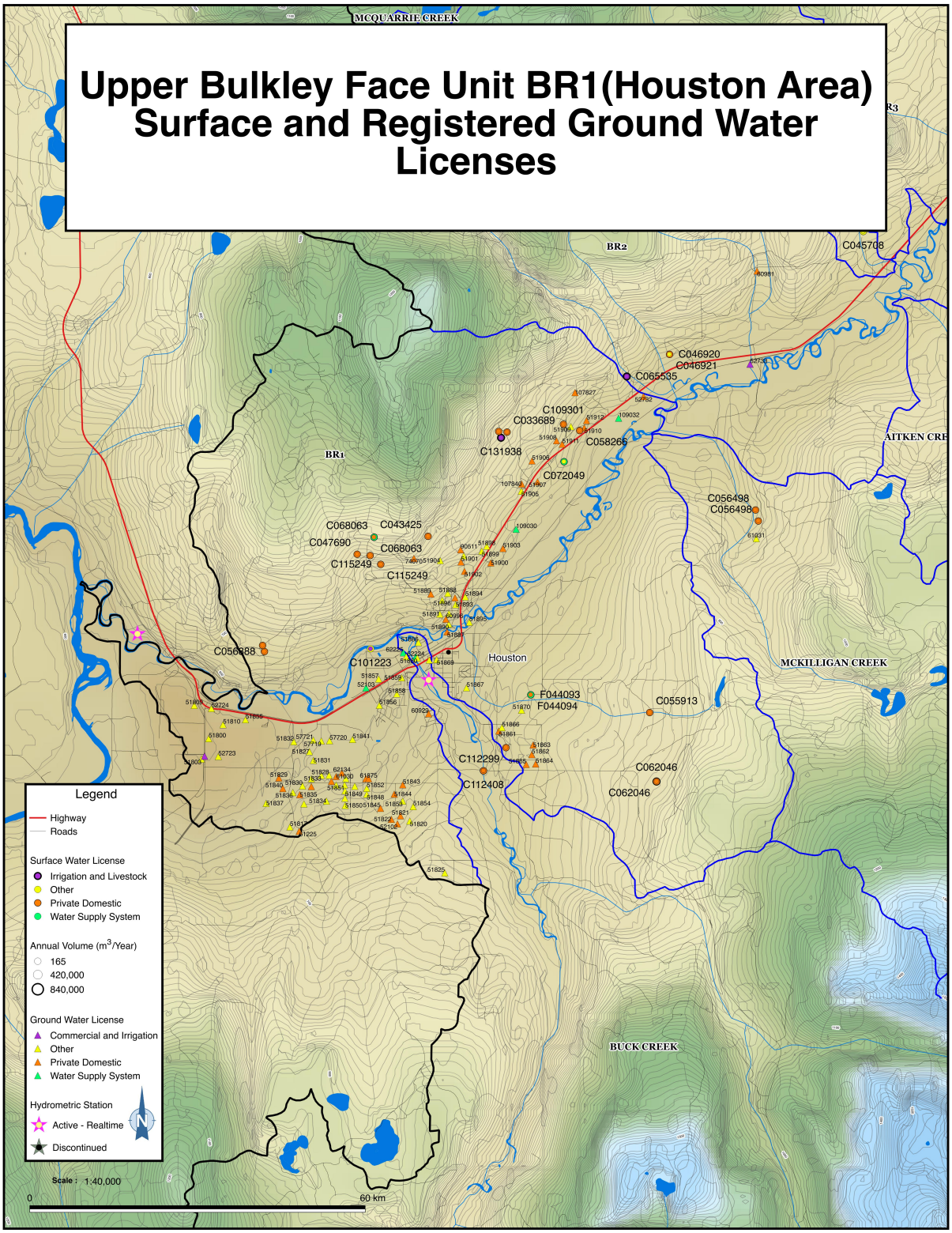

Figure 27. Surface Water Licenses and Groundwater Wells within the Upper Bulkley sub-watersheds Unit 1

5.15. Bulkley River Unit 2 Sub-watersheds (BR2)

The Bulkley River sub-watersheds Unit 2 (BR2) is an amalgamation of three small Freshwater Atlas Assessment watersheds along the Bulkley River east of Houston (Figure 27). Sub-watersheds include Raspberry Creek and two unnamed creeks east of Raspberry Creek.

BR2 comprises 1.1% of the average annual runoff volume and 0.3% of the total existing annual surface water allocations within the Upper Bulkley (Table 8). Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Bulkley River Unit 2 Sub-watershed are presented in Table 36 and Figure 28.

Within the BR2 three surface water licenses are registered including a conservation/storage use, one domestic well and one livestock use (Table 37). The WELLS database indicates one commercial/industrial, one private domestic, and two unknown well uses within the Bulkley River sub-watersheds Unit 2.

Table 36. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Bulkley River Sub-watersheds Unit 2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	9.50	12.40	14.20	33.40	118.20	99.70	40.30	17.40	17.30	35.40	29.90	19.40	447
AVG Discharge ($m^{3/s}$)	-	-	-	0.10	0.50	0.50	0.10	0.10	0.10	0.10	0.10	0.10	2
AVG Runoff Volume (10^3m^3)	113.60	148.10	170.50	403.40	1,436.90	1,220.60	500.20	221.30	212.40	431.00	359.50	233.00	5,451
Environmental Needs (10^3m^3)	96.60	125.90	144.90	342.80	1,221.30	1,037.40	425.10	188.20	180.50	366.30	305.50	198.00	4,633
Potential Allocation (10^3m^3)	17.00	22.30	25.50	60.50	215.50	183.10	75.10	33.10	31.80	64.70	53.90	34.90	817
Existing Allocation (10^3m^3)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	2.40
Remaining Allocation (10^3m^3)	17.00	22.10	25.40	60.30	215.40	183.00	74.90	33.00	31.80	64.50	53.80	34.70	816

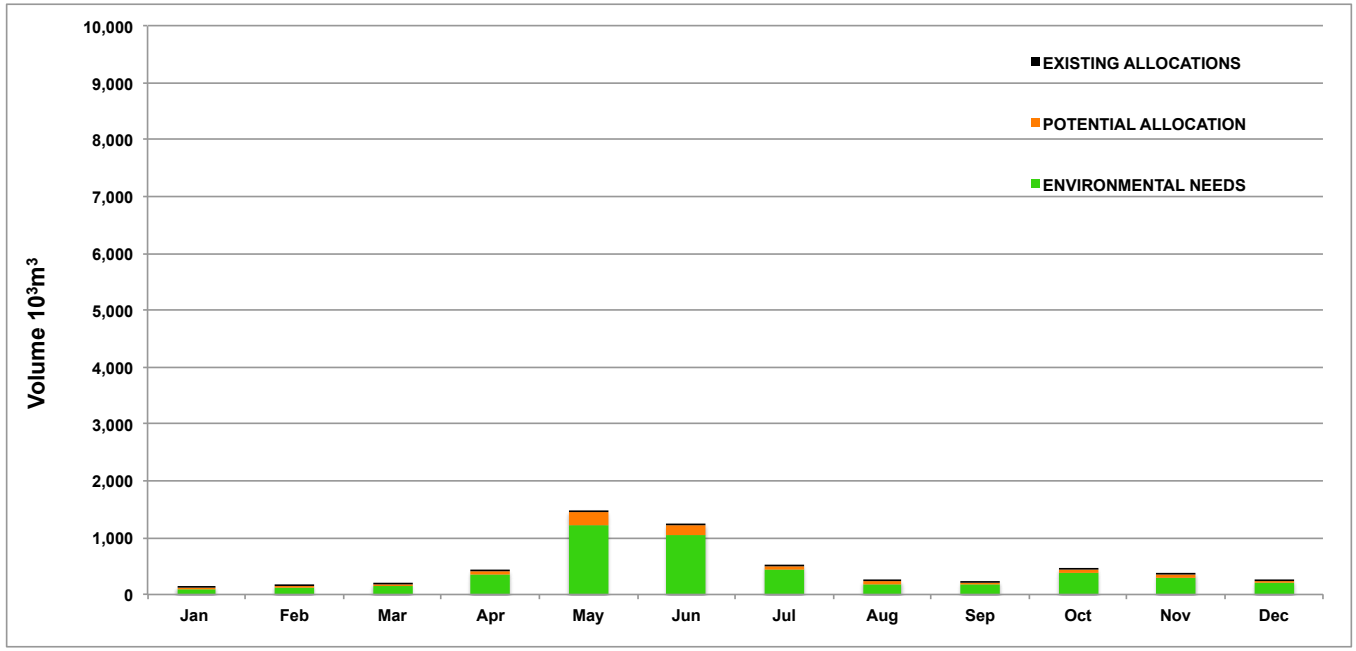

Figure 28. Environmental Needs, Potential and Existing Surface Water Allocations by month for Bulkley River sub-watersheds Unit 2 (BR2)

Table 37. Surface Water Allocations in Bulkley River sub-watersheds Unit 2

Purpose	Number of Licenses	Total Quantity (m^3/year)	Proportion of Allocation (%)
Conservation/ Storage	1	493.39	22.92%
Domestic	1	829.65	38.54%
Irrigation		0.00	0.00%
Land Improve		0.00	0.00%
Livestock	1	829.65	38.54%
Pond & Aquaculture		0.00	0.00%
Totals	**3**	**2,152.69**	**100.00%**

5.16. Bulkley River Unit 3 Sub-watersheds (BR3)

The Bulkley River Face Unit 3 (BR3) sub-watershed is an amalgamation of three Freshwater Atlas Assessment watersheds along the Bulkley River near Houston (Figure 10). This unit includes McInnes Creek and two first order watersheds east of McInnes Creek.

BR3 comprises 0.6 % of the average annual runoff volume and 0.3 % of the total existing annual surface water allocations within the Upper Bulkley (Table 8). Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Bulkley River Unit 3 Sub-watershed are presented in Table 38 and Figure 29.

Table 38. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Bulkley River Sub-watersheds Unit 3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	17.70	20.20	22.40	45.80	141.90	105.60	30.70	8.30	17.60	48.40	42.80	32.30	534
AVG Discharge ($m^{3/s}$)	-	-	-	-	0.10	0.10	-	-	-	-	-	-	0
AVG Runoff Volume (10^3m^3)	91.50	106.60	119.00	250.70	803.90	615.40	197.00	53.60	104.40	267.10	230.10	170.10	3,009
Environmental Needs (10^3m^3)	77.80	90.60	101.20	213.20	683.30	523.20	167.40	45.50	88.70	227.00	195.70	144.60	2,558
Potential Allocation (10^3m^3)	13.80	16.00	17.90	37.60	120.60	92.30	29.60	8.10	15.70	40.10	34.60	25.40	452
Existing Allocation (10^3m^3)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	2.40
Remaining Allocation (10^3m^3)	13.60	15.80	17.70	37.50	120.50	92.10	29.40	7.90	15.50	40.00	34.40	25.30	450

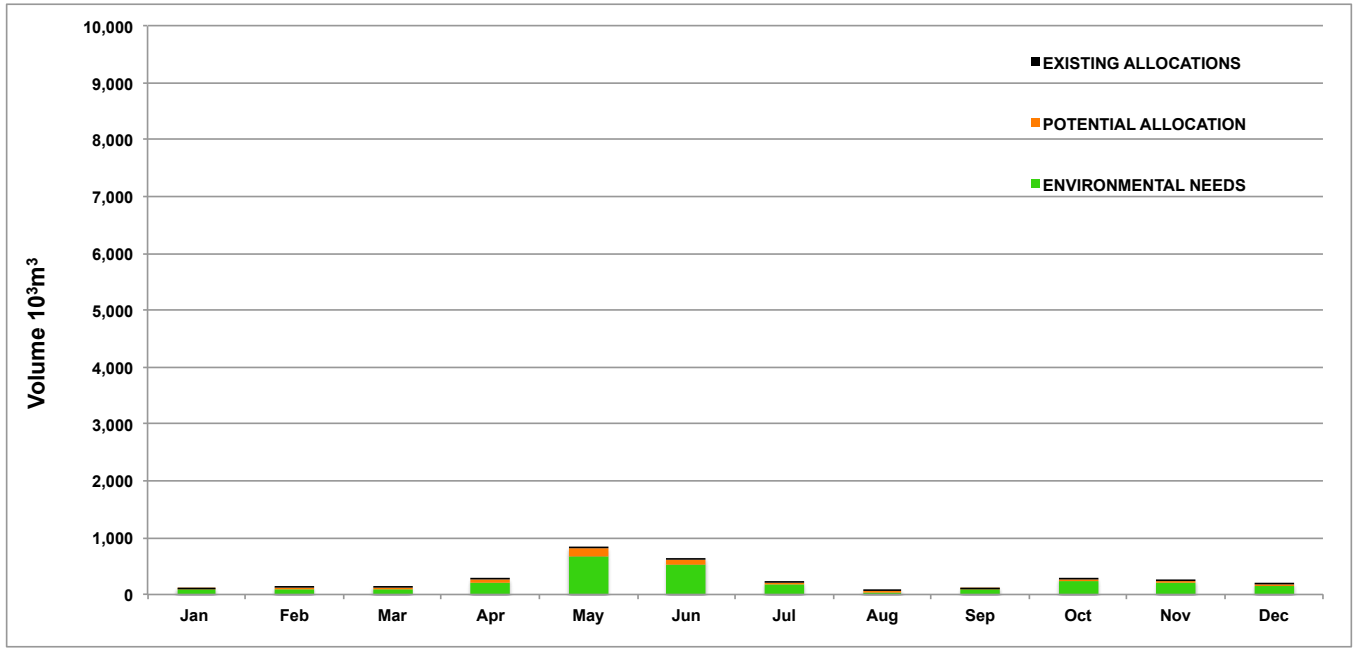

Figure 29. Environmental Needs, Potential and Existing Surface Water Allocations by month for Bulkley River sub-watersheds Unit 3

The BR3 has two domestic surface water licenses with a total allocation of 1,825.37 m^3/year.

The WELLS database indicates one private domestic well and one well designated as unknown.

5.17. Bulkley River Unit 4 Sub-watersheds (BR4)

The Bulkley River Face Unit 4 (BR4) (Figure10) comprises 0.7 % of the average annual runoff volume within the Upper Bulkley (Table 8). No surface water licenses are registered within this watershed group and only one commercial/industrial groundwater well is registered. Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Bulkley River Unit 4 Sub-watershed are presented in Table 39 and Figure 30.

Table 39. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Bulkley River Sub-watersheds Unit 4

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	4.50	4.70	5.30	2.10	42.20	34.40	13.40	4.20	6.40	12.70	10.50	7.40	148
AVG Discharge ($m^{3/s}$)	-	-	-	0.10	0.30	0.30	0.10	-	0.10	0.10	0.10	0.10	1
AVG Runoff Volume (10^3m^3)	98.80	103.30	118.20	267.30	934.80	763.80	297.70	92.80	143.00	281.60	232.30	164.30	3,498
Environmental Needs (10^3m^3)	84.00	87.80	100.50	227.20	794.60	649.20	253.00	78.90	121.60	239.30	197.40	139.60	2,973
Potential Allocation (10^3m^3)	14.80	15.50	17.70	40.10	140.20	114.60	44.70	13.90	21.50	42.20	34.80	24.60	525
Existing Allocation (10^3m^3)	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
Remaining Allocation (10^3m^3)	14.80	15.50	17.70	39.80	140.20	114.60	44.70	13.90	21.50	42.20	34.80	24.60	524

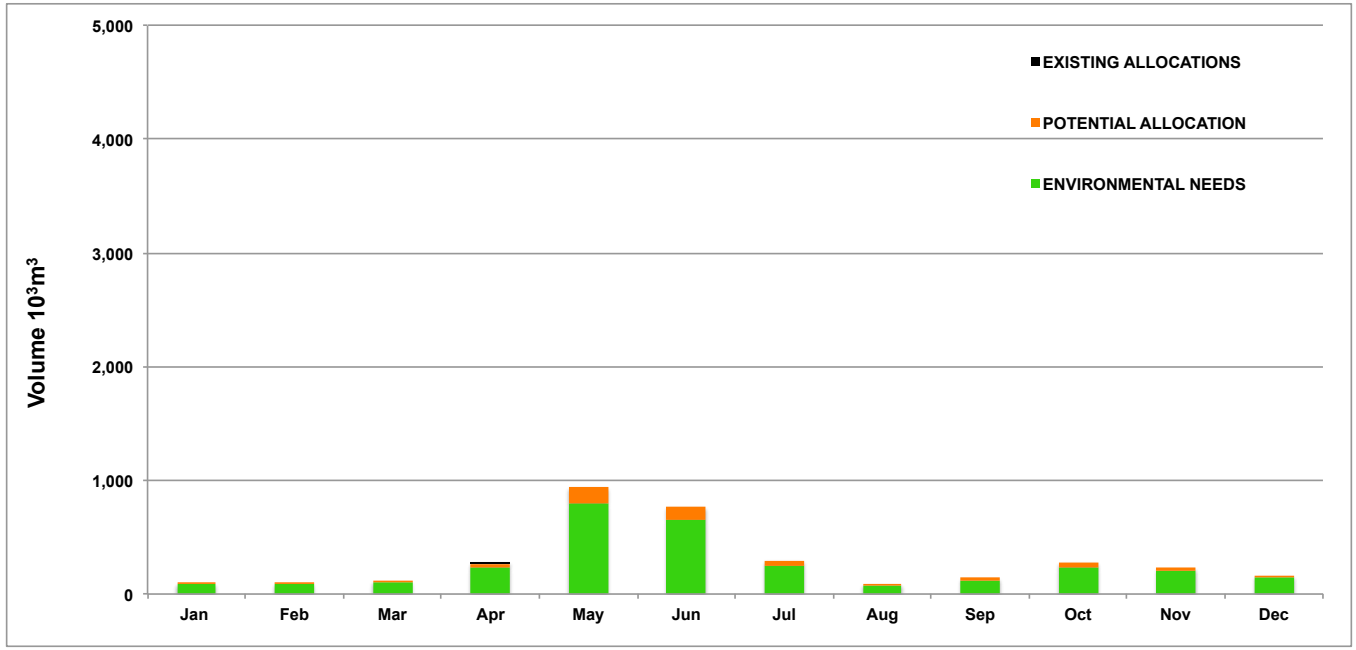

Figure 30. Environmental Needs, Potential and Existing Surface Water Allocations by month for Bulkley River sub-watersheds Unit 4

5.18. Bulkley River Unit 5 Sub-watersheds (BR5)

The Bulkley River Face Unit 5 (BR5) sub-watershed is an amalgamation of six Freshwater Atlas Assessment watersheds along the Bulkley River east of Houston (Figure 10).

BR5 comprises 0.5 % of the average annual runoff volume and 0.05% of the total existing annual surface water allocations within the Upper Bulkley (Table 8). Two surface water licenses are registered within this watershed group. Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Bulkley River Unit 5 Sub-watershed are presented in Table 40 and Figure 31.

Table 40. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Bulkley River Sub-watersheds Unit 5

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	46.40	42.20	46.80	94.30	300.50	228.00	68.70	15.80	41.50	92.10	92.10	70.20	1,139
AVG Discharge ($m^{3/s}$)	-	-	-	-	0.20	0.20	-	-	-	-	-	-	0
AVG Runoff Volume (10^3m^3)	104.70	94.20	105.30	218.10	719.60	562.20	185.50	41.80	105.00	214.10	211.00	158.50	2,720
Environmental Needs (10^3m^3)	89.10	80.10	89.50	185.30	611.80	477.90	157.60	35.50	89.20	181.90	179.40	134.80	2,312
Potential Allocation (10^3m^3)	15.70	14.20	15.70	32.60	107.90	84.20	27.80	6.00	15.60	32.10	31.70	23.80	407
Existing Allocation (10^3m^3)	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40
Remaining Allocation (10^3m^3)	15.30	13.80	15.30	32.20	107.50	83.80	27.40	5.90	15.20	31.70	31.30	23.40	403

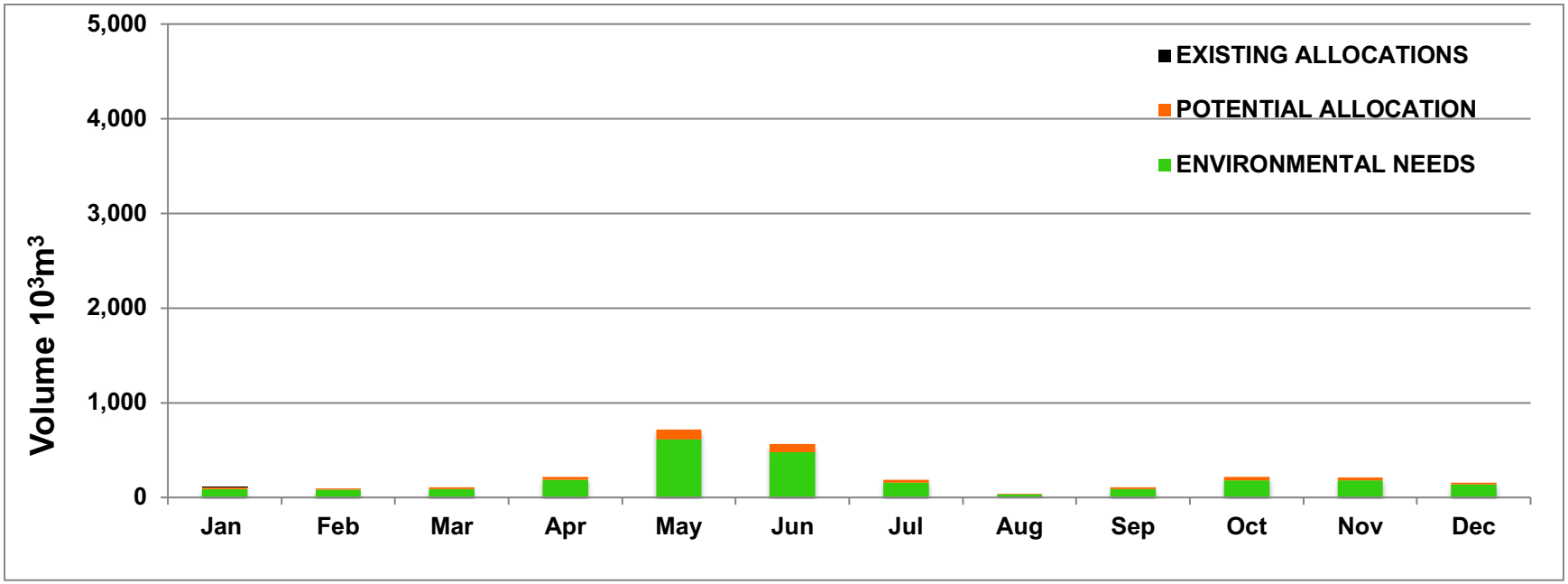

Figure 31. Environmental Needs, Potential and Existing Surface Water Allocations by month for Bulkley River sub-watersheds Unit 5

One domestic license and one livestock surface water license are located within BR5 (Table 41).

Table 41. Surface Water Allocations in BR5

Purpose	Number of Licenses	Total Quantity (m^3/year)	Proportion of Allocation (%)
Conservation/ Storage		0.00	0.00%
Domestic	1	4,148.23	227.25%
Irrigation		0.00	0.00%
Land Improve		0.00	0.00%
Livestock	1	829.65	45.45%
Pond & Aquaculture		0.00	0.00%
Totals	**2**	**4,977.88**	**100.00%**

The BR5 also has a total of 55 groundwater wells recorded in the groundwater WELLS database (Table 42). Thirty of these wells are assigned to private domestic use and 16 wells have an unknown use and are possibly no longer in use.

Table 42. Ground Water Wells in BR5

Groundwater Wells within BR5	
Commercial and Industrial	6
Private Domestic	30
Water Supply System	1
Observation Well Count	0
Other	2
Unknown Well Use	16
Total	55

5.19. Bulkley River Unit 6 Sub-watersheds (BR6)

The Bulkley River Face Unit 6 (BR6) sub-watershed comprises 1.0 % of the average annual runoff volume within the Upper Bulkley (Table 8, Figure 10). No surface water licenses are registered within this watershed group and only one domestic groundwater well is registered. Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Bulkley River Unit 6 Sub-watershed are presented in Table 43 and Figure 32.

Table 43. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Bulkley River Sub-watersheds Unit 6

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	4.80	4.40	5.00	10.80	36.20	28.50	9.80	2.30	5.50	10.70	9.50	7.20	135
AVG Discharge ($m^{3/s}$)	0.10	0.10	0.10	0.20	0.50	0.40	0.10	-	0.10	0.20	0.10	0.10	2
AVG Runoff Volume (10^3m^3)	185.50	169.30	192.20	419.20	1,405.50	1,104.00	379.50	87.70	212.60	413.80	369.50	279.10	5,218
Environmental Needs (10^3m^3)	157.70	143.90	163.40	356.30	1,194.60	938.40	322.60	74.50	180.70	351.80	314.10	237.20	4,435
Potential Allocation (10^3m^3)	27.80	25.40	28.80	62.90	210.80	165.60	56.90	13.20	31.90	62.10	55.40	41.90	783
Existing Allocation (10^3m^3)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Remaining Allocation (10^3m^3)	27.80	25.40	28.80	62.90	210.80	165.60	56.90	13.20	31.90	62.10	55.40	41.90	783

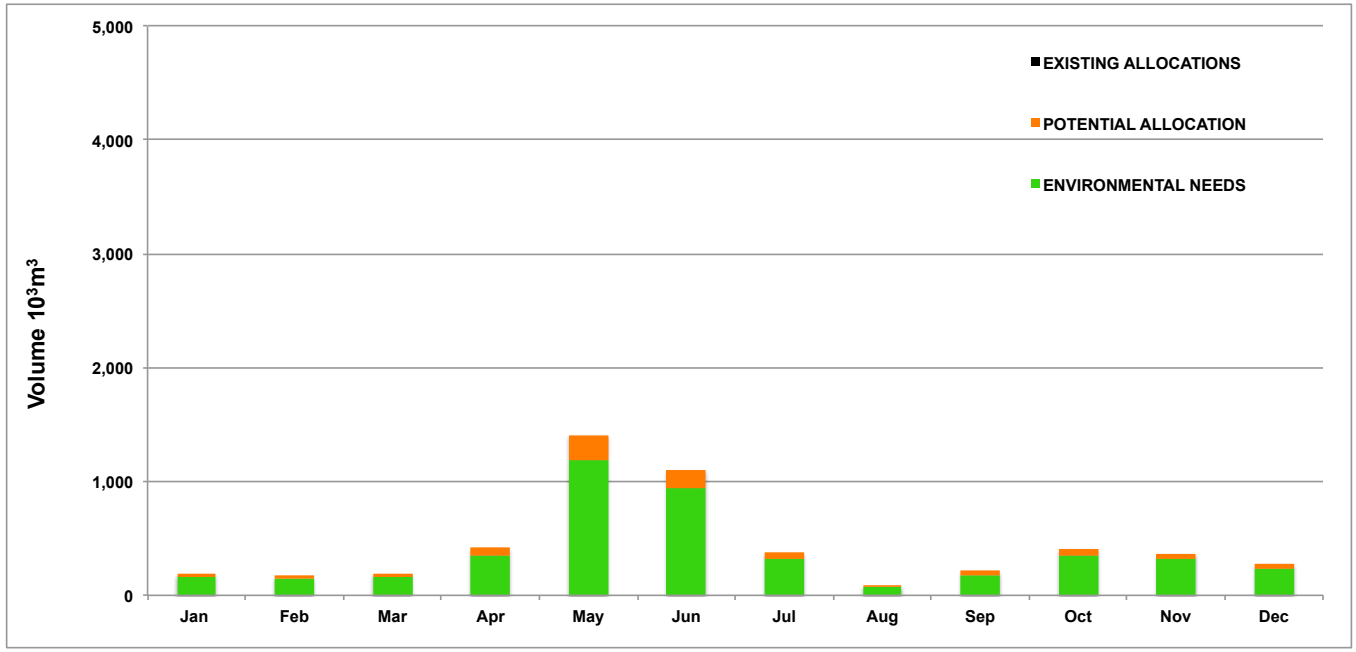

Figure 32. Environmental Needs, Potential and Existing Surface Water Allocations by month for Bulkley River sub-watersheds Unit 6

5.20. Bulkley River Unit 7 Sub-watersheds (BR7)

The Bulkley River Face Unit 7 (BR7) sub-watershed is an amalgamation of 6 Freshwater Atlas Assessment watersheds along the Bulkley River near Houston (Figure 10).

BR7 contains 0.8 % of the average annual runoff volume and 0.3 % of the total existing annual surface water allocations within the Upper Bulkley. Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Bulkley River Unit 7 Sub-watershed are presented in Table 44 and Figure 33.

Table 44. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Bulkley River Sub-watersheds Unit 7

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	54.00	46.30	51.90	106.60	350.10	262.10	79.60	16.60	50.30	102.10	102.00	78.40	1,300
AVG Discharge ($m^{3/s}$)	-	-	-	-	0.40	0.20	-	-	-	-	-	-	1
AVG Runoff Volume (10^3m^3)	158.40	137.00	153.20	314.90	1,025.90	765.60	229.30	49.00	145.10	302.90	300.70	231.80	3,814
Environmental Needs (10^3m^3)	134.70	116.30	133.20	273.70	892.60	666.00	199.50	42.60	126.30	263.30	261.50	201.60	3,311
Potential Allocation (10^3m^3)	23.80	20.60	22.90	47.30	153.90	115.00	34.50	7.30	21.60	45.40	45.10	34.80	572
Existing Allocation (10^3m^3)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Remaining Allocation (10^3m^3)	23.80	20.60	22.90	47.30	153.90	115.00	34.50	7.30	21.60	45.40	45.10	34.80	572

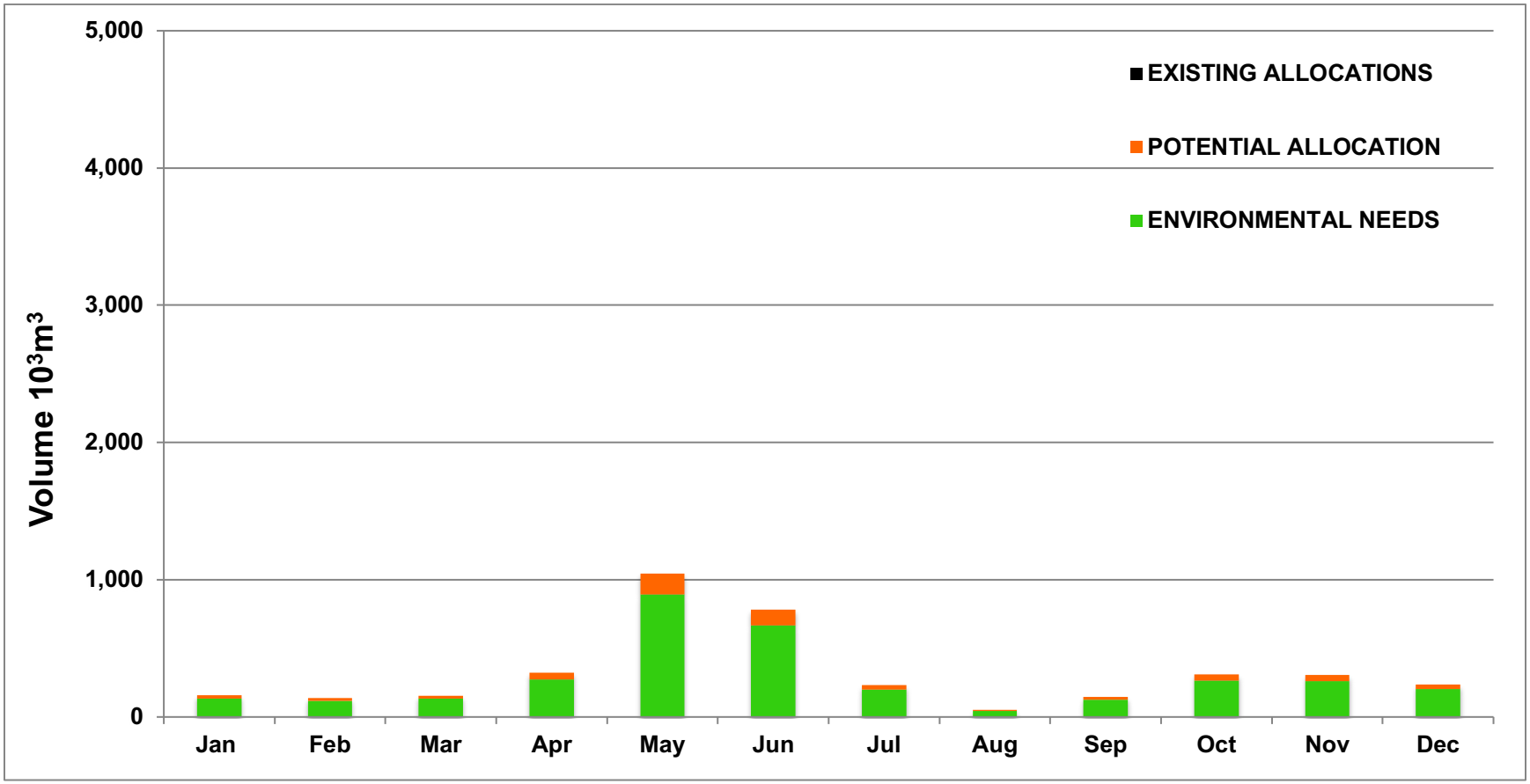

Figure 33. Environmental Needs, Potential and Existing Surface Water Allocations by month for Bulkley River sub-watersheds Unit 7

The BR7 Unit has two surface water licenses include one domestic and one conservation/storage license.

The BR7 Unit also has a total of five groundwater wells recorded in the groundwater WELLS database. Two wells are assigned a domestic purpose and three are designated as unknown use (Table 45).

Table 45. Groundwater wells in BR7

Purpose	Number of Licenses	Total Quantity (m^3/year)	Proportion of Allocation (%)
Conservation/ Storage	1	355,242.24	19461.38%
Domestic	1	829.65	45.45%
Irrigation		0.00	0.00%
Land Improve		0.00	0.00%
Livestock		0.00	0.00%
Pond & Aquaculture		0.00	0.00%
Totals	**2**	**356,071.89**	**100.00%**

5.21. Bulkley River Unit 8 Sub-watersheds (BR8)

The Bulkley River Face Unit 8 (BR8) sub-watershed (Figure 17) contains 1.0 % of the average annual runoff volume within the Upper Bulkley with no water licences (Table 8). Two light domestic water wells are registered within the BR8 sub-watershed. Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Bulkley River Unit 8 Sub-watershed are presented in Table 46 and Figure 34.

Table 46. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Bulkley River Sub-watersheds Unit 8

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	46.40	42.20	46.80	94.30	300.50	228.00	68.70	15.80	41.50	92.10	92.10	70.20	1,139
AVG Discharge ($m^{3/s}$)	-	-	-	-	0.20	0.20	-	-	-	-	-	-	0
AVG Runoff Volume (10^3m^3)	104.70	94.20	105.30	218.10	719.60	562.20	185.50	41.80	105.00	214.10	211.00	158.50	2,720
Environmental Needs (10^3m^3)	89.10	80.10	89.50	185.30	611.80	477.90	157.60	35.50	89.20	181.90	179.40	134.80	2,312
Potential Allocation (10^3m^3)	15.70	14.20	15.70	32.60	107.90	84.20	27.80	6.00	15.60	32.10	31.70	23.80	407
Existing Allocation (10^3m^3)	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40
Remaining Allocation (10^3m^3)	15.30	13.80	15.30	32.20	107.50	83.80	27.40	5.90	15.20	31.70	31.30	23.40	403

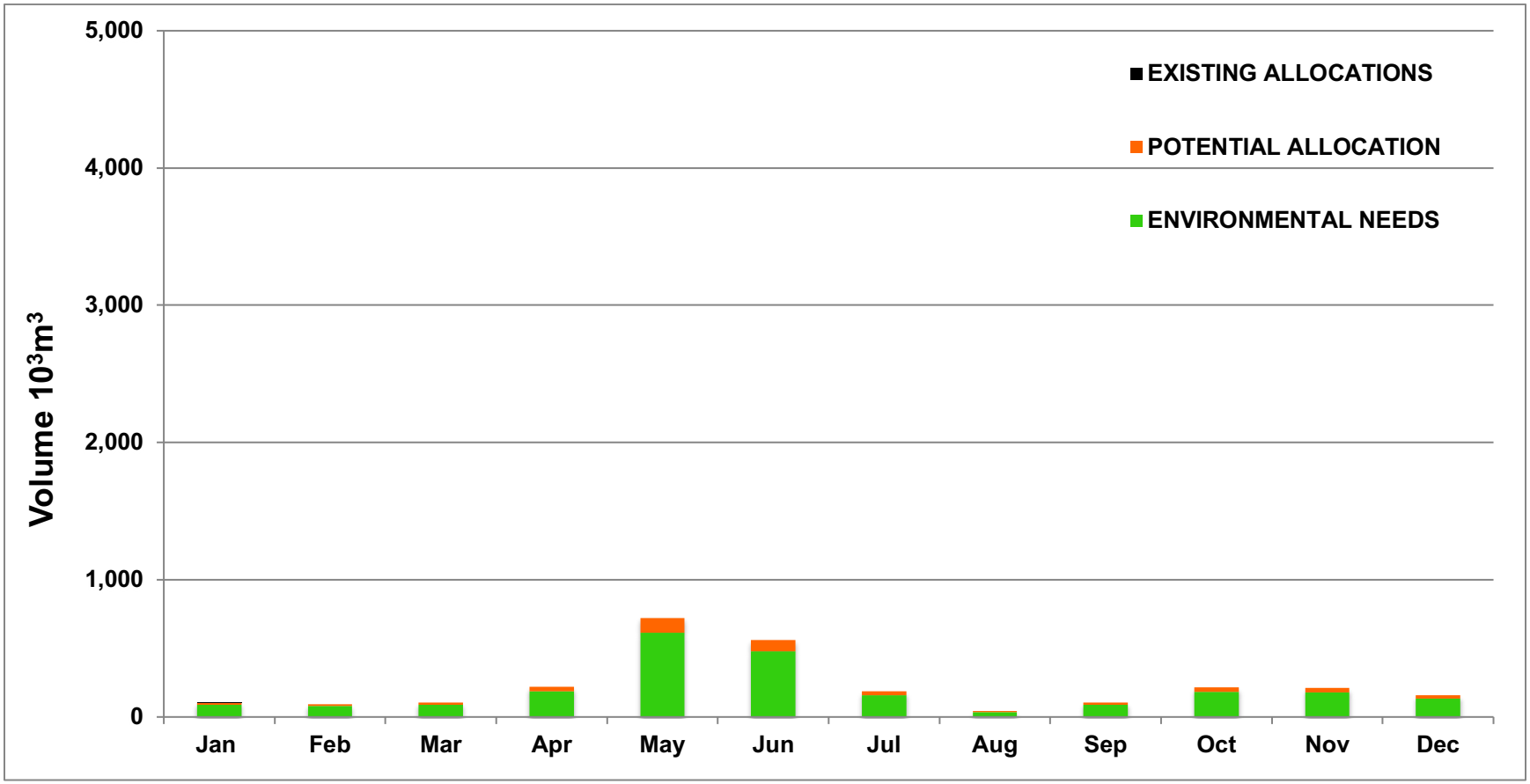

Figure 34. Environmental Needs, Potential and Existing Surface Water Allocations by month for Bulkley River sub-watersheds Unit 8

5.22. Bulkley River Unit 9 Sub-watersheds (BR9)

The Bulkley River Unit 9 (BR9) sub-watershed is an amalgamation of two Freshwater Atlas Assessment watersheds along the Bulkley River (Figure 17).

BR9 contains 4.3 % of the average annual runoff volume and 0.3 % of the total existing annual surface water allocations within the Upper Bulkley. Average (30 year) runoff volumes, environmental flow needs, and annual surface water allocations for Bulkley River Unit 9 Sub-watershed are presented in Table 47 and Figure 35.

Table 47. Average (30 year) Runoff Volume, Environmental Flow and Annual Surface Water Allocations by Month for the Bulkley River Sub-watersheds Unit 9

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
AVG Unit Runoff (mm)	14.60	11.20	13.10	31.50	123.60	107.70	46.90	16.40	21.60	30.50	27.20	19.70	464
AVG Discharge ($m^{3/s}$)	0.30	0.30	0.30	0.50	2.20	1.90	0.80	0.30	0.40	0.50	0.50	0.40	8
AVG Runoff Volume (10^3m^3)	708.00	538.00	628.80	1,489.60	5,763.80	4,971.00	2,128.80	719.30	995.80	1,442.80	1,294.70	946.60	21,627
Environmental Needs (10^3m^3)	601.90	457.40	534.40	1,266.20	4,899.30	4,225.40	1,809.50	611.40	846.50	1,226.40	1,100.50	804.60	18,384
Potential Allocation (10^3m^3)	106.30	80.70	94.40	223.50	864.50	745.60	319.30	107.90	149.40	216.40	194.20	142.00	3,244
Existing Allocation (10^3m^3)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	2.40
Remaining Allocation (10^3m^3)	106.00	80.50	94.10	223.20	864.40	745.50	319.20	107.70	149.20	216.20	194.00	141.70	3,242

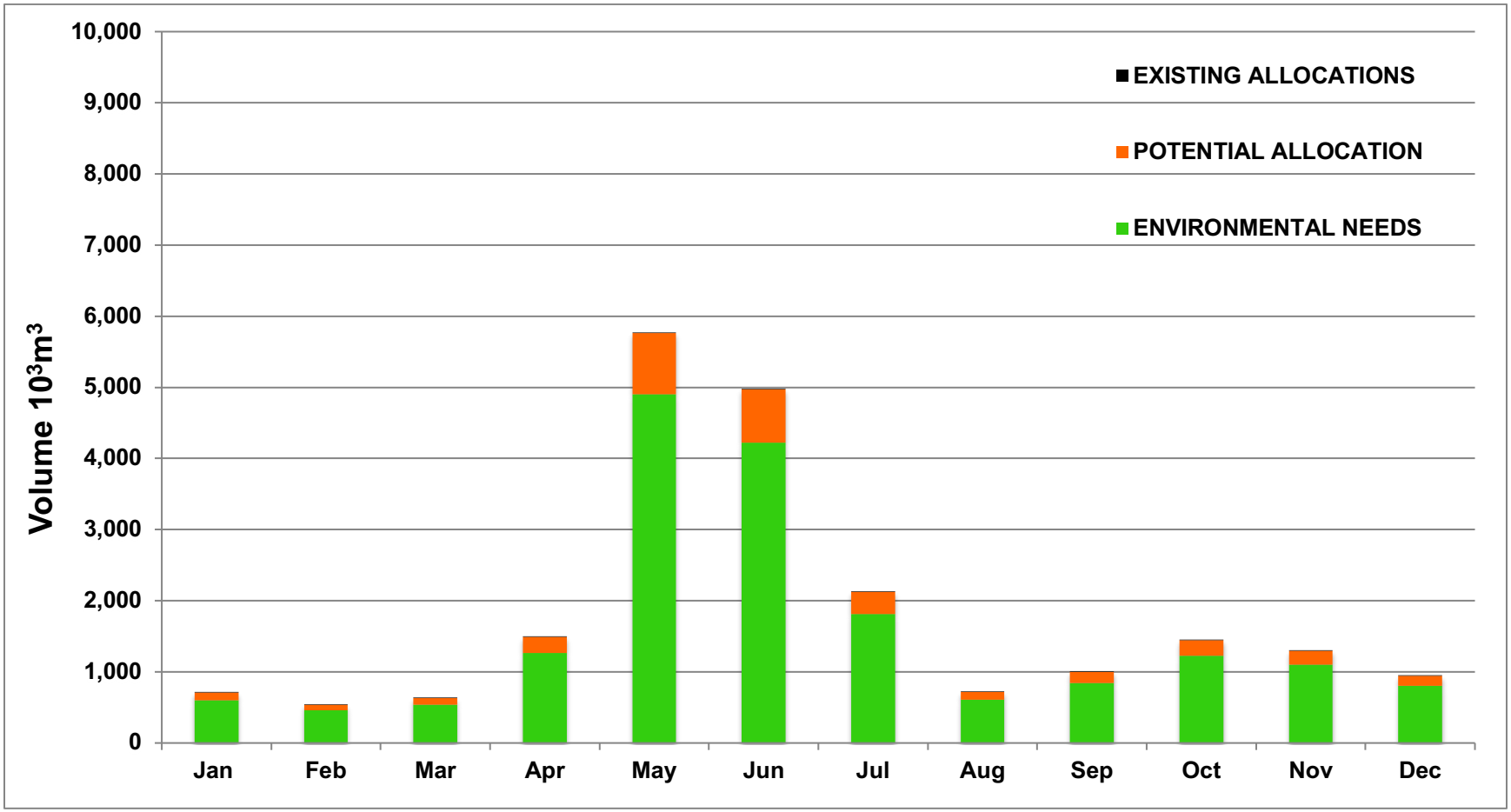

Figure 35. Environmental Needs, Potential and Existing Surface Water Allocations by month for Bulkley River sub-watersheds Unit 9

The BR9 Unit has two domestic use surface water licenses (Table 48).

Table 48. Surface Water Allocations in BR9

Purpose	Number of Licenses	Total Quantity (m^3/year)	Proportion of Allocation (%)
Conservation/ Storage		0.00	0.00%
Domestic	2	2,488.94	136.35%
Irrigation		0.00	0.00%
Land Improve		0.00	0.00%
Livestock		0.00	0.00%
Pond & Aquaculture		0.00	0.00%
Totals	**2**	**2,488.94**	**100.00%**

The BR9 Unit also has a total of seven ground water wells. One commercial/industrial, two domestic, and four wells with an unknown use.

6. DISCUSSION AND RECOMMENDATIONS

This summary highlights sub-watersheds within the Upper Bulkley that may be experiencing land use pressures on fish habitat based on water allocation uses.

In 2016, Eclipse Geomatics completed an assessment of key salmon habitat indicators within the Upper Bulkley including total accessible stream length (Eclipse 2016). This indicator consists of streams (or portions thereof) where resident and anadromous fish presence has been observed or is inferred based on gradient and fish passage. Within the Upper Bulkley 95.88% of the watershed demonstrates observed or inferred accessible stream length (Eclipse 2016).

As access to streams by fish is not a limiting factor within the Upper Bulkley, this report examines water allocation and use to determine if there are any flow limitations within the various sub-watersheds due to surface water licenses and groundwater well use.

This report summary does not apply any thresholds to the various metrics. However, a subjective rating scale has been applied to each sub-watershed in order to guide further investigation, shown in Table 49. A green rating is applied to highlight sub-watersheds that require no further investigation specific to water allocations, amber rating indicating further investigation require but no immediate concerns, and red rating to indicate sub-watersheds with a recommendation for immediate further investigation to verify report results and data.

Table 49. Sub-basin characterization and water allocation summary with low, medium, and high priority ratings

Sub-watershed	Area (km^2)	Sub-Watershed Annual Runoff Volume (10^3 m^3)	Proportion of Average Runoff Volume (%)	Existing Allocation (10^3 m^3/year)	Proportion of Water License Allocation (%)	No. of Surface Water Licenses	No. of Groundwater wells	Comments
Ailport Creek	97.13	26,241.00	5.19%	29.0	3.52%	6	2	Moderate irrigation
Aitken Creek	148.66	33,020.00	6.53%	250.00	30.34%	4	1	Heavy Irrigation
Barren Creek	25.81	4,739.00	0.94%	2.00	0.24%	2	0	light domestic
Buck Creek	566.77	139,095.00	27.51%	31.00	3.76%	31	13	Heavy domestic
Byman Creek	94.04	23,107.00	4.57%	57.00	6.92%	1	4	Short-term approvals
Cesford Creek	36.7	9,351.00	1.85%	0.00	0.00%	0	0	No water licenses or wells
Crow Creek	73.96	15,425.00	3.05%	1.00	0.12%	2	1	Light Domestic
Johnny David Creek	43.73	9,812.00	1.94%	0.00	0.00%	0	0	No water licenses or wells
Maxan Creek	370.73	82,896.00	16.40%	166.00	20.15%	5	0	Conservation/storage/land improvement (GoldCorp/Equity Silver)
McKilligan Creek	38.2	7,342.00	1.45%	1.00	0.12%	1	1	Light Domestic
McQuarrie Creek	114.62	26,090.00	5.16%	57.00	6.92%	0	0	No water licenses or wells
Perow Creek	20.63	4,101.00	0.81%	4.00	0.49%	3	4	Light Domestic
Richfield Creek	161.81	41,729.50	8.25%	125.70	15.25%	3	3	Heavy Irrigation
BR1	78.47	7,299.00	1.44%	25.80	3.13%	23	96	Heavy Domestic and Irrigation
BR2	51.21	5,451.00	1.08%	2.40	0.29%	3	4	Domestic and Irrigation
BR3	75.84	3,009.40	0.60%	2.40	0.29%	2	2	Light Domestic
BR4	30.07	3,498.00	0.69%	0.30	0.04%	0	1	Light Industrial
BR5	36.87	2,720.00	0.54%	0.40	0.05%	2	55	Heavy Private Domestic/Unknown Groundwater Wells
BR6	59.21	5,218.00	1.03%	0.00	0.00%	0	1	Light domestic
BR7	64.63	3,813.00	0.75%	2.40	0.29%	2	5	Light domestic
BR8	32.23	5,025.20	0.99%	0.00	0.00%	0	2	Light domestic
BR9	93.77	21,627.20	4.28%	2.40	0.29%	2	7	Light domestic
Main Stem Bulkley River		24,952.70	4.94%	64.20	7.79%			

High Priority Sub-watersheds

Four sub-watersheds have been assigned a high priority rating including Aitken, Richfield, BR1 and BR5.

Aitken Creek is assigned a high priority because although it only contributes 6.53% to the volume of the Upper Bulkley flow it is assigned 30.34% of the water license allocation. This allocation (250,000 m^3/year) is dedicated to four irrigation licenses. Irrigation use is generally distributed across the months of June, July, August and September. This use could correspond with seasonal low flows resulting in a possible impact on existing fish habitat. Aiken Creek has 96.05 % of the total stream length accessible to fish, with no observed salmon presence (Eclipse 2016). More accurate stream volumes are required to determine the relationship between low flows, irrigation, and fish habitat.

Of the three water licenses on Richfield Creek the one irrigation license has an allocation of 123,348.00 m^3/year (98.02% of the total allocation for Richfield Creek) and is most likely withdrawing water during the growing season (June, July, August, and September). This one irrigation license is tied to two points of diversion along Richfield Creek and the quantity allocated at each POD is unknown. Richfield Creek has 98.25 % of the total stream length accessible to fish, with observed salmon presence identified along 1.22% of this stream length (Eclipse 2016). More accurate stream volumes are required to determine the relationship between low flows, irrigation, and fish habitat.

BR1 is an amalgamation of 17 first- and-second order Freshwater Atlas Assessment watersheds along the Bulkley River east of Houston (Figure 27). This watershed unit is rated high priority because it contains 1.4% of the average annual runoff volume and 24.7% % of the total existing annual surface water allocations within the Upper Bulkley.

Stream flow within BR1 is of significant interest because of the high fish presence identified within this sub-watershed. BR1 has 95.59 % of the total stream length accessible to fish and 14.45 % of this stream length has observed salmon presence identified (Eclipse 2016).

BF5 is rated high priority due to the large number of groundwater wells situated within this sub-watershed unit. BR5 has 100 % of the total stream length accessible to fish and 37.41 % of this stream length has observed salmon presence identified (Eclipse 2016). More investigation is required to determine if the recorded ground water wells are still in use.

Medium Priority Sub-watersheds

Ailport, Buck, Byman and Maxan Creeks all provide a significant contribution to the volume of the Upper Bulkley with the proportion of average runoff volume ranging from 4.5% to 27.5%. Each of these watersheds are designated an amber rating as they each exhibit unique water use allocations.

Of the six water licenses within Ailport Creek the main draw on water use (3.52%) is directed towards irrigation purposes. Irrigation use is generally distributed across the months of June, July, August and September. This use could correspond with seasonal low flows resulting in a possible impact on existing fish habitat. Ailport Creek has 74.10% of the total stream length accessible to fish, with 9.75% of this length identified as salmon habitat (Eclipse 2016). More accurate stream volumes are required to determine the relationship between low flows, irrigation, and fish habitat.

Buck Creek has a large number of domestic wells (31) and groundwater wells (13) registered within the sub-basin. The sub-watershed contributes a significant 27.5% of the volume towards the Upper Bulkley. Buck Creek has 91.92% of the total stream length accessible to fish, with 8.39 % of this length identified as salmon habitat (Eclipse 2016). More accurate stream volumes are required to determine if there is any concern between stream allocation, groundwater wells and fish habitat.

Byman Creek is unique because the majority of allocations within this sub-watershed are specific to two short-term approvals including an approval of 56,825 m^3/year to Canfor for industrial uses. Byman Creek has 99.18 % of the total stream length accessible to fish with 1.18 % of this length documented with salmon presence (Eclipse 2016).

Maxan Creek is assigned an amber rating because it is allocated 20.2% of the water allocations within the Upper Bulkley. The uses within this sub-watershed are focused on conservation/storage and land improvement. BC Environment is the licensee for the two conservation licenses. GoldCorp Canada Ltd. Equity Division is the licensee for the two land improvement licenses at Lu Lake and Lu Cree, as well as the stream storage license at Lu Lake. Maxan Creek has 98.19 % of the total stream length accessible to fish, with 4.16 % of this length documented with salmon presence (Eclipse 2016).

Low Priority Sub-Watersheds

The remaining thirteen sub-watersheds within the Upper Bulkley are rated as green (no follow up required) as they have minimal surface water allocations and very few ground wells registered.

7. REFERENCES

Data Sources

BC WELLS database taken from web site April 2017
https://catalogue.data.gov.bc.ca/dataset/ground-water-wells

GeoBC Surface Water Licenses and Points of Diversion taken from web site April 2017. https://catalogue.data.gov.bc.ca/dataset/bc-points-of-diversion-with-water-licence-information

Government of Canada Real Time Hydrometric Data. Taken from web site May 10th
https://wateroffice.ec.gc.ca/google_map/google_map_e.html?search_type=region&region=PYR

Northwest Water Tool. 2017. Taken from web site April 2017.
http://www.bcwatertool.ca/nwwt/#6/56.078/-126.716

General References

Brocklehurst, S. 1998. Historical data review on the Upper Bulkley River Watershed. Report prepared by J.O.A.T. Consulting for DFO, Smithers, BC.

Chapman, A., B. Kerr, D. Wilford. 2012. Hydrological Modelling and Decision-Support Tool Development for Water Allocation, Northeastern British Columbia; in Geoscience BC Summary of Activities 2011, Geoscience BC, Report 2012-1, 81-86.

Department of Fisheries and Oceans. 2005. Canada's Policy for Conservation of Wild Pacific Salmon. Fisheries and Oceans Canada, Vancouver, BC. Cat. No. Fs23-476/2005E

Eclipse Geomatics Information Systems (Eclipse). 2016. Upper Bulkley Fish and Aquatic Review Summary of Data, Methodology, Results, and Thresholds for Pressure Indicators Representing Key Freshwater Habitat Quantity. Prepared for the BC Ministry of Forests, Lands, Natural Resources Operations and Rural Development.

Gray, M. 2009. The BC Freshwater Atlas. Streamline Watershed Management Bulletin, Vol.12/No.2, 24- 26

Locke, A., and A. Paul. 2011. A Desk-top Method for Establishing Environmental Flows in Alberta Rivers and Streams. Alberta Environment and Alberta Sustainable Resource Development.

Nijman, R. (1986). Skeena-Nass Area Bulkley River Basin Water Quality Assessment and Objectives. *Water Management Branch, Government of BC*.

Remington, D. 1996. Review and Assessment of Water Quality in the Skeena River Watershed, British Columbia, 1995. Can. Data Rep. Fish. Aquat. Sci. 1003: 328 p.

Stalberg, H.C., Lauzier, R.B., MacIsaac, E.A., Porter, M., and Murray, C. 2009. Canada's policy for conservation of wild pacific salmon: Stream, lake, and estuarine habitat indicators. Can. Manuscr. Fish. Aquat. Sci. 2859: xiii + 135p.

Province of British Columbia. 2016. Determining the Likelihood of Hydraulic Connection - Guidance for the Purpose of Apportioning Demand from Diversion of Groundwater on Streams. Version 1.0. Water Science Series, WSS2016-01. Prov. B.C., Victoria B.C. http://www2.gov.bc.ca/gov/content/environment/air-landwater/water/water-science-data/water-science-series. https://wateroffice.ec.gc.ca/search/historical_e.html

Watson, B. Personal Communication. 2017.

Appendix A - Discontinued Water Survey of Canada Sites

WSC Site No.	**08EE009**		
Location:	**Richfield Creek Near Topley**		
Service Dates	**Type**	**Operational Schedule**	**Gauge Type**
1964 - 1965	Flow	Seasonal	Recorder
1966 - 1974	Flow	Continuous	Recorder

WSC Site No.	**08EE018**		
Location:	**Maxan Creek Above Bulkley Lake**		
Service Dates	Type	**Operational Schedule**	**Gauge Type**
1974 - 1979	Flow	Continuous	Recorder

WSC Site No.	**08EE019**		
Location:	**Maxan Creek at Outlet of Maxan**		
Service Dates	**Type**	**Operational Schedule**	**Gauge Type**
1974 - 1975	Flow	Miscellaneous	Manual
1976 - 1976	Flow	Continuous	Manual

WSC Site No.	**08EE015**		
Location:	**Foxy Creek Above Lu Creek**		
Service Dates	**Type**	**Operational Schedule**	**Gauge Type**
1974 - 1975	Flow	Seasonal	Manual

WSC Site No.	**08EE016**		
Location:	**Lu Creek Near the Mouth**		
Service Dates	**Type**	**Operational Schedule**	**Gauge Type**
1974 - 1975	Flow	Seasonal	Manual

Appendix B – Surface Water License Use Definitions