Streamflow

Hydrometric stations operated by the Water Survey of Canada were analyzed to identify several key parameters of flow characteristics in the study area, including:

total annual flow volumes

- inter-annual variability
- seasonal flow volumes

These analyses provide information useful to understanding flow conditions in the associated watersheds such as intra-annual timing of peak flows, periods of low flow and magnitude of flood and drought flow events. Regression analyses were performed on total annual flows, drought flows and peak flows to relate flow characteristics to watershed size, and can be found in the ungauged watersheds section.

Several hydrometric stations exist along the Peace River, between the W.A.C. Bennett Dam and the B.C. Alberta border. Data from these stations were not analyzed under the scope of this project as discharge from the dams at the western end of the valley is regulated by B.C. Hydro. Seasonal variations in discharge along the Peace do vary, as all of the watersheds reviewed as part of this project empty into the Peace and their yearly flow patterns influence conditions therein.

A number of tributary watersheds are found along the Peace River valley, and may provide potential sources of water. Portage, Lynx, and Dry Creeks, and Maurice and Johnson Creeks are found at the west end of the valley, nestled on the north and south sides of the Peace River, respectively, between the Farrell Creek and Moberly River watersheds and the Peace River. Wilder and Tea Creek are between the Cache Creek and Beatton River watersheds and the Peace River. Pingel, Six and Eight Mile Creek watersheds are between the Pine and Kiskatinaw River watersheds on the south side of the Peace River Valley. On the north side of the river in this part of the valley are Rudyk Coulee and Four Mile Creek watersheds.

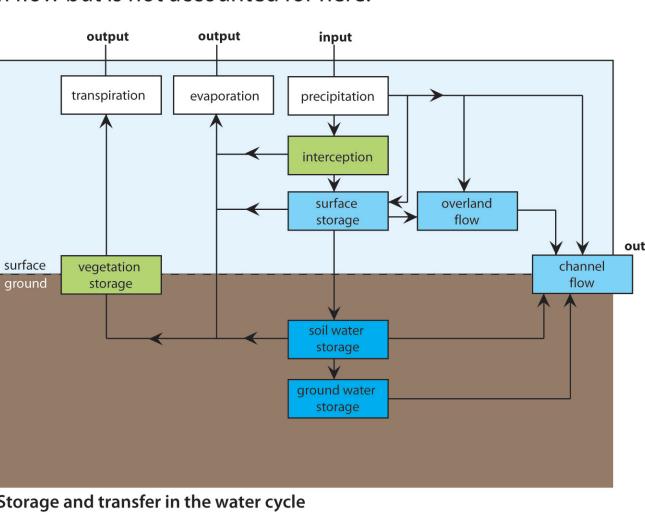
Watersheds in the Montney Water Project Area
(highlighted watersheds are in the Peace River Valley)
* Modified Strahler order, the number of upstream
branches in the watershed.
** Modified Shreves magnitude, the number of stream
segments contributing to the outlet of the watershed.

Watershed	Area (km²)	Stream Order*	Stream Magnitude**
Pine River	13497	8	23052
Halfway River	9358	8	18334
Kiskatinaw River	4053	6	3163
Moberly River	1897	6	2142
Pouce Coupe River	1633	6	1794
Cache Creek	935	6	850
Farrell Creek	643	5	597
Lynx Creek	320	5	220
Maurice Creek	262	5	226
Johnson Creek	210	5	324
Wilder Creek	100	4	119
Eight Mile Creek	96	4	50
Six Mile Creek	74	4	54
Dry Creek	58	3	29
Pingel Creek	41	4	48
Rudyk Coulee	40	3	18
Tea Creek	33	3	26
Four Mile Creek	12	2	10

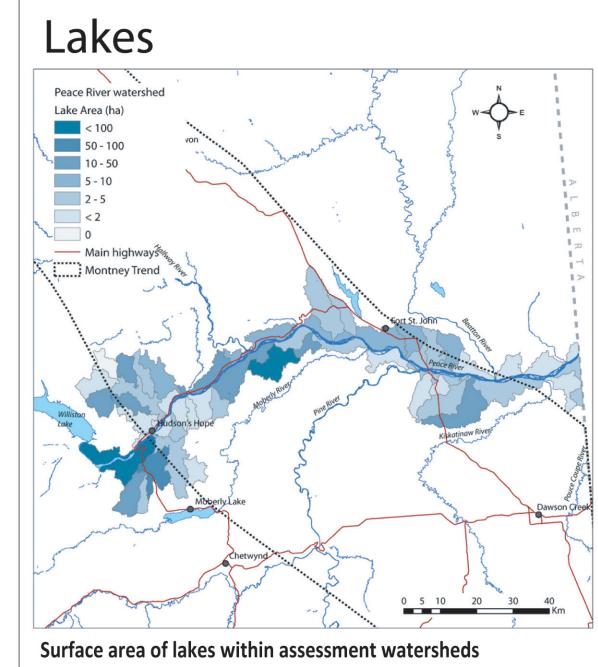
Water Balance

Creating a water balance for the hydrologic cycle weighs input to the system against outputs. Precipitation (rain and snowfall) are the only input to the system. Variations occur depending on when, where and at what rate precipitation occurs but for this purpose all of the water that enters the watershed leaves on an average annual basis. The three dominant processes that transport water out of the watershed are evaporation, transpiration and channel flow. Water that passes through ground water stores may take several years to exit the system. This complicates coupling water balances on a year to year basis. The relationship between ground water and surface water processes requires more in depth investigation, and in this application only considers ground water in communication with streams. Glacial meltwater may contribute to historical stream flow but is not accounted for here.

ClimateBC and ClimateWNA (see Future Climate section) are models which were used to produce mean annual precipitation maps for the watersheds. These maps were summed to calculate total volume of water input. Gauged streamflow records provide one output calculations, leaving evaporation, transpiration and loss to groundwater (ET/GW) unknown. The Consultative Group for International Agricultural Research estimate actual evapotranspiration to be in the range of 40 - 50 cm per year.

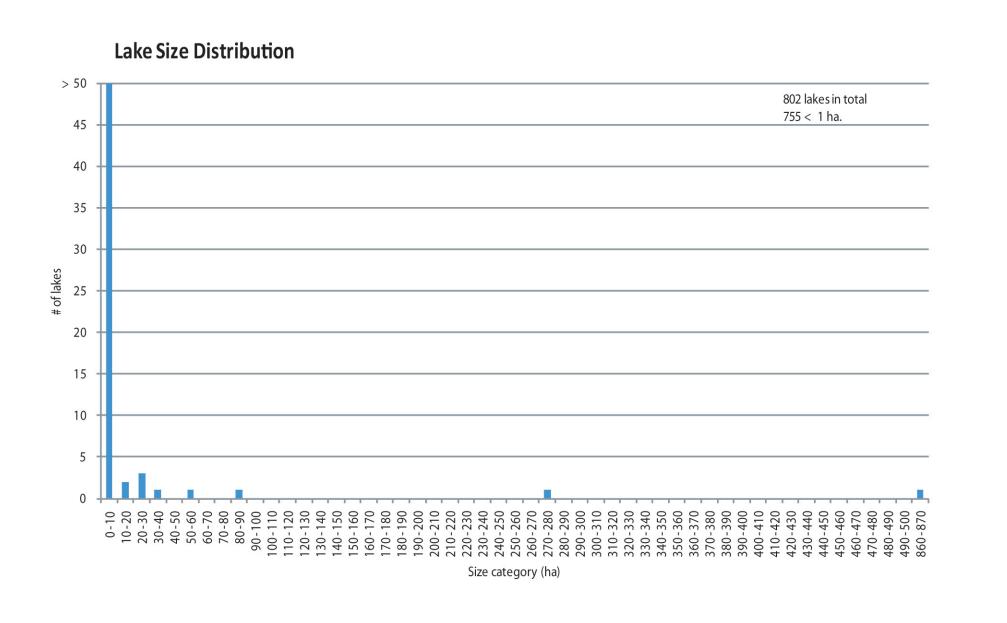


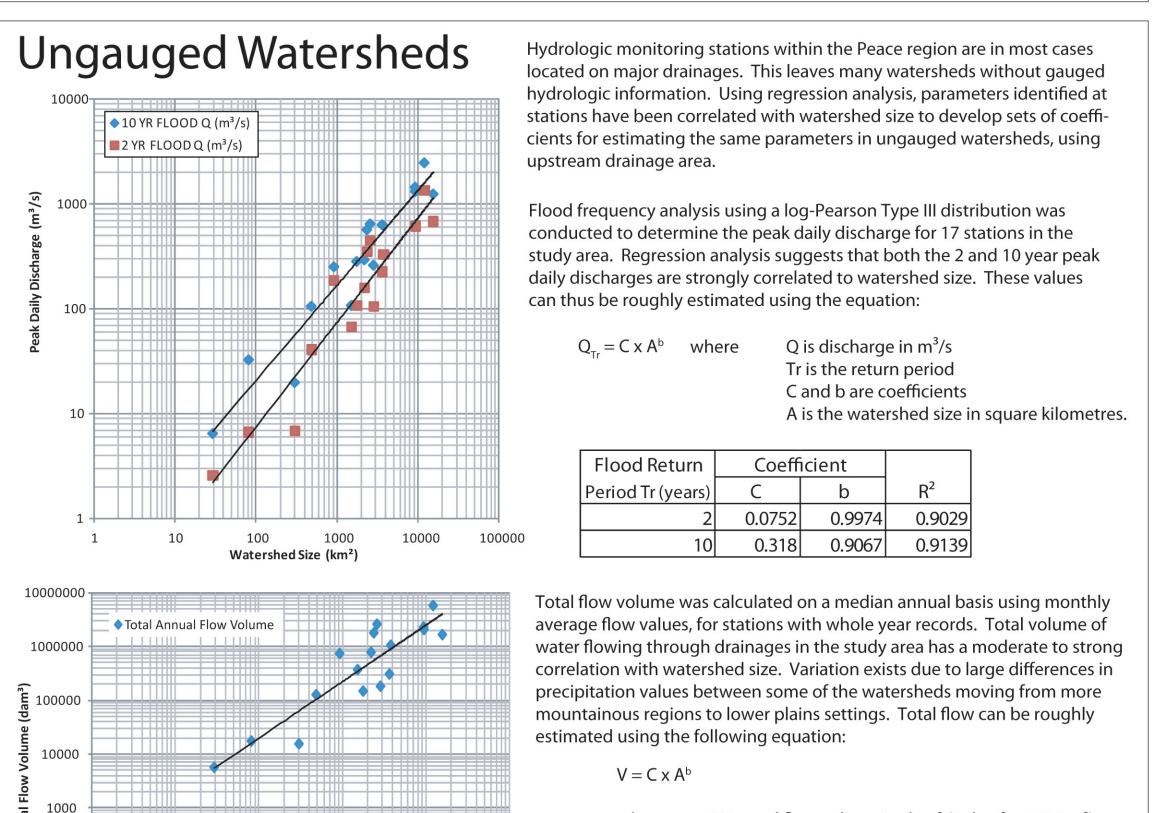
It was not possible to create a water balance for the Peace River Valley watersheds as there is no hydrometric data available. Consideration of water balances created for other watersheds in the Montney Water Project area, based on size and precipitation patterns may provide insight into the water balance in these watersheds. The water balances created for stations 07FC003 and 07FB008 are the closest analogues for the Peace River valley watersheds. Water balances for these watersheds are available in the accompanying report. Stations 07FB004 and 07FB005 in the Pine River watershed are located on very small drainages (88 and 35 km²) and may also be useful, however these are located at much higher eleva-



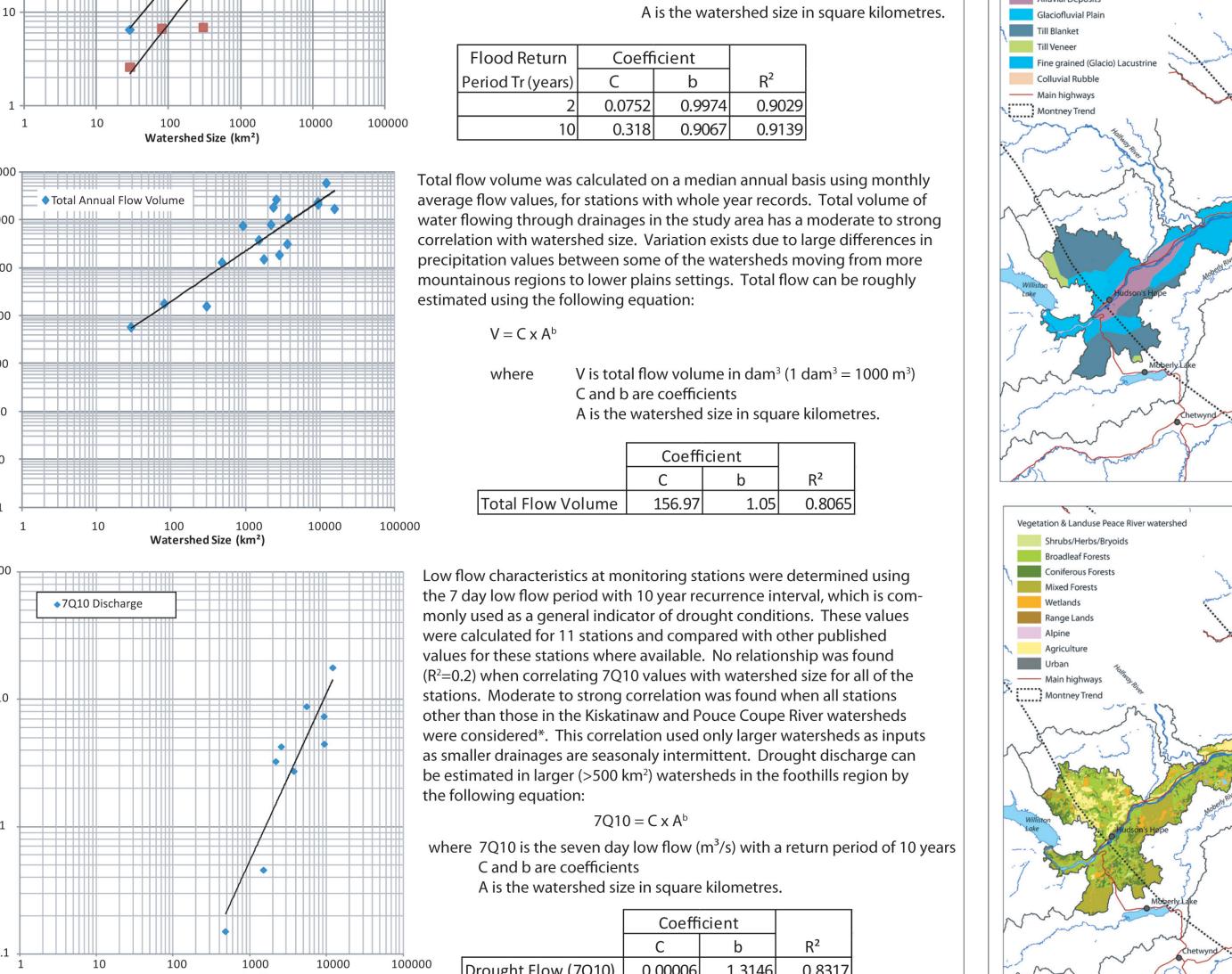
Approximately 800 lakes are mapped in the Peace River Valley and smaller tributary watersheds from the W.A.C. Bennett Dam to the Alberta border. Only 26 of these lakes are greater than 2 ha in size. A cluster of 5 larger lakes (> 20 ha) including Boudreau Lake are found on the south side of the Peace River across from the confluence with the Halfway River. Dinosaur Lake is the largest lake in the valley and is the reservoir for the Peace Canyon Dam just west of Hudson's Hope. Tower Lake is the largest lake in the lower Peace and is located on Eight Mile Creek, on the south side of the Peace River between the Pine and Kiskatinaw River water-

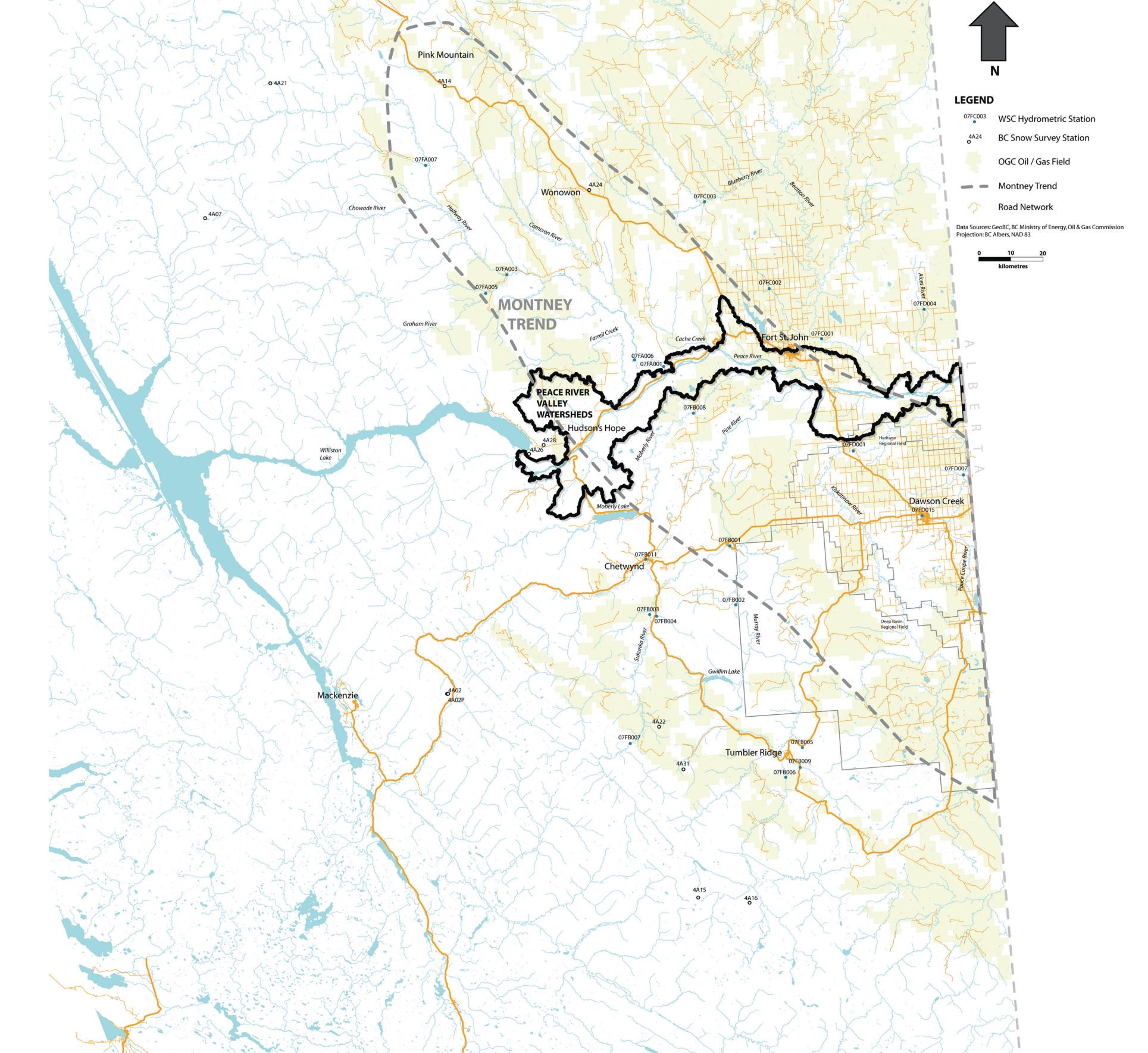
There are no lakes in the Peace River valley with publically available bathymetric data. Several hundred other lakes in the MWP area have had bathymetric surveys. These bathymetric maps have been collected by the B.C. Ministry of Environment and provide information such as maximum and average depths, perimeter, area and volume. All bathymetric maps are available in the database for this proj-





Methodology after British Columbia Streamflow Inventory, BC Ministry of Environment, 1998.

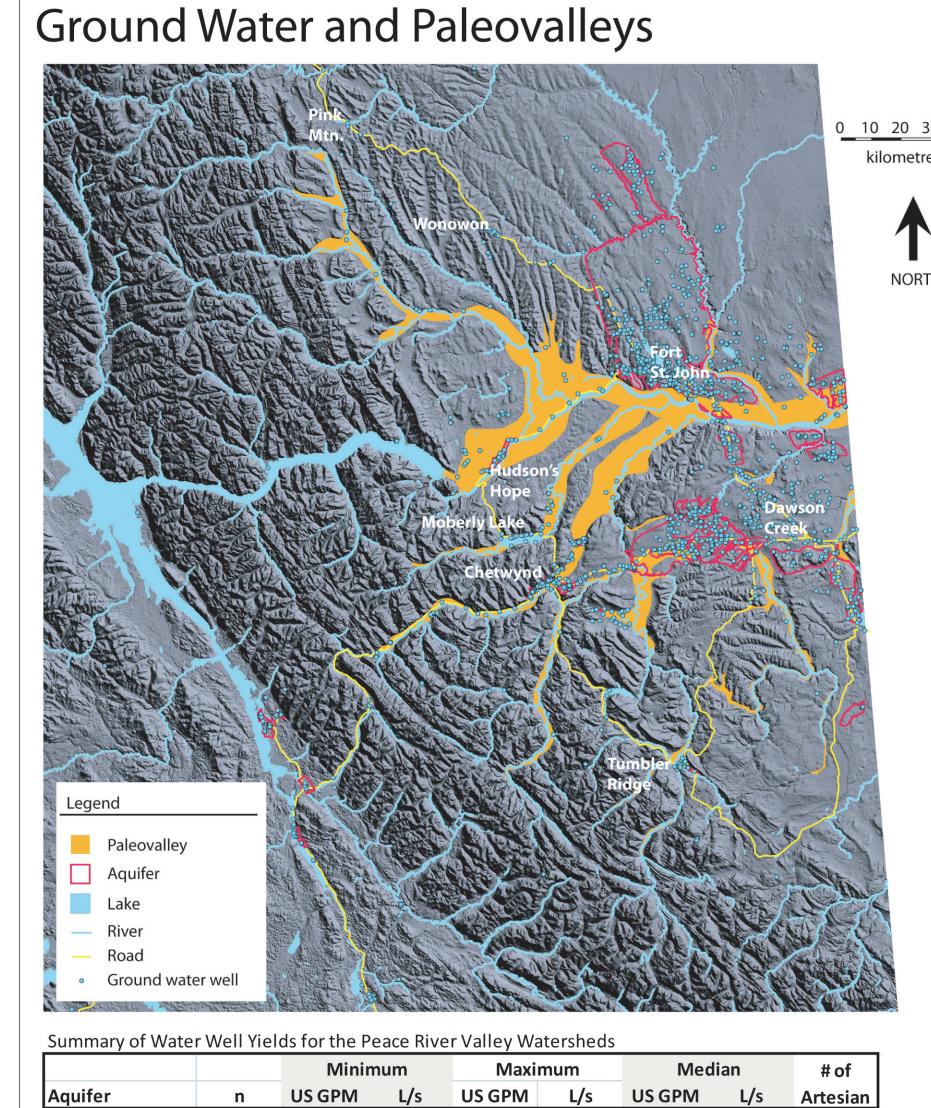




Surficial Materials and Land Use Most of the Peace River valley is glaciolacustrine sediments, with the valley benefits such as construction aggregate resource identification.

Baseline Thematic Mapping, GeoBC

sides composed of colluvium deposited by slope failures. The map to the left is coarse scale, national mapping at 1:5,000,000 scale. As part of the Montney Water Project more detailed mapping is being compiled into digital format. N.T.S. Map Sheets 94A and 93P will be available at 1:250,000 and 94A/SE and 93P/NE will be available at 1:50,000. Surficial material type is an important component for hydrological modelling and can provide other operational The B.C. Ministry of Forests Vegetation Resources Inventory provides detailed stand level mapping including tree species, age and height estimates. Coverage of the Montney Water Project area is not complete. GeoBC provides Baseline Thematic Mapping, which reflects current conditions as of the date of imagery of the product (1992) which is out of date for time sensitive or transitional areas (e.g. burned, logged, etc). A third data set useful in characterizing vegetation characteristics is the Biogeoclimatic Ecosystem Classification (BEC) Program which classifies the province into zones based on forest type, moisture and temperature. The Peace River valley is mostly broadleaf forest in the west near Hudson's Hope, and is extensively cultivated for agriculture moving eastwards towards and past Fort St. John. Scattered wetlands exist especially in the western part Aquifer Surficial Materials of Canada, GSC Map 1880A Undifferentiated 28 0.5 0.03 120.0 7.57 12.0 0.76 0 Vegetation Resources Inventory, BC Ministry of Forests and Range 90 0.5 0.03 150.0 9.46 6.0 0.38 nconsolidated 120 <0.1 <0.01 200.0 12.62 8.0 0.50 0



The majority of the Peace Region is covered by glacial and interglacial sediments deposited during repeated glaciations in the Quaternary Period. These sediments o 10 20 30 40 vary significantly in thickness. In some locations, bedkilometres rock is covered by a thin veneer of sediment or is exposed at surface. In others places, such as in pre-glacial buried paleovalleys, these sediments can be over 10 m thick. In many cases modern rivers occupy pre-glacial iver valleys and the thick unconsolidated valley-fill sediments may host aquifers with significant volumes of water. Areas with thick Quaternary sediments are targets for further aquifer evaluation.

> The BC Ministry of Environment maintains a database of water wells drilled in the province and delineates ground water aquifers based on this database and other geologic and hydrogeological information.

> As part of the Montney Water Project, geologic analysis is being performed by the B.C. Ministry of Energy to more accurately map the thicknesses of Quaternary sediments that may have potential for hosting water. The B.C. Ministry of Environment is collecting additional water well information, which is being used to update the online water well database and refine mapping of aguifers in unconsolidated sediments and bedrock.

This map illustrates the geographic distribution of water wells, currently mapped and classified aquifers and areas that likely have thick Quaternary sediment which will be evaluated for their aquifer potential.

Ground water Aquifers, B.C. Ministry of Environment aleovalleys, B.C. Ministry of Energy unpublished Ground water wells, B.C. Ministry of Environment

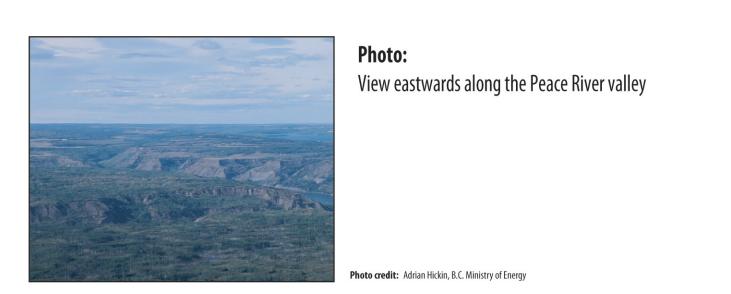
Peace River Valley Watersheds Overview

The Peace River valley is a broad plain from the W.A.C. Bennett Dam in the west to the B.C./Alberta border in the east (Figure 1). Four main tributaries flow north into the Peace River (Maurice, Pingel, Six Mile and Eight Mile Creeks); six tributaries flow south into the Peace (Lynx, Dry, Wilder, Tea, Four Mile Creeks and Rudyk Coulee) and one tributary occurs partially in B.C. but empties into the Peace River east of the B.C./Alberta border (Merlin Creek).

The communities of Fort St. John (population 19,000), Taylor (population 1,300) and Hudson's Hope (population 1,000) are all located in the valley. The City of Fort St. John is the largest regional service center in northeastern BC, servicing 60,000 people in the area.

The south-western most arm of the watershed including the banks of the Peace River from the W.A.C. Bennett Dam to Dinosaur Lake, and Maurice Creek watershed, is largely forested and unin habited. Lynx and Dry Creek, on the north side of the Peace River are still generally forested but contain more rural areas and farmland. Traveling east from Hudson's Hope to the B.C./Alberta border the watershed is dominated by settlements, farm and ranch land on the north side of the river. The watershed areas south of the Peace River from Hudson's Hope to Taylor are generally forested. Tributaries flowing north into the Peace River east of Taylor (Pingel, Six Mile and Eight Mile Creeks) change from forested to mostly agricultural in the rolling lowland areas.

The W.A.C. Bennett Dam is located in the most westerly part of this watershed with a second, Th Peace Canvon Dam, located 16km downstream. These dams together contribute to 1/3 of the elec trical power generated in the province. In addition, this watershed hosts natural gas, forestry, coal tourism and agriculture resources and related activities.



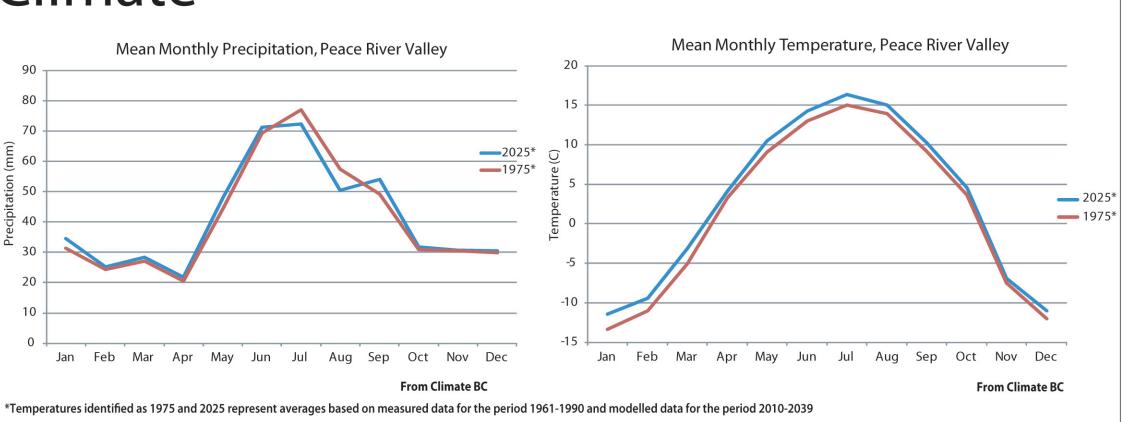
Peace Region

The Peace River originates in the mountains of British Columbia and forms the southwestern branch of the Mackenzie River System. From its headstreams in the Rocky Mountains the Peace River flows northeast into Alberta and eventually empties into the Slave River, which enters the Arctic Ocean through the Mackenzie basin. The Peace River's total course from the head of the Finlay is 1,923 km, and it covers a total area of 302,500 km². The B.C. portion of the Peace River basin covers an area of 41,600 km².

The largest tributaries of the Peace River basin in B.C. are the Pine, Halfway, Beatton, Moberly, and Kiskatinaw Rivers. The Peace River is influenced by BC Hydro's WAC Bennett and Peace Canyon Dams in the upper reaches of its drainage. These hydro-electric dams produce 31% of British Columbia's hydro-electric power.

The basin includes the major communities of Fort St. John, Dawson Creek, Chetwynd Mackenzie, Tumbler Ridge, and Hudson's Hope. Much of the basin is forested with significant natural gas exploration and production in the Montney shale gas play, a northwest to southeast trending geologic zone underlying the river basin from Pink Mountain to the BC border at Dawson Creek. Agricultural production occurs near the communities of Fort St. John and Dawson Creek. Natural gas, mining, agriculture, forestry, and tourism are the basis of the local and regional economies with mining and natural gas development being the biggest employers in the region.

Climate



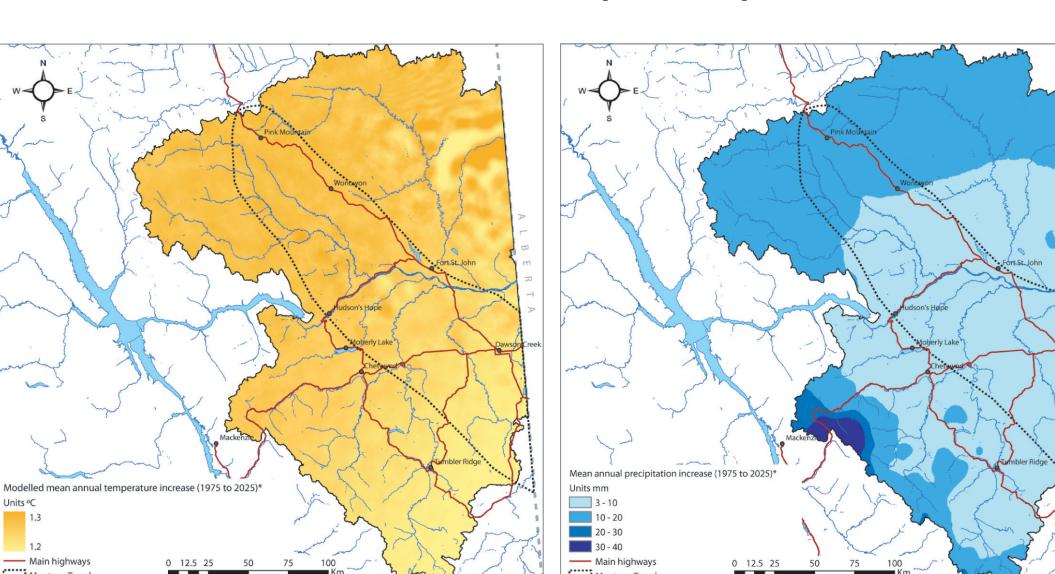
Along the Peace River Valley, the majority of precipitation occurs as rainfall during the summer. More precipitation falls on the plains above the valley slopes and at the west end of the valley near the W.A.C. Ben-

At Pine Pass, an automated snow pillow collects information on snow accumulations. Peak accumulation regularly occurs in April. Snow water equivalent (swe) is a standardized method of communicating the water volume in snow pack considering depth and density.

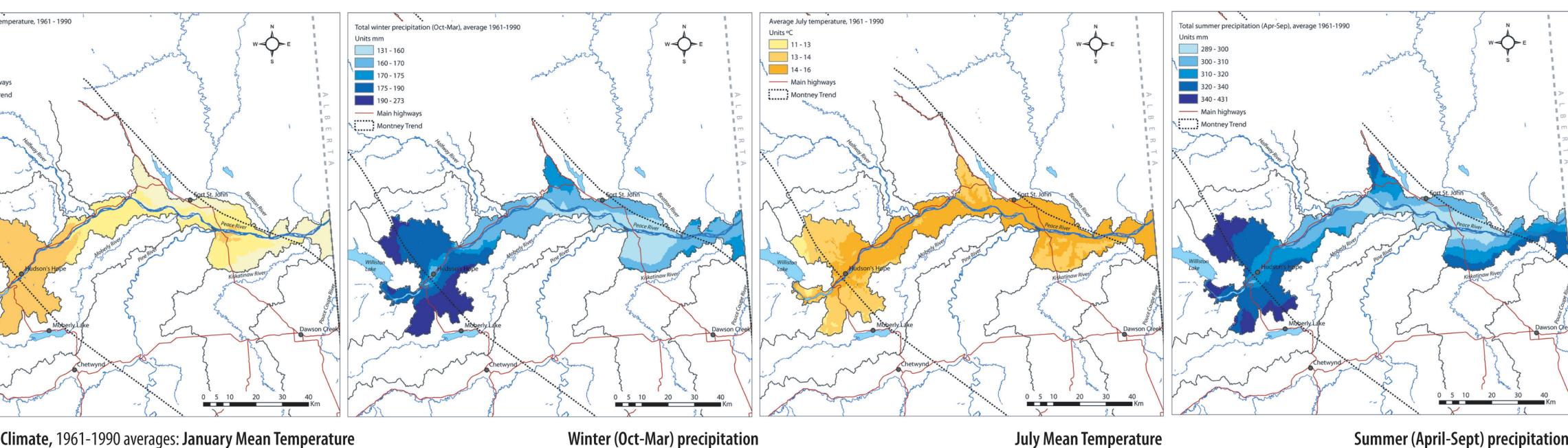
There are 14 other snow monitoring locations within or very near the Montney Water Project area, the majority of which are high in the mountains in the headwaters of the watersheds. Stations 4A25 at Fort St. John, and 4A26 and 4A28 at Portage and Bullhead Mountains near Hudson's Hope are in or near the Peace River Valley. Maximum accumulation at Fort St. John typically occurs in March.

Environment Canada, and the BC Ministries of Transportation and Forests operate weather stations throughout the Peace region. Climate data from these stations is available in the database for the project.

Future Climate Model (2025)



ClimateBC is a modelling program developed by researchers at the University of British Columbia in collaboration with the BC Ministry of Forests, in order to provide high resolution climate data for resource management in Western Canada. Recent updates have expanded the scope of the project to Western North America in ClimateWNA. These products are based on PRISM Climate Data developed by Oregon State University, with improved elevation related variations, additional modelled parameters, and the introduction of forward looking climate predictions based on a variety of global circulation models. Th period of normals (1961-1990) has been compared with predicted values for the period 2010-2039 using the CGCM2-A2x global circulation model. Mean annual temperatures as well as mean annual precipitation is expected to increase across the Peace region. Temperature is expected to increase in a relative way, consistent across the region, while the magnitude of precipitation will vary.



Seasonal Climate, 1961-1990 averages: January Mean Temperature All data from ClimateBC

Diagram of Hydrologic Cyc

discussion, and references.

For the surface water component of the Montney Water Project, several parts of

the water cycle have been assessed and described. Themes include flow charac-

water balances and discussion of estimating conditions in ungauged watersheds.

Posters have been created highlighting key aspects of these themes, in each of the

accompanying the poster series, and includes additional analyses, more thorough

major watersheds in the region. Supporting information is available in a report

teristics in gauged watersheds, lake size distributions, climate and projected

future climate, groundwater, vegetation and surficial geology characteristics

July Mean Temperature

he Montney Shale Gas Play in northeast British Columbia is a world-class unconventional natural gas resource development. Operations in the Montney are moving into developmer drilling, which will increase the demand for water and deep sites for the disposal of fluids. Provincial, First Nations and local governments, industry, communities, and environmental groups all want to ensure that water sources are carefully managed during natural gas development. These stakeholders require detailed, scientifically-based and unbiased information about existing water resources to make appropriate policies, regulations and permit decisions as well as to support public discussion on issues related to water use.

In response to this need, Geoscience BC met with industry and government in early 2010 and began a collaboration to undertake water studies in the Montney area. The Project is designed to create a comprehensive database of surface water, ground water and deep saline aguifers in the Montney area.

Phase I of the study focuses on collecting, analyzing and interpreting available water information in the Montney region.

required, a second phase of the study will focus research on addressing remaining data gaps. Three components of the project are as follows: Surface Water: Collection and presentation of data on surface water system (lakes, streams and wetlands) and processes that control availability of water (timing and amount).

Unconsolidated and shallow bedrock: Unconsolidated and shallow bedrock aguifers host a significant source of water in the Peace Region. These aguifers are best developed in

Analysis of these components provides insight into important aspects of the regional water cycle, including seasonal flow conditions, climate, vegetation and land use

areas with thick Quaternary age sediments often associated with buried paleovalleys. This component of the MWP has focused on compiling a database of available surface and subsurface data that elucidates the thickness of the unconsolidated drift and the bedrock topography. These data will be used to model and map major drift thickness trends and bedrock topography which represent high potential target areas for water in unconsolidated aquifers.

Deep bedrock: Define and characterize candidate aquifers (water sources) and potential deep disposal zones, providing a general description and indicating the homogeneity of each aquifer. The work focuses in zones deeper than domestic water wells and in zones typically explored by the oil and gas sector, greater than 250 m below surface. Compilation of existing hydro-stratigraphic data and development of groundwater flow models for select areas will assist in the identification of regional aguifers with suitable reservoir characteristics, fluid content, and capacity to be viable source/disposal candidates.

Montney Water Project Partners:

440 - 890 W. Pender St.



Geoscience BC is an industry-led, industry-focused not-for-profit society. Its man-

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date includes the collection, interpretation and marketing of geoscience data and expertise to promote investment in resource exploration and development in British Columbia. Geoscience BC is funded through grants from the Provincial Government and works in partnership with industry, academia, government, First Nations and communities to attract mineral and oil & gas investment to B

Derek Brown, Janet Fontaine - Strategic West Energy Ltd Adrian Hickin - B.C. Ministry of Energy Ben Kerr, Norma Serra-Sogas, Merie Beauchamp - Foundry Spatial Ltd.



