Rook I Project

Environmental Impact Statement

Annex IV.1: Regional Meteorological and Hydrological Characterization Report

REGIONAL METEOROLOGICAL AND HYDROLOGICAL CHARACTERIZATION REPORT FOR THE ROOK I PROJECT

Prepared for:

NexGen Energy Ltd.

Prepared by:

Golder Associates Ltd.

March 2022

Executive Summary

The regional meteorological and hydrological characterization study was completed as part of the hydrology program to establish baseline conditions to support an Environmental Assessment (EA) of the Rook I Project (Project). The objective of the study was to provide long-term regional meteorology and hydrology records to characterize conditions at the Project as local monitoring data available to characterize meteorological and hydrological conditions were limited in duration. To achieve this objective, monitoring data were compiled from regional desktop data sources to compare with and extend the available local records and represent a wider range of conditions.

Meteorological monitoring at the Project began in 2015, and the Rook I Meteorological Station was expanded in 2018 to include additional parameters. A long-term meteorological record for the Project was developed for the years 1979 to 2017 using a combination of data from meteorological stations near the Project as well as global re-analysis products including European Re-analysis Interim (ERAI) data sourced from a numerical weather prediction system. Historical meteorological data were compiled from Environment and Climate Change Canada (ECCC) stations within 225 km of the Project including Fort McMurray, Cree Lake, Key Lake, and Cluff Lake. These observations were used to test the accuracy of ERAI data in the region by comparing total precipitation and air temperature for concurrent time periods at the location of each ECCC station. Given that the ERAI data agreed well with historical observations at regional meteorological stations on a monthly time step, ERAI data were used to compile long-term monthly records of total precipitation, air temperature, solar radiation, and dew point temperature. Using these data, monthly records of evaporation, evapotranspiration, and sublimation were developed.

Over the 40-year record, ERAI annual total precipitation ranged from 399 mm to 695 mm with a mean of 531 mm. In an average year, the total precipitation consists of 144 mm falling as snow and 387 mm falling as rain. The annual snowfall was range from 83 mm to 209 mm in the historical record. For the same 40-year period, annual lake evaporation loss was estimated to be 514 mm using the Penman Combined method (Dingman 2002), and terrestrial evapotranspiration was estimated to be 262 mm using the Granger and Gray (1989) model; input data for atmospheric loss calculations were based on ERAI data.

Historical hydrometric records were compiled for the regional watersheds that were found to best represent conditions along the Clearwater River near the Project. The hydrometric station on the Douglas River near Cluff Lake was identified as the best analogue for flows in the upper Clearwater River (to the confluence with the Mirror River) and has been in operation from 1975 to present. The hydrometric station on the Clearwater River at the outlet of Lloyd Lake outlet was identified as the best analogue for flows farther downstream along the Clearwater River within Saskatchewan and was in operation from 1973 to 1995. Annual water yield in the Clearwater River at the outlet of Lloyd Lake ranged from 120 mm to 199 mm, and averaged 171 mm. Annual water yield in the Douglas River ranged from 103 mm to 292 mm, and averaged 175 mm.

This report summarizes climatic variability and the streamflow regime for the Project. The baseline meteorological and hydrological characterization study achieved study objectives, including describing historical meteorological and hydrological conditions in the baseline study area to support the EA and related studies such as hydrological modelling.

If referencing this report, please use for the following citation:

Golder (Golder Associates Ltd.). 2022. Regional Meteorological and Hydrological Characterization Report for the Rook I Project. Prepared for NexGen Energy Ltd.

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Abbreviations and Units of Measures

Abbreviation	Definition
EA	Environmental Assessment
ECCC	Environment and Climate Change Canada
ECMWF	European Centre for Medium-Range Weather Forecasts
ERAI	European Re-analysis Interim
GlobSnow	Global Snow Monitoring for Climate Research
Golder	Golder Associates Ltd.
ID	identification
IDF	intensity-duration-frequency
LSA	local study area
MLE	maximum likelihood estimation
MLM	method of L-moments
MOM	method of moments
NexGen	NexGen Energy Ltd.
NHC	Northwest Hydraulic Consultants Ltd.
PMP	probable maximum precipitation
Project	Rook I Project
RSA	regional study area
SWE	snow water equivalent
TLU	Traditional Land Use
WSC	Water Survey of Canada

Unit	Definition
%	percent
°	degree
°C	degrees Celsius
km	kilometre
km^2	square kilometre
$L/s/km^2$	litres per second per square kilometre
m	metre
m^3/s	cubic metres per second
mm	millimetre
mm/h	millimetres per hour
W/m^2	watts per square metre

1.0 INTRODUCTION

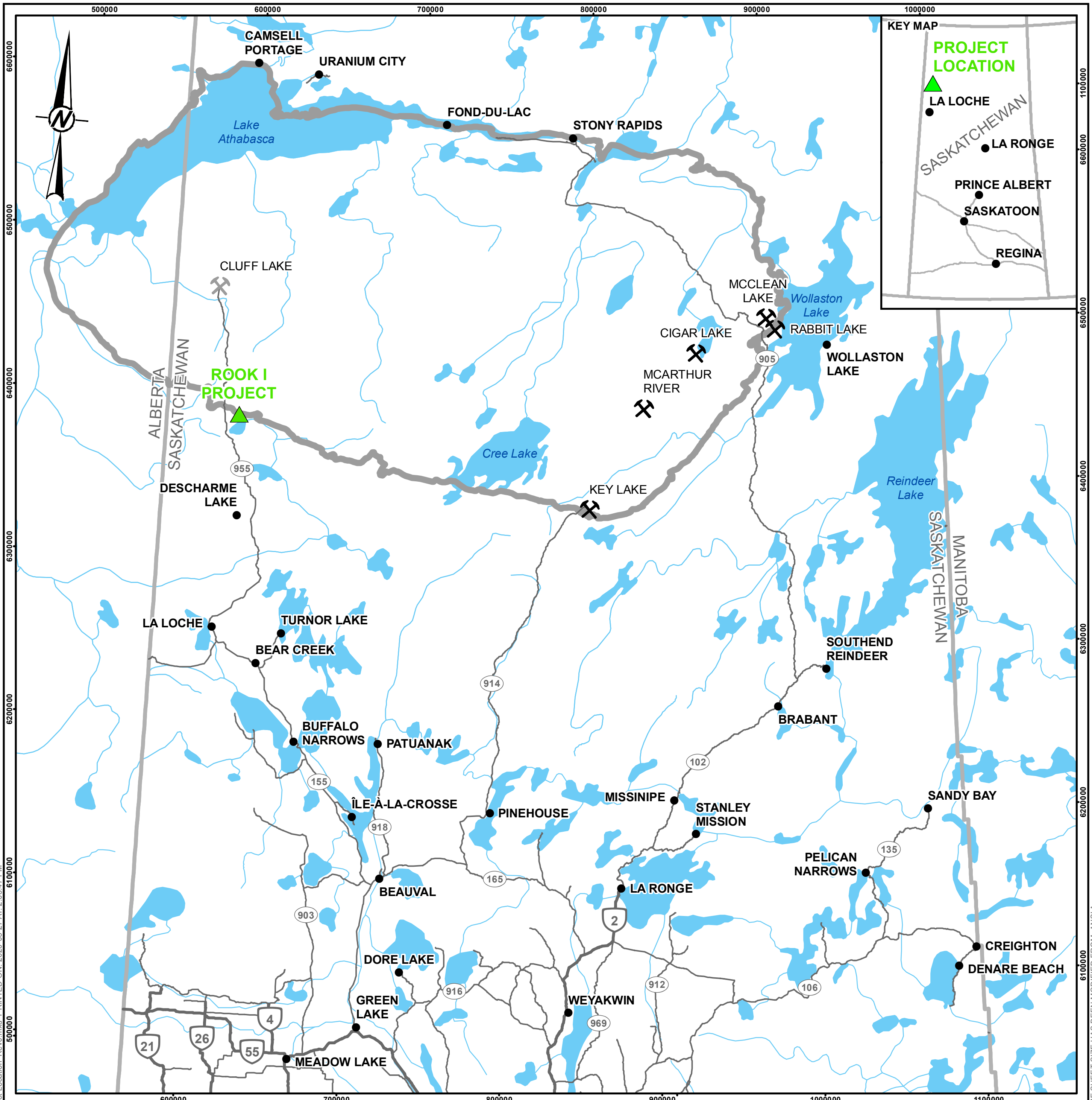
The Rook I Project (Project) is a proposed new uranium mining and milling operation that is 100% owned by NexGen Energy Ltd. (NexGen). The Project would be located in northwestern Saskatchewan, approximately 40 km east of the Saskatchewan-Alberta border, 130 km north of the town of La Loche, and 640 km northwest of the city of Saskatoon (Figure 1). The Project would reside within Treaty 8 territory and within the Métis Homeland. At a regional scale, the Project would be situated within the southern Athabasca Basin adjacent to Patterson Lake, and along the upper Clearwater River system (Figure 2). Access to the Project would be from an existing road off Highway 955. The Project would include underground and surface facilities to support the extraction and processing of uranium ore from the Arrow deposit, a land-based, basement-hosted, high-grade uranium deposit.

The regional meteorological and hydrological baseline report represents a component of a comprehensive baseline program that documents the natural and socio-economic environments in the anticipated area of the Project. The hydrological baseline program, of which the regional meteorological and hydrological baseline study is a part, was undertaken to provide context from which Project environmental hydrological effects could be assessed in the Environmental Impact Statement.

Since exploration at the Project commenced in 2013, NexGen has engaged regularly and established relationships with local First Nation and Métis Groups (collectively referred to as Indigenous Groups) and northern communities, specifically those closest and with greatest access to the proposed Project. NexGen respects the rights of Indigenous Peoples and the unique relationship Indigenous Peoples have with the environment, and recognizes the importance of full and open discussion with interested or potentially affected Indigenous communities regarding the development, operation, and decommissioning of the proposed Project. Engagement activities to date, as well as future planned engagement activities, reflect the value NexGen places on meaningful engagement with Indigenous Groups and northern communities who could be potentially affected by the proposed Project. Engagement mechanisms have included, but are not limited to: meetings with leadership, workshops and community information sessions, Project site tours, establishing Joint Working Groups to support the gathering and incorporation of Indigenous and Local Knowledge throughout the Environmental Assessment (EA) process, and providing funding for Traditional Land Use (TLU) Studies[1] to understand how the proposed Project may interact with the Indigenous communities' traditional use of the anticipated area of the Project.

Feedback received during engagement activities was documented for contribution to the EA for the Project; examples of feedback received include discussion of concerns, interests, potential adverse effects, mitigation, and design alternatives. Many baseline studies were initiated in advance of formal engagement on the EA for the Project; however, engagement during the execution of baseline studies has helped inform the understanding of baseline conditions and confirmed components of the natural and socio-economic environments that required study. A summary of feedback related to the hydrometric monitoring baseline program is presented in Appendix A of the Hydrology Road Map (Annex IV).

[1] Traditional Land Use (TLU) Studies include all land use studies developed by the Project's affected Indigenous Groups, including Traditional Land Use and Occupancy studies, Traditional Knowledge and Use studies, and Indigenous Rights and Knowledge studies, henceforth referred collectively as TLU Studies.



LEGEND

- POPULATED PLACE
- URANIUM MINING FACILITY (ACTIVE)
- URANIUM MINING FACILITY (DECOMMISSIONED)
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- WATERCOURSE
- WATERBODY
- ATHABASCA BASIN BOUNDARY
- PROJECT LOCATION

0 100 200

1:3,500,000 KILOMETRES

REFERENCE(S)

1. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT

NexGen Energy Ltd.

PROJECT

ROOK I PROJECT

TITLE

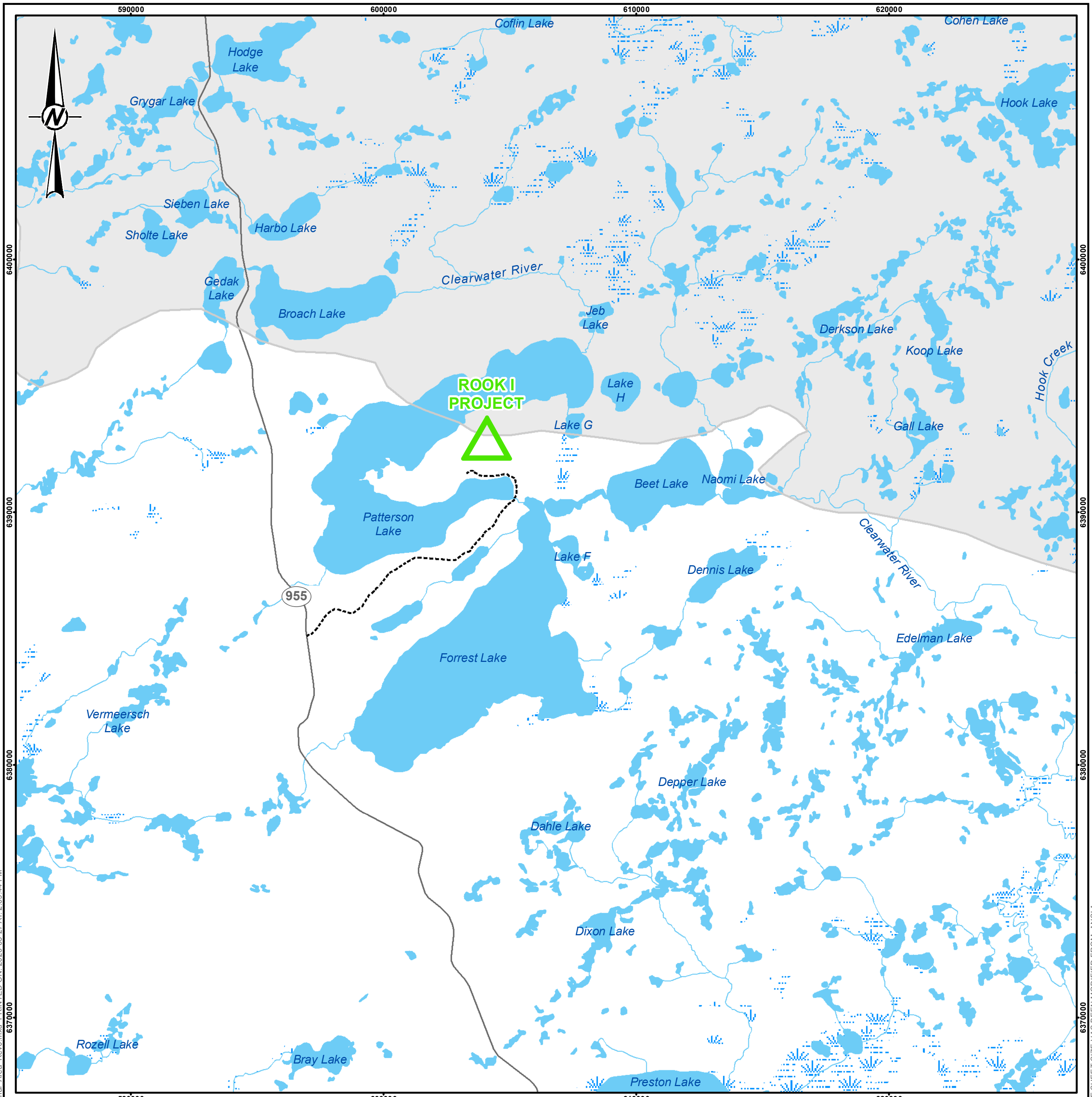
LOCATION OF THE ROOK I PROJECT, SASKATCHEWAN

CONSULTANT

GOLDER

YYYY-MM-DD	2020-03-27
DESIGNED	SS
PREPARED	NO/AK
REVIEWED	JMC
APPROVED	MM

PROJECT NO.	PHASE	REV.	FIGURE
19114981		0	1



LEGEND

- SECONDARY HIGHWAY
- WATERCOURSE
- WATERBODY
- WETLAND
- ATHABASCA BASIN
- PROJECT LOCATION
- EXISTING ACCESS ROAD

0 5,000 10,000

1:225,000 METRES

REFERENCE(S)

1. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
NexGen Energy Ltd.

PROJECT
ROOK I PROJECT

TITLE
REGIONAL AREA OF THE ROOK I PROJECT

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-27
DESIGNED	JMC
PREPARED	NO/AK
REVIEWED	JMC
APPROVED	MM

PROJECT NO.	PHASE	REV.	FIGURE
19114981		0	2

2.0 STUDY OBJECTIVES

The overall objective of this baseline study was to describe the existing regional meteorological and hydrological conditions in the baseline study area to support the EA of the Project. Long-term meteorological and hydrological records were necessary to complete the hydrological modelling. Long-term records account for a wide range of climatic variability and, in turn, hydrological variability, and allow for the assessment of routine conditions as well as extreme runoff events.

The specific objectives of the study were to:

- characterize the natural variability of climate in the region and the anticipated area of the Project;
- characterize the natural variability of flows in regional watersheds with published long-term data records to provide an estimate of the expected variability of flows in the Clearwater River;
- develop a long-term baseline record of hydro-meteorological variables to support the quantitative assessment of changes in surface water quantity; and
- acquire accurate baseline information that supports the Project EA.

3.0 STUDY AREAS

The baseline study areas considered in the hydrological baseline program include the following and are shown on Figure 3:

- local study area (LSA): the Clearwater River watershed to the outlet of Naomi Lake; and
- regional study area (RSA): the Clearwater River watershed above the confluence with the Mirror River.

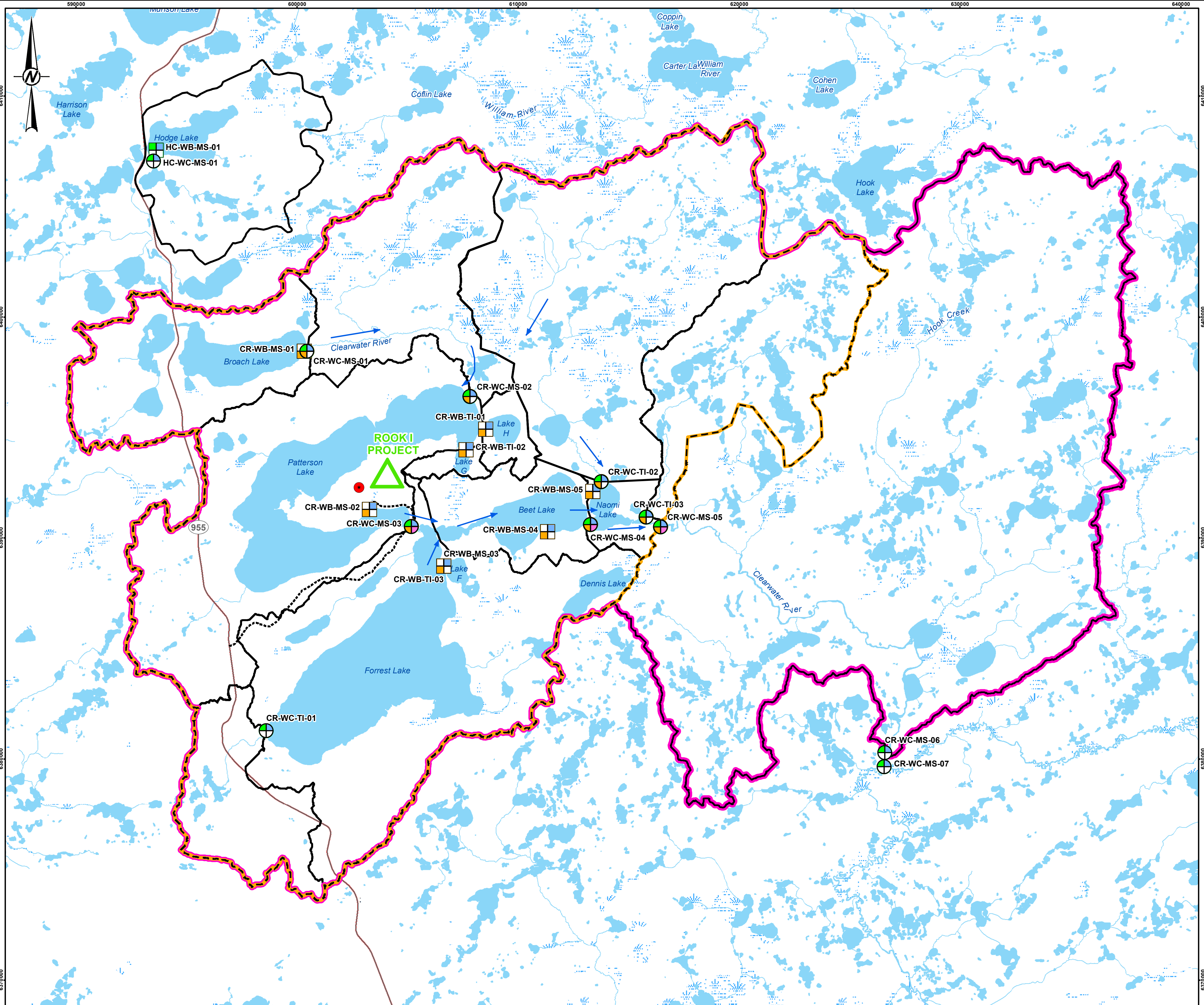
The proposed Project would be located adjacent to Patterson Lake, which is in the upper portion of the Clearwater River system at Broach Lake. The Clearwater River upper reach flows from Broach Lake through a series of lakes including Patterson Lake, Forrest Lake, Beet Lake, and Naomi Lake (listed in order from upstream to downstream). From Naomi Lake, the Clearwater River flows 20 km southeast before reaching the Mirror River confluence. Below the Mirror River confluence, the river deepens with higher flow volumes from the Mirror River, and the channel form changes to meandering within a well-defined river valley. Farther downstream, the Clearwater River flows through Lloyd Lake, which is immediately upstream of Clearwater River Provincial Park; the downstream end of the park is at the Saskatchewan-Alberta border.

Hydrological baseline studies focused on the Clearwater River watershed upstream of the Patterson Lake outlet and along the main lake chain downstream, including Forrest Lake, Beet Lake, Naomi Lake, and the reaches of the Clearwater River separating these lakes.

Based on the potential effects of the Project and hydrologic characteristics of the region, the LSA is defined as the Clearwater River watershed to the Naomi Lake outlet (Figure 3). The Clearwater River watershed above the Naomi Lake outlet drains an area of 685 km^2. Seven waterbody monitoring locations are included in the LSA. Five of the monitored waterbodies are along the main lake chain: Broach Lake, Patterson Lake, Forrest Lake, Beet Lake, and Naomi Lake. The remaining waterbodies, Lake G and Lake H, may be influenced by Project activities. There are eight watercourse monitoring locations in the LSA: Broach Lake outflow, Patterson Lake inflow, Patterson Lake outflow, Beet Lake outflow, Naomi Lake, and three tributaries that flow into the Clearwater River mainstem (Figure 3).

The RSA for hydrology includes waterbodies and watercourses within the Clearwater River watershed above the Mirror River confluence, which includes the LSA. The Clearwater River watershed above the Mirror River confluence drains an area of 1,070 km^2. The spatial extent of the Clearwater River watershed above the Mirror River confluence is expected to provide an ecologically relevant RSA for the EA. The RSA spans an area that provides habitat requirements for a discernible population unit for large-bodied fish species where cumulative effects may occur. The hydrometric stations in the RSA are shown in Figure 3.

There are three hydrometric stations at locations of interest downstream of the RSA boundary; these are referred to as far-field stations. These locations contribute valuable information about hydrological variation in the upper Clearwater River and include the Clearwater River below Mirror River confluence, at the outlet of Lloyd Lake, and above Warner Rapids. Locations and watershed boundaries for the three far-field hydrometric stations relevant to the hydrology baseline program are shown in Figure 4.



LEGEND

FLOW DIRECTION
SECONDARY HIGHWAY
WATERCOURSE
WATERBODY
WETLAND

PROJECT FEATURES
EXISTING ACCESS ROAD
PROJECT LOCATION

METEOROLOGICAL STATION

WATERBODY HYDROMETRIC STATIONS
DISCHARGE
SURVEYED BENCHMARK (GEODETIC DATUM)
TOTAL SUSPENDED SOLIDS AND BEDLOAD
WATER SURFACE ELEVATION

WATERCOURSE HYDROMETRIC STATIONS
DISCHARGE
SURVEYED BENCHMARK (GEODETIC DATUM)
TOTAL SUSPENDED SOLIDS AND BEDLOAD
WATER SURFACE ELEVATION

HYDROLOGY LOCAL STUDY AREA
HYDROLOGY REGIONAL STUDY AREA
WATERSHED

0 3,500 7,000
1:175,000 METRES

REFERENCE(S)
1. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
2. WATERSHEDS DELINEATED BY GOLDER USING GREENKENUE SOFTWARE BASED ON CANADIAN DIGITAL ELEVATION DATA AND NATIONAL HYDROGRAPHIC NETWORK WATERCOURSES.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
NexGen Energy Ltd.

PROJECT
ROOK I PROJECT

TITLE
HYDROLOGY BASELINE STUDY AREAS

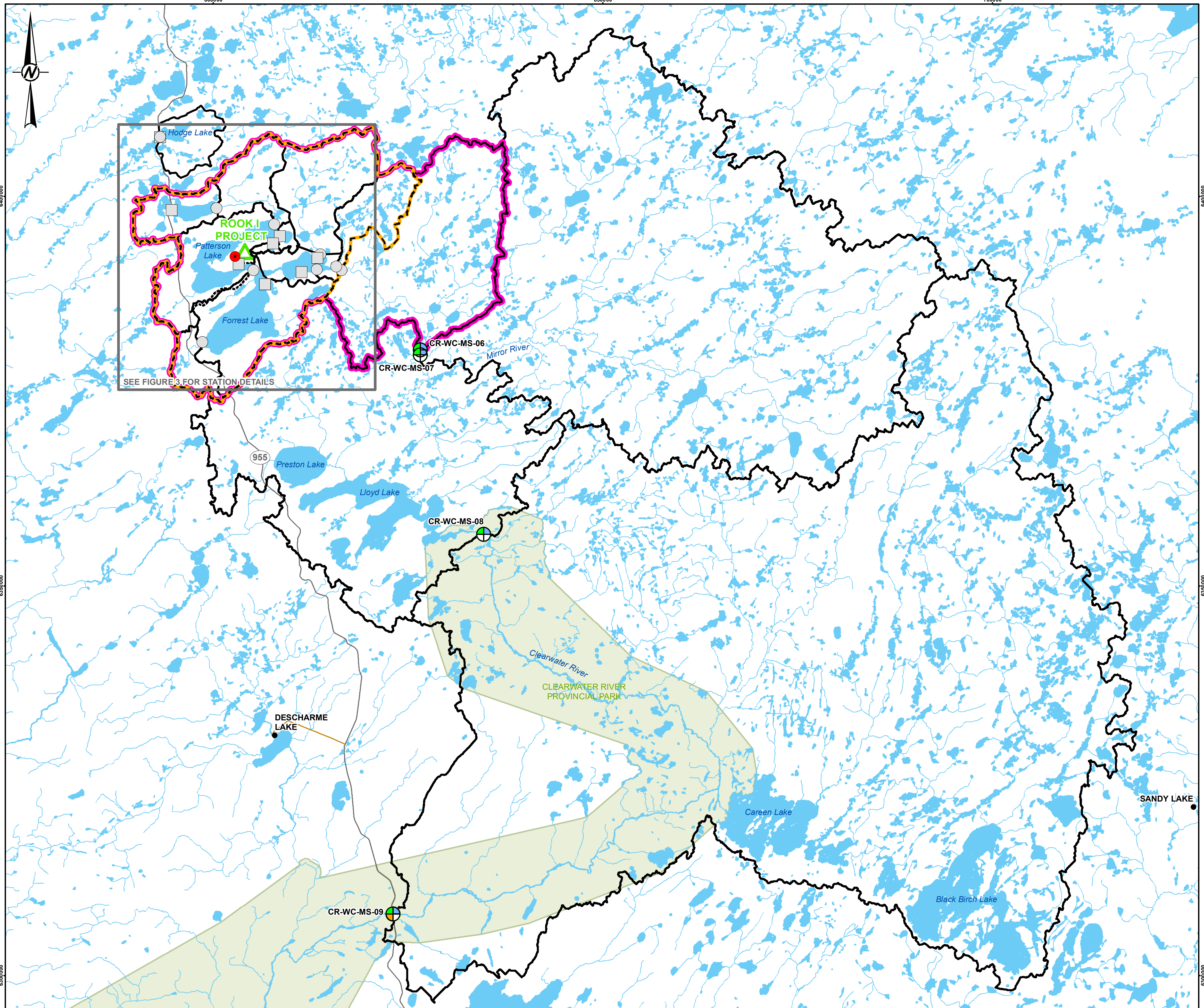
CONSULTANT
GOLDER

YYYY-MM-DD	2022-02-17
DESIGNED	JH
PREPARED	NO
REVIEWED	RP
APPROVED	KS

PROJECT NO.	PHASE	REV.	FIGURE
20138965	1000	0	3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

PATH: I:\CLIENTS\NexGen\20138965\Mapping\Products\Hydrology\Fig3_20138965-1000_Hydrology_BaselineStudyArea_Rev0.mxd



LEGEND

- POPULATED PLACE
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- PARK
- WATERBODY

PROJECT FEATURES

- EXISTING ACCESS ROAD
- PROJECT LOCATION

- METEOROLOGICAL STATION

WATERBODY HYDROMETRIC STATIONS

- DISCHARGE
- SURVEYED BENCHMARK (GEODETIC DATUM)
- TOTAL SUSPENDED SOLIDS AND BEDLOAD
- WATER SURFACE ELEVATION

WATERCOURSE HYDROMETRIC STATIONS

- DISCHARGE
- SURVEYED BENCHMARK (GEODETIC DATUM)
- TOTAL SUSPENDED SOLIDS AND BEDLOAD
- WATER SURFACE ELEVATION

- HYDROLOGY LOCAL STUDY AREA
- HYDROLOGY REGIONAL STUDY AREA
- WATERSHED

0 10 20

REFERENCE(S)

1. PROJECT FEATURES OBTAINED FROM NEXGEN, OCTOBER 28, 2019.
2. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
3. WATERSHEDS DELINEATED BY GOLDER USING GREENKENUE SOFTWARE BASED ON CANADIAN DIGITAL ELEVATION DATA AND NATIONAL HYDROGRAPHIC NETWORK WATERCOURSES.

PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT

NexGen Energy Ltd.

PROJECT

ROOK I PROJECT

TITLE

FAR-FIELD HYDROMETRIC STATIONS

CONSULTANT

GOLDER

YYYY-MM-DD	2022-02-17
DESIGNED	JH
PREPARED	NO
REVIEWED	RP
APPROVED	NS

PROJECT NO.	PHASE	REV.	FIGURE
20138965		0	4

4.0 METHODS

4.1 Review of Existing Information

Northwest Hydraulic Consultants Ltd. (NHC) completed a desktop hydrology and geomorphology analysis to assess the likely changes to receiving waters from the proposed Project (NHC 2016). The NHC assessment assumed that annual treated effluent discharge from the proposed Project would be about 0.13 m^3/s, with maximum discharge rates that could be an order of magnitude higher. Five potential effluent discharge sites were assessed in terms of their estimated assimilation capacity and potential geomorphological changes from increased discharge. The sites were in various watersheds surrounding the anticipated area of the Project, including Rozell Lake, Vermeersche Lake, the Davidson River tributary, Patterson Lake, and the William River. The NHC (2016) report recommended Patterson Lake as a preferred treated effluent discharge site due to proximity to the proposed Project, high percentage of lake coverage in the watershed, and the highest year-round flows compared to other potential locations (NHC 2016).

Northwest Hydraulic Consultants (NHC 2016) recommended three active Water Survey of Canada (WSC) hydrometric stations to represent the hydrology of the anticipated area of the Project: Station 07QC008 Charlot River at the Webb Lake outlet, Station 07DA018 Beaver River north of the Syncrude project, and Station 07MA003 Douglas River near Cluff Lake. The lattermost station (WSC Station 07MA003) is carried forward as an analogue for the hydrology RSA due to its advantages of having a long period of record (i.e., 1975 to present), similar terrain as the Patterson Lake watershed (i.e., being typical of the Athabasca Sedimentary Basin geology), and closer proximity.

Previous hydrology baseline studies have been completed at other locations in the Athabasca Sedimentary Basin and data collection may be ongoing, but recent data from the hydrology monitoring locations are not publicly available. Selected regional Environment and Climate Change Canada (ECCC) meteorological stations that have publicly available data were used in this study.

4.2 Establishing a Long-Term Meteorological Dataset

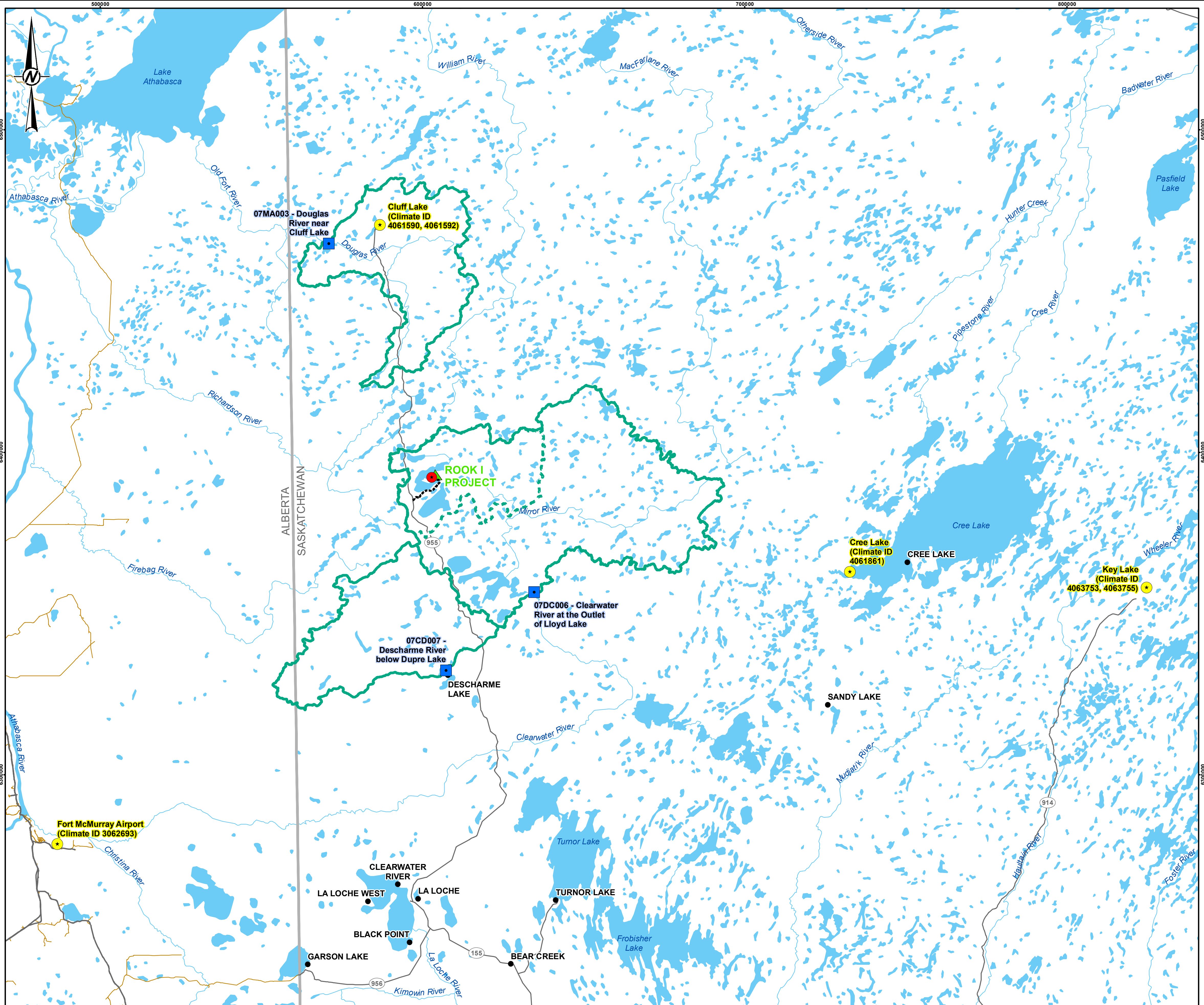
Long-term historical meteorological data are not available near the proposed Project location. Long-term historical meteorological data are available from six meteorological stations, at four locations in the region, operated by ECCC within a 225 km radius of the anticipated area of the Project. These are summarized in Table 1 and shown in Figure 5.

A continuous historical daily climate data record (1979 to 2019) was developed based on data collected in the anticipated area of the Project, relationships to regional data, and European Re-analysis Interim (ERAI) data. European Re-analysis Interim is a global climate re-analysis dataset that is available from January 1979 to August 2019, produced by the European Centre for Medium-Range Weather Forecasts (ECMWF). The details about data assimilation method, forecast model, and input dataset have been documented by the ECMWF (2007) and Dee et al. (2011). The grid-based dataset is publicly available to download with an approximate 80 km spatial resolution on 60 vertical levels from the surface up to 0.1 hectopascal. The temporal resolution of the surface level parameters such as precipitation is twice daily data or forecasts (i.e., from 00 and 12 Coordinated Universal Time). However, some parameters such as wind speed are output at six-hour frequency (i.e., four times per day).

Table 1: Regional Environment and Climate Change Canada Meteorological Stations

Station Number	Station Name[(a)]	Elevation (masl)	Distance to Project (km)	Period of Record
4061590	Cluff Lake	330.1	76	1980 to 1999
4061592	Cluff Lake Auto	330.0	76	1996 to 2005
4061861	Cree Lake	494.6	145	1969 to 1996
4063753	Key Lake Airport	513.9	222	2010 to present
4063755	Key Lake	509.0	225	1953 to present
3062693	Fort McMurray Airport	369.1	170	1976 to present

masl = metres above sea level. a) All stations are or were operated by Environment and Climate Change Canada.



LEGEND

- POPULATED PLACE
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- WATERBODY
- HYDROMETRIC STATION - ENVIRONMENT CANADA
- METEOROLOGICAL STATION - ENVIRONMENT CANADA
- METEOROLOGICAL STATION - ROOK I
- WATERSHED
- CLEARWATER RIVER ABOVE THE MIRROR RIVER

PROJECT FEATURES

- EXISTING ACCESS ROAD
- PROJECT LOCATION

REFERENCE(S)

PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT

NexGen Energy Ltd.

PROJECT

ROOK I PROJECT

TITLE

LOCATION OF REGIONAL METEOROLOGICAL AND HYDROMETRIC STATIONS

CONSULTANT

GOLDER

YYYY-MM-DD	2022-02-17
DESIGNED	RP
PREPARED	LMS
REVIEWED	RWP
APPROVED	NPS

PROJECT NO.	PHASE	REV.	FIGURE
19114981	7000	0	5

0
25mm

Data Comparison

To test the validity of ERAI data for the anticipated area of the Project, ERAI total precipitation and air temperature data were compiled for the regional ECCC meteorological stations and compared to historical observations for the overlapping time period. Accumulated precipitation data over 12-hour intervals from 1 January 1979 to 31 August 2019 were downloaded from the ECMWF data server using the Python program. Data extraction and processing were completed using MATLAB (The Mathworks 2021). The desired area to download meteorological data was bounded by four points (i.e., longitude [long] -112°, latitude [lat] 59°; long -105°, lat 59°; long -105°, lat 56°; long -112°, lat 56°) and targeted the location of the regional ECCC meteorological stations at Cluff Lake, Cree Lake, Fort McMurray, Key Lake, and the anticipated area of the Project.

A statistical summary of ERAI total precipitation data for the regional ECCC meteorological stations is presented in Table 2, along with ECCC's published Climate Normals for the years 1981 to 2010 (ECCC 2019a). The ERAI data were also compiled for the same period (i.e., 1981 to 2010) for comparing Climate Normals between the two datasets.

Table 2: Annual Total Precipitation Compiled for the Locations of Regional Meteorological Stations (1981 to 2010) Compared to Climate Normals (1981 to 2010)

Summary Statistic		Annual Total Precipitation (mm)				
		Cree Lake	Fort McMurray	Cluff Lake	Key Lake	Project
ERAI Statistics	Minimum	394.5	341.2	358.1	360.4	399
	25th percentile	454.8	451.8	437.4	457.6	464.6
	Median	502.4	503.8	469.4	505.5	520.8
	75th Percentile	578	545.8	546.9	574.1	596.7
	Maximum	713.3	663.5	669.6	766.2	695.4
	Mean	521.5	503.4	486.6	517.6	531
	Mean during Climate Normals Period (1981-2010)	527	498.7	490.9	523.4	535.4
ECCC 1981 to 2010 Climate Normals		n/a	418.6	451.0	482.5	n/a
ERAI / Climate Normal		n/a	119%	109%	108%	n/a

ECCC = Environment and Climate Change Canada; ERAI = European Re-analysis Interim; n/a = not applicable.

Total precipitation derived from ERAI data was plotted against concurrent daily, monthly, and annual observations made at the regional ECCC meteorological stations. The correlation between ERAI total precipitation and ECCC observed precipitation was generally highest on a monthly time step, with correlation of daily values being relatively poor (Figure 6). The monthly correlation is more important in the context of hydrology in the RSA and the influence of poor daily correlation on RSA hydrology appears to be low as runoff response is attenuated by slower runoff pathways and lake storage. The ERAI air temperature was plotted against daily, monthly, and annual observations at the regional ECCC meteorological stations. The correlation between ERAI data and ECCC observations was good at all the assessed time intervals (Figure 7).

Data Analysis

Frequency analyses were conducted for total annual precipitation using a Golder Associates Ltd. (Golder) frequency analysis software tool, which is similar to the ECCC Consolidated Frequency Analysis but with enhanced methods. The Golder frequency analysis software tool was used for flood frequency analyses, as well as statistical tests for independence (i.e., not serially correlated), trend, randomness, and homogeneity that were used in turn to determine the quality of the annual flood or low flow series. The Golder software tool includes modern boot strapping and estimation of confidence intervals.

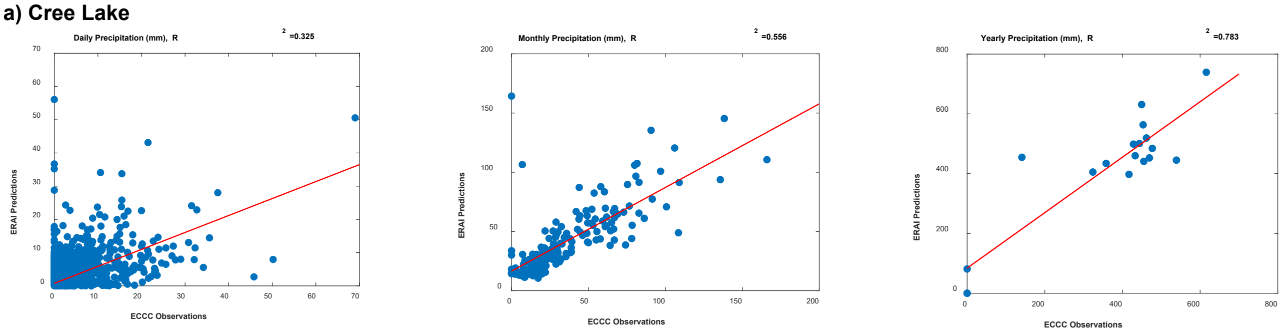
The following probability distributions were analyzed with selected parameter estimation methods (i.e., method of moments [MOM], maximum likelihood estimation [MLE], and method of L-moments [MLM]) using the methods outlined in Pilon and Harvey (1993):

- Three-Parameter Log Normal (MLE, or MOM if MLE fails);
- Generalized Extreme Value Distribution that includes extreme value 1, 2, and 3 distributions (MLM);
- Log Pearson Type III (MLE, or MOM if MLE fails); and
- Weibull (MOM).

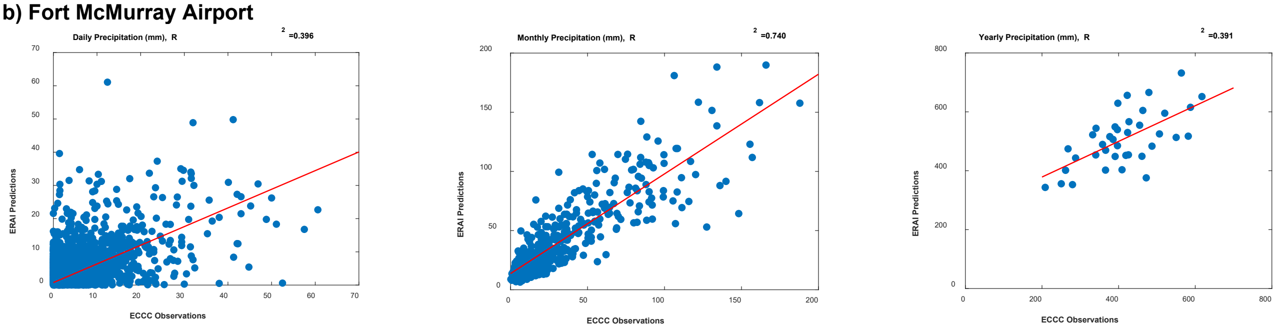
Numerical goodness-of-fit tests were performed including the non-parametric Anderson-Darling test (Stephens 1974) and a least-squares test. A probability distribution was chosen that best fit the data based on the goodness-of-fit tests and/or the best graphical fit at the flood or low flow values that were of interest.

Figure 6: European Re-analysis Interim Data Compared to Concurrent Daily, Monthly, and Annual (Yearly) Total Precipitation Observations

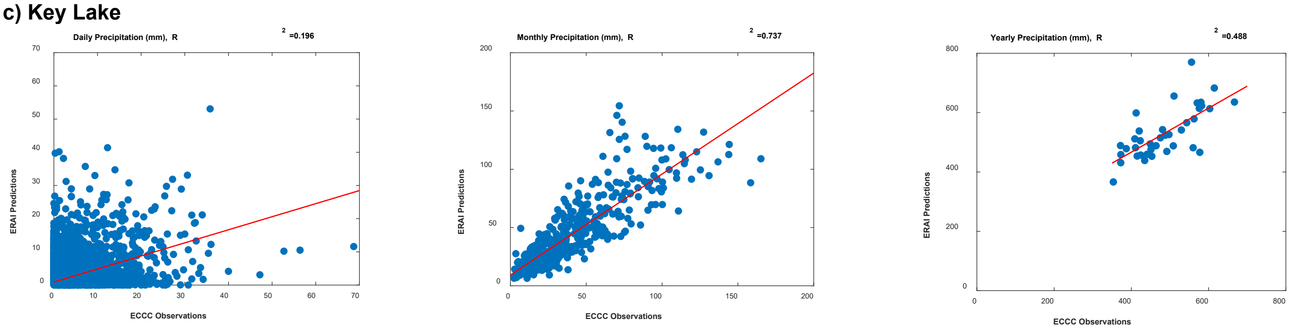
a) Cree Lake



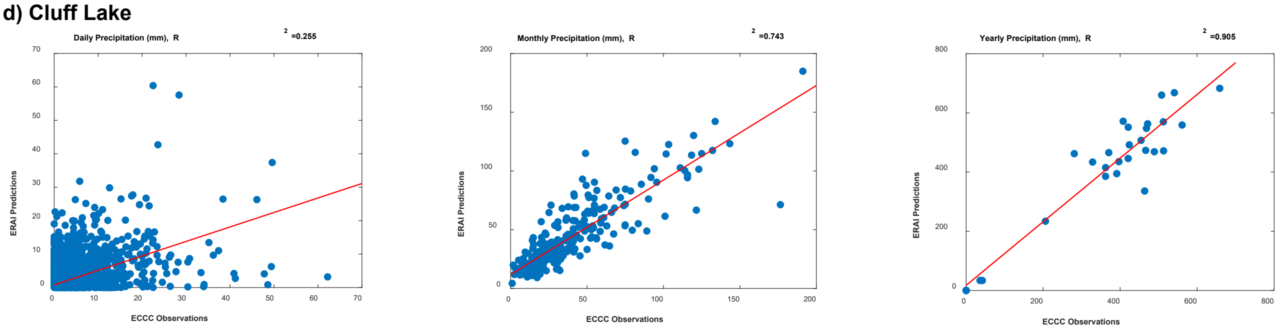
b) Fort McMurray Airport



c) Key Lake



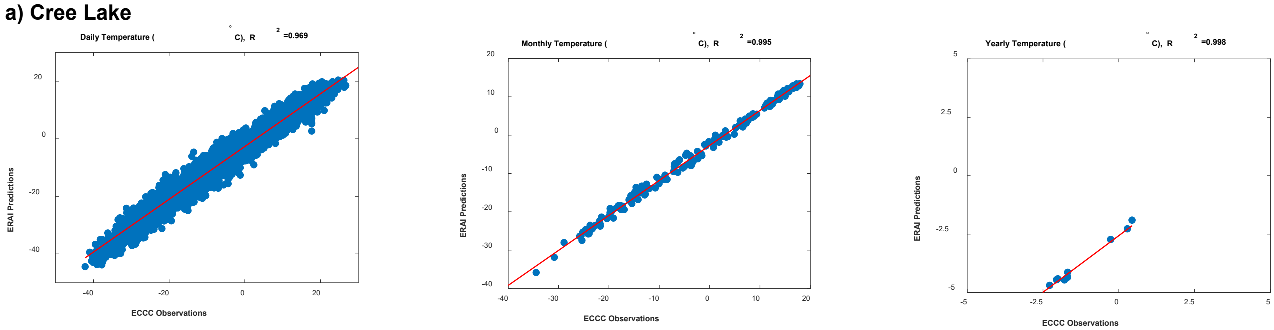
d) Cluff Lake



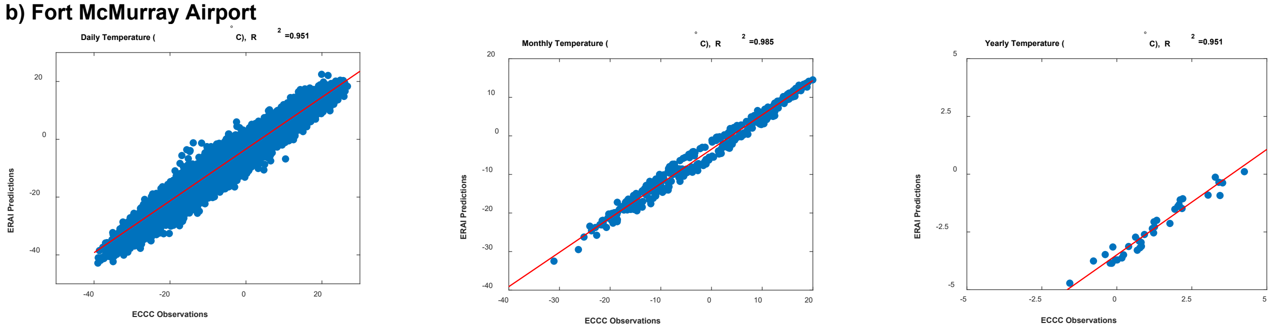
ECCC = Environment and Climate Change Canada; ERAI = European Re-analysis Interim.

Figure 7: European Re-analysis Interim Data Compared to Concurrent Daily, Monthly, and Annual (Yearly) Air Temperature Observations

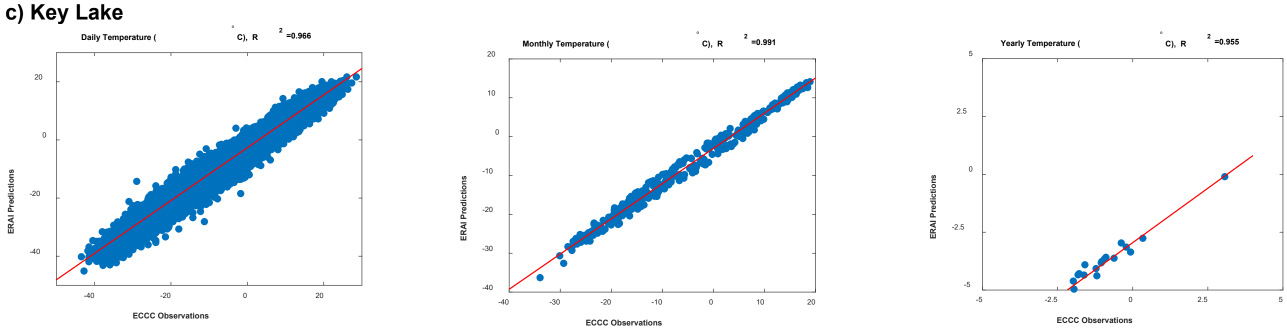
a) Cree Lake



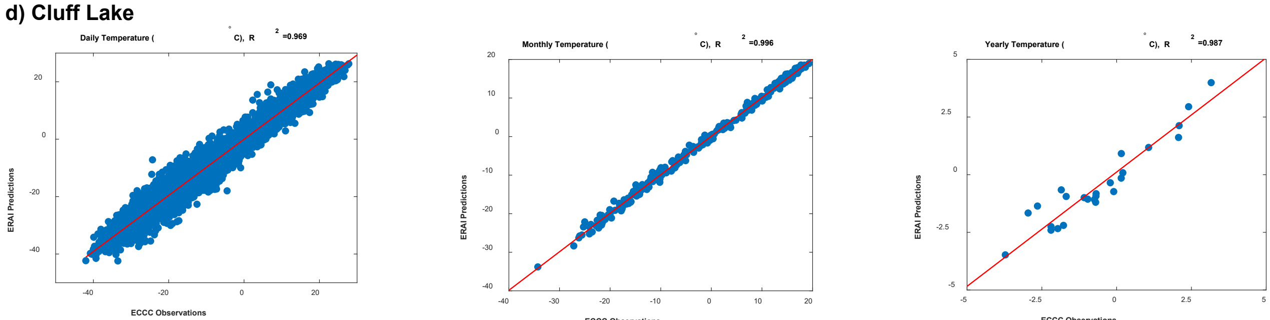
b) Fort McMurray Airport



c) Key Lake



d) Cluff Lake



ECCC = Environment and Climate Change Canada; ERAI = European Re-analysis Interim.

4.3 Regional Data Sources

4.3.1 Long-Term Snowfall Data

Undercatch-corrected snowfall data are available for the ECCC station at Cree Lake (Climate ID 4061861) between 1962 and 1993 (Mekis and Vincent 2011). Adjusted snowfall data provide more reliable records for water balance studies than data not corrected for gauge undercatch; the amount of undercatch also varies with wind speed during snowfall events. The station is located 145 km east of the proposed Project and adequately represents the general climate conditions for the area, based on the similarities in ERAI annual precipitation statistics for the two locations (Table 2), elevation, and latitude. Over the period of 1962 to 1993, annual snowfall ranged from a low of 104 mm to a high of 272 mm. The mean annual snowfall was 183 mm and the median was 187 mm (Table 3). Daily snowfall amounts and snow depth on the ground are available at most ECCC climate stations.

Table 3: Summary of Undercatch-Corrected Snowfall Recorded for Cree Lake, 1962 to 1993

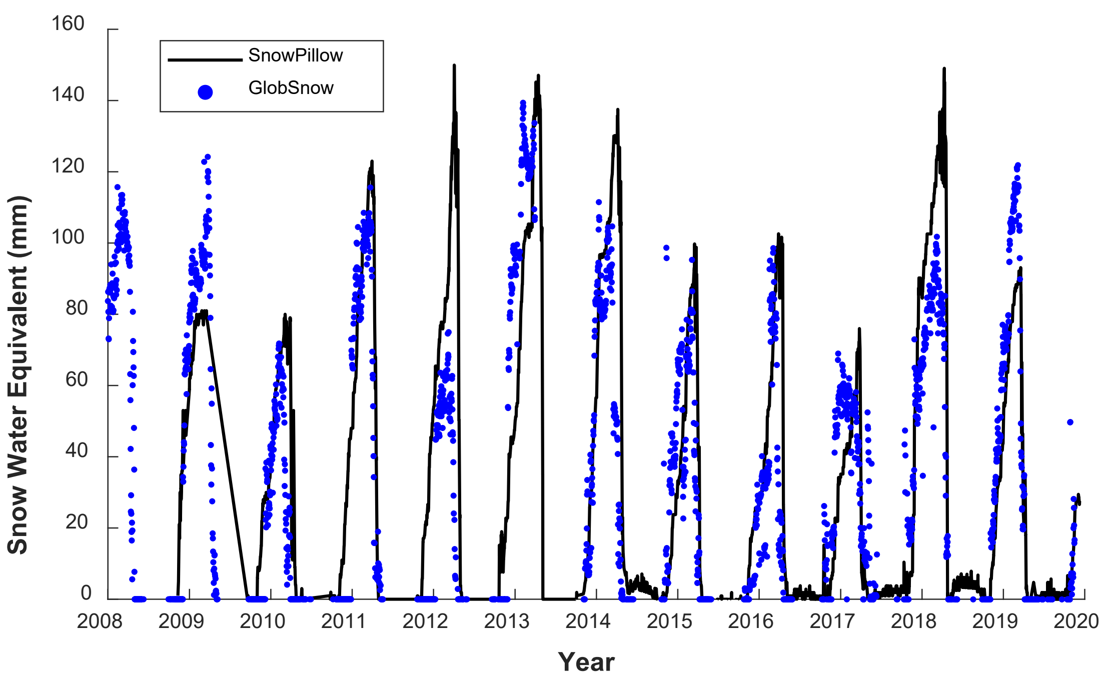
Statistic	Undercatch-Corrected Snowfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	25.8	21.9	22.5	20.0	5.8	0.4	0.0	0.1	4.8	19.9	33.1	29.8	183
Minimum	10.9	4.3	5.9	0.7	0.0	0.0	0.0	0.0	0.0	1.8	12.8	12.5	104
25th Percentile	19.6	14.5	13.1	12.0	0.4	0.0	0.0	0.0	0.1	9.7	20.3	21.5	156
Median	25.4	19.5	23.0	18.7	2.6	0.0	0.0	0.0	1.2	17.3	24.7	26.5	187
75th Percentile	30.2	28.4	27.2	25.2	7.4	0.2	0.0	0.0	2.2	28.6	48.5	35.3	209
Maximum	46.5	50.7	55.5	53.7	31.2	4.4	0.0	0.6	67.5	55.3	81.4	51.9	272

Source: Mekis and Vincent 2011.

4.3.2 Snow on the Ground

Snow on the ground measured as snow water equivalent (SWE) is one of the most important hydrological processes in the region as snowmelt usually dominates the annual hydrograph. Long-term direct observations are not available to characterize annual variability for the anticipated area of the Project. However, daily estimates of SWE are available for the northern hemisphere at a coarse spatial resolution (25 km by 25 km grid cells) from the Global Snow Monitoring for Climate Research (GlobSnow) project operated by the European Space Agency and the Finnish Meteorological Institute. The SWE data (ESA 2019) are derived using a combination of ground-based data and satellite microwave radiometer measurements. The suitability of the GlobSnow SWE dataset for the Project was evaluated by comparing the estimates to a nearby regional snow pillow station (Station 07CE801) at Gordon Lake Lookout from 2008 to 2019 (Government of Alberta 2019). The comparison is shown in Figure 8. There were only a few years when GlobSnow underestimated (i.e., 2012 and 2018) or overestimated (i.e., 2009 and 2019) peak SWE relative to snow pillow observations at Gordon Lake Lookout. Overall, GlobSnow datasets captured seasonal and inter-annual variability reasonably well, with the exception of peak values for the four years already mentioned (i.e., 2009, 2012, 2018, and 2019). The GlobSnow data are expected to provide an acceptable representation of SWE characteristics for the anticipated area of the Project.

Figure 8: Comparison of Snow Water Equivalent between Snow Pillow and GlobSnow Datasets at Gordon Lake, Alberta



4.3.3 Short-Duration and Probable Maximum Precipitation

For short-duration rainfall storm events, data were reviewed from intensity-duration-frequency (IDF) curves published by ECCC (2019b) for Buffalo Narrows, Cluff Lake, and Cree Lake in Saskatchewan and for Fort McMurray Airport in Alberta. Cree Lake was carried forward as the most representative of the anticipated area of the Project, based on similar latitude, elevation, ERAI annual total precipitation data, and similar isolines for a probable maximum precipitation (PMP) event (Hopkinson 1999). Cree Lake has an IDF data record of 24 years compared to 16 years for Cluff Lake and 41 years for Buffalo Narrows.

The PMP is the greatest depth of precipitation for a given duration that is meteorologically possible for a storm area at a given location and time of year. The PMP is dependent on the maximum persisting dew point in the atmosphere; both are highest during the warmest periods of the year. The PMP is commonly used as a design criterion of extremely high-risk water impoundment structures such as tailings dams. Hopkinson (1994) developed point PMP estimates for northern Saskatchewan with a focus on the Collins Bay region and the Cameco Rabbit Lake operation. The assessment was expanded to provide estimates of point PMP, with an area in the order of 1.0 km^2 and rainfall duration of 1, 6, and 24 hours for the prairie provinces (Hopkinson 1999).

4.3.4 Long-Term Atmospheric Losses

Water in its liquid form is lost to the atmosphere from the terrestrial environment mainly through evapotranspiration and from the aquatic environment or surface water mainly through evaporation. These losses are important components of the hydrology water balance for waterbodies and watersheds and were calculated on a daily time step in the hydrology model for the Project (Appendix 9A, Hydrological Modelling Summary Report). Data inputs for both methods included air temperature, dew point temperature, and wind speed. Daily net radiation was required to calculate actual evapotranspiration, while short and longwave radiation data were required for lake evaporation. These data were compiled for January 1979 to August 2019 based on ERAI data.

Actual evapotranspiration from terrestrial surfaces was estimated using the Granger and Gray (1989) model. Lake evaporation was estimated on a daily time step using the Penman Combined method (Dingman 2002) modified for lake evaporation estimation by considering change in heat storage in the waterbody (McJannet et al. 2013). The heat storage term was calculated as a function of Julian day, net shortwave radiation, and net longwave radiation following the method outlined in Jensen (2010).

Snow evaporation or sublimation is an important component of winter water budget. Data inputs for the sublimation model included air temperature, wind speed, and outgoing longwave radiation, which were based on ERAI data for January 1979 to August 2019. Sublimation loss from the snowpack was estimated on a daily time step using the Kuchment and Gelfan (1996) model. This model is based on vapour pressure deficit, which is estimated by air and snow temperatures. The required snow surface temperature was back calculated from outgoing longwave radiation using the Stefan-Boltzman relationship assuming an emissivity of 1 (Vionnet et al. 2012).

4.3.5 Long-Term Hydrometric Data

Interpretation of long-term hydrometric data from publicly available sources can provide valuable estimates of past hydrological conditions in the RSA when hydrometric records from the RSA are not available. The WSC operates a network of hydrometric stations in northern Saskatchewan. The hydrometric stations in the network are few, geographically sparse, and most have watershed areas much larger than the RSA. Comparisons between WSC stations and the RSA are more relevant if the WSC station watershed is similar in terms of watershed topography and size, landcover characteristics, and attenuation characteristics.

Two distinct geographic areas were defined for the purposes of this baseline study to account for differences in watershed that would influence selection of a similar WSC station watersheds: the RSA, which is the Clearwater River watershed upstream of the Mirror River confluence; and watersheds located downstream of the RSA including the far-field stations referenced in Section 3.0 located on the Clearwater River below the confluence with the Mirror River (Figure 4). Below the confluence, the river deepens with higher flow volumes from the Mirror River, and the channel form changes to meandering within a well-defined river valley. Long-term characteristics of the Clearwater River flow regime closer to the anticipated area of the Project (i.e., upstream of the confluence with the Mirror River) will be analyzed differently than farther downstream, mainly due to the large increase in watershed area below the confluence of the Clearwater and Mirror rivers.

Hydrometric Station Selection

Three regional streamflow stations near the anticipated area of the Project were evaluated for use as possible reference stations (Table 4). Two of the stations were discontinued in 1995 but have sufficiently long records to be considered in the analysis. The third station is an active station.

The discontinued WSC station on the Clearwater River below Lloyd Lake (WSC Station 07CD006) is on the same river system as many of the Project baseline hydrometric stations. The watershed area at the hydrometric outlet of Lloyd Lake is quite large compared to most of the baseline hydrometric stations upstream of the Mirror River confluence, but this station is assumed to adequately represent flows along the Clearwater River farther downstream from the anticipated area of the Project. This station was used to represent historical flows downstream of the confluence of the Clearwater and Mirror rivers.

The Douglas River station near Cluff Lake (WSC Station 07MA003) is located north of the anticipated area of the Project and just south of the decommissioned Cluff Lake uranium mine. The Douglas River flows generally north near its headwaters and then westward within the Athabasca Sedimentary Basin. It is a tributary of the Old Fort River that empties into the south end of Lake Athabasca in Alberta. The headwaters of the Douglas River start at McEachern Lake, which is about 32 km north of Patterson Lake. The Douglas River hydrometric data provides the longest record (i.e., 1975 to present) within a similar geographical region to the anticipated area of the Project and has a smaller watershed at the gauge compared with the Clearwater River at the outlet of Lloyd Lake. This station was used to represent historical flows upstream of the confluence of the Clearwater and Mirror rivers.

The discontinued station on the Descharme River (WSC Station 07CD007) is located southwest of the anticipated area of the Project; the headwaters begin near Agar Lake about 33 km south of Patterson Lake. Although this station has a similar drainage area to the Douglas River station, it has a shorter period of record than the other two stations (i.e., 1977 to 1995) and was only used for comparison purposes as described below.

The average annual basin yield (total runoff distributed over the contributing watershed) is 175 mm for the Douglas River and 171 mm for the Clearwater River. This corresponds to an approximate unit-area discharge of 5.6 L/s/km^2 for the Douglas River, and 5.4 L/s/km^2 for the Clearwater River (Appendix B).

Table 4: Regional Hydrometric Station Information

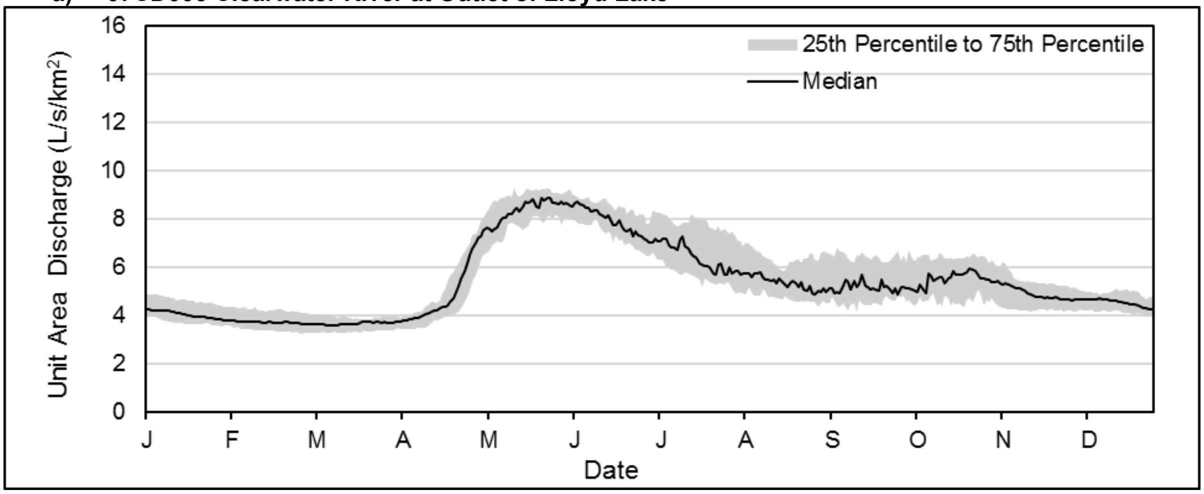
WSC Station Number	Station Name	Distance to Project (km)	Watershed Area (km^2)	Period of Record [(a)]	Average Annual Basin Yield (mm)
07CD006	Clearwater River at Outlet of Lloyd Lake	45	4,250	1973 to 1995	171
07CD007	Descharme River below Dupre Lake	60	1,690	1977 to 1995	169
07MA003	Douglas River near Cluff Lake	80	1,690	1975 to 2019	175

a) The periods of record indicated include years with partial data.
WSC = Water Survey of Canada.

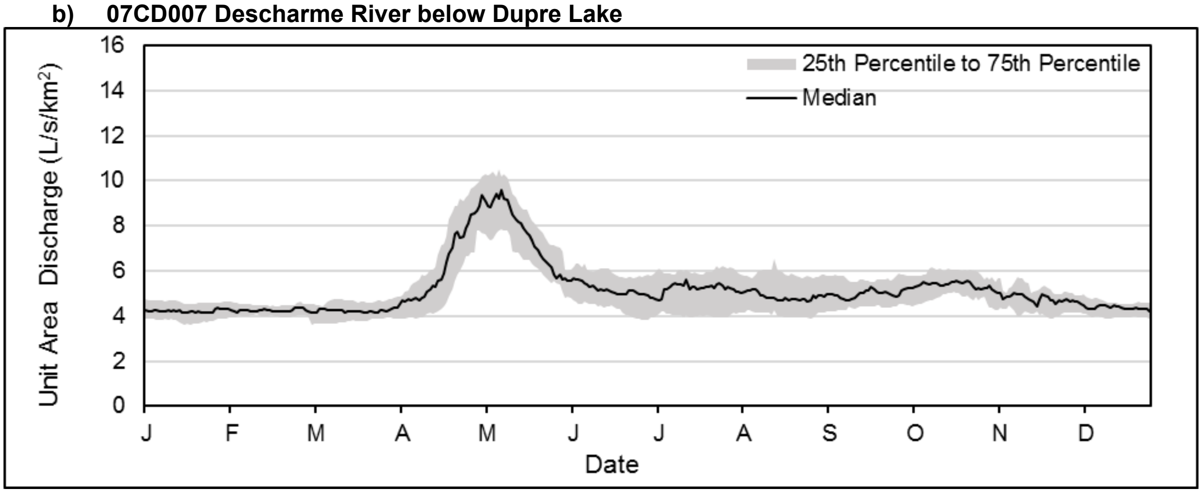
Figure 9 compares the unit-area discharge hydrographs for the Clearwater, Descharme, and Douglas rivers, respectively, based on available long-term records. The physical attributes that would influence hydrograph shape include topography, soils, land cover, and the influence of relatively large lakes in attenuating outflows. All three rivers have a similar baseflow in the winter, and the median discharge hydrographs show a similar general shape with peak flows occurring during the spring freshet in late April and May and recession during the summer and fall. The Clearwater River station hydrograph shows lower spring runoff peaks than the other two stations and is likely attenuated by water storage in Lloyd Lake and other large lakes in the watershed; this lower spring runoff may also be a function of its larger size watershed. Median and 75th percentile Douglas River station peak flows are higher than the other two stations on a unit-area basis. Thus, use of peak flows at this station to estimate flood magnitude and frequency for locations within the RSA generates higher peaks for the smaller watersheds within the RSA and results are more likely to be realistic.

Figure 9: Estimated Daily Statistical Unit-Area Discharge Hydrographs based on Reference Information from Active and Discontinued Water Survey of Canada Hydrometric Gauges

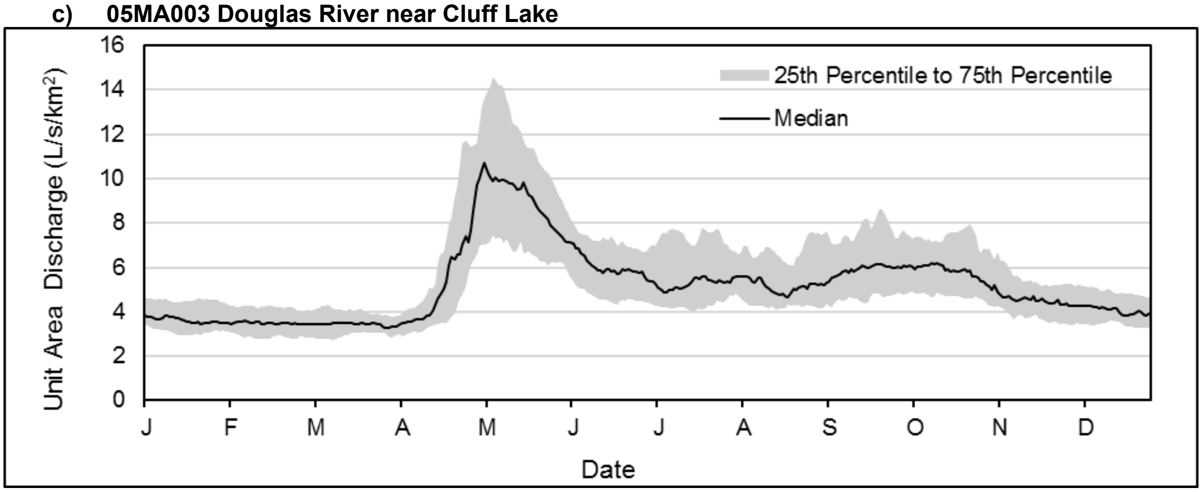
a) 07CD006 Clearwater River at Outlet of Lloyd Lake



b) 07CD007 Descharme River below Dupre Lake



c) 05MA003 Douglas River near Cluff Lake



Regional Hydrology Data Analysis

Daily mean discharge records for two regional hydrometric stations were used to characterize the flow regime for the RSA and far-field watersheds: the Douglas River station (WSC Station 07MA003), and the discontinued station on the Clearwater River at the outlet of Lloyd Lake (WSC Station 07CD006) (Figure 5). Discharge records were converted to unit-area discharge values based on the watershed areas at selected locations. The long-term discharge records based on all available data were used to calculate monthly and annual statistics, show historical average and extreme hydrographs for the calendar year, provide flood and low flow frequency, and compare long-term time series on a unit-area basis.

The maximum annual, minimum annual, and minimum seven-day average discharges were calculated for each year of the record, not including partial years' data if gaps occurred during typical spring freshet or low flow months in the late winter. Instantaneous flood peaks were not calculated, but the published instantaneous flood peaks for the Douglas River station were only 1.0% higher than daily mean peaks.

Golder frequency analysis software was used for flood frequency analyses, as well as for statistical tests for independence (i.e., not serially correlated), trend, randomness, and homogeneity that were used to determine the quality of the annual flood or low flow series. The software tool includes modern boot strapping and estimation of confidence intervals.

Probability distributions (i.e., Three-Parameter Log Normal, Generalized Extreme Value Distribution, Log Pearson Type III, and Weibull) were analyzed with selected parameter estimation methods as presented in Section 4.2. Numerical goodness-of-fit tests were performed, and probability distribution was chosen that best fit the data based on these tests and/or the best graphical fit at the flood or low flow values that were of interest.

Comparison with Baseline Hydrometric Data

Provisional WSC discharge data for the Douglas River near Cluff Lake (WSC Station 07MA003) in 2018 and 2019 were compared to statistics for the long-term record. Daily mean discharge records from August 2018 to September 2019 for a key baseline hydrometric station at the Patterson Lake outflow (Station CR-WC-MS-03) were compared with regional unit-area discharge daily flow hydrographs (converted to unit-area discharge). Discharge measured at the Clearwater River below Lloyd Lake (CR-WC-MS-08) in 2018 and spring 2019 was also compared with the long-term records of the Clearwater River (WSC Station 07CD006).

5.0 RESULTS

5.1 Climate Conditions

The proposed Project is in northwestern Saskatchewan near the headwaters of the Clearwater River system. The climate is characterized by cold winters and cool summers. The region is typical of a sub-arctic continental climate with year-round precipitation according to the Köppen classification, which is based on average monthly air temperatures and seasonal precipitation patterns (Kottek et al. 2006). The following sections describe meteorological conditions in detail. The climate conditions and specific meteorological parameters in the anticipated area of the Project were characterized using historical data from ECCC (2019a) weather stations in the region (Figure 5), as well as ERAI data (ECMWF 2019) generated for this region.

5.1.1 Precipitation

Annual and Monthly Total Precipitation

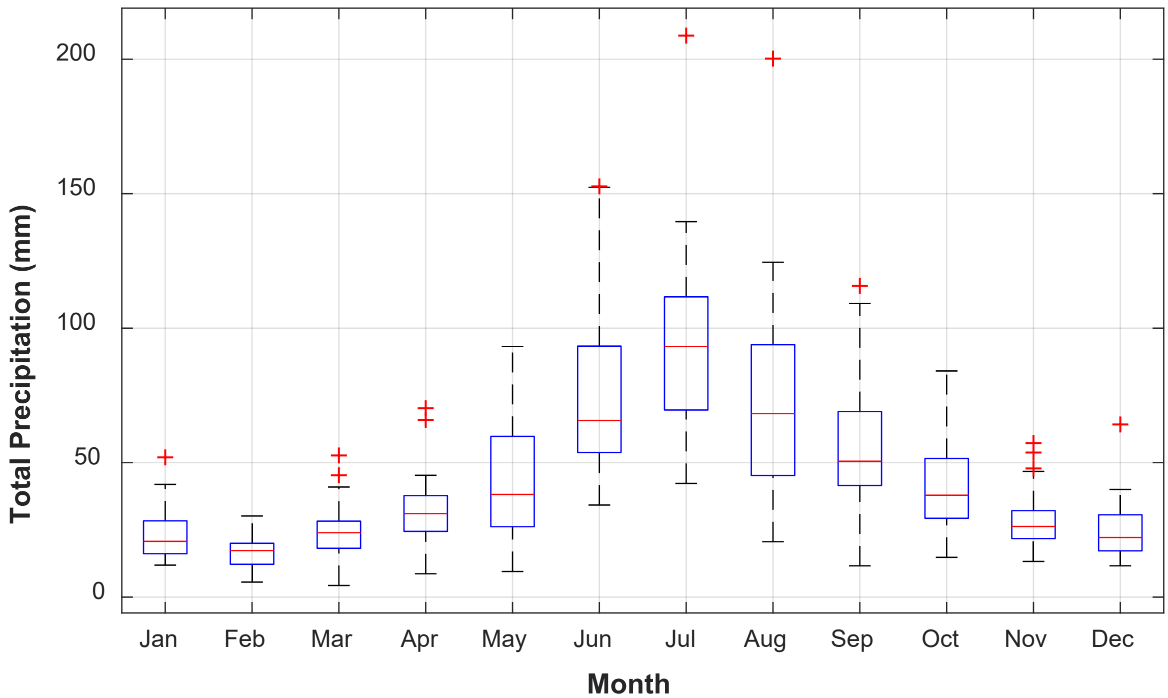
A record of total precipitation in each month was developed for the anticipated area of the Project based on ERAI data between 1979 and 2019 (Table 5). Over this period, annual precipitation ranged from 399 mm to 695 mm and averaged 531 mm. Box and whisker plots were generated to summarize the historical variability of total monthly precipitation (Figure 10). The length of the box in the plots represents the interquartile range (i.e., 25th and 75th percentiles), with the median denoted by the horizontal line within the box. The whiskers represent the minimum and maximum values of the dataset (i.e., the maximum precipitation that occurred in all the months on record). Any outliers in the data are represented by a "+" sign. Annual total precipitation in the area of the Project is expected to average 531 mm, with 144 mm falling as snow and 387 mm falling as rain (Appendix A). The annual snowfall was observed to range from 83 mm to 209 mm in the historical record, while the annual rainfall was observed to range from 259 mm to 530 mm (Appendix A). The average monthly apportioning of total precipitation as snow or rain is presented in Figure 11.

Table 5: Derived Monthly and Annual Total Precipitation Statistics for the Anticipated Area of the Project, 1979 to 2019

Total Precipitation (mm)							
Month	**Minimum**	**25th Percentile**	**Median**	**75th Percentile**	**Maximum**	**Mean**	**Standard Deviation**
January	11.9	16.3	20.7	28.3	51.9	22.5	9.3
February	5.6	12.6	17.3	19.9	30.2	16.7	6.3
March	4.3	18.3	24.0	28.2	52.7	24.3	10.3
April	8.7	24.5	31.0	37.6	70.2	30.5	12.9
May	9.5	26.6	38.2	59.1	93.1	41.6	21.4
June	34.2	53.9	65.7	93.2	152.7	72.6	33.2
July	42.3	70.1	93.2	111.2	208.8	91.6	34.5
August	20.6	45.3	68.2	90.9	200.2	71.3	37.0
September	11.6	42.0	50.5	68.9	115.8	55.2	24.5
October	14.8	29.5	37.9	51.0	84.1	40.5	18.8
November	13.3	21.8	26.3	32.0	57.3	27.9	10.9
December	11.6	17.2	22.2	30.2	64.2	24.1	10.2
Annual	399.0	464.6	520.8	596.7	695.4	531.0	81.5

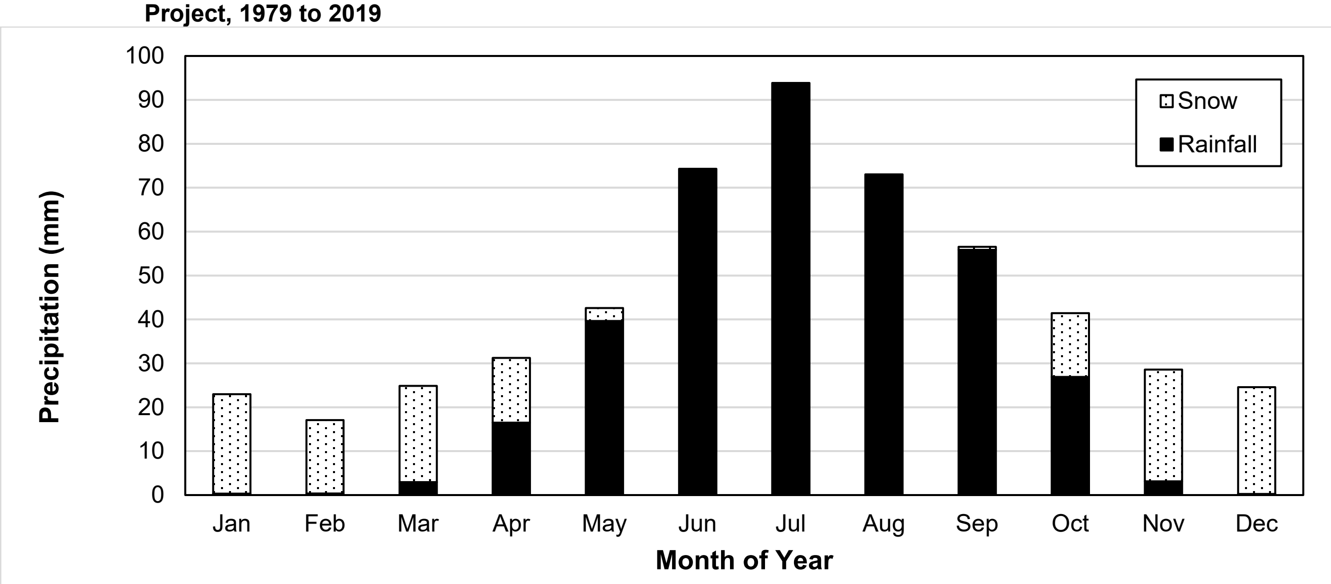
Source: ECMWF 2019.

Figure 10: Summary of Derived Historical Monthly Total Precipitation for the Anticipated Area of the Project, 1979 to 2019



Note: Outliers are denoted by “+” sign in the figure.

Figure 11: Derived Historical Monthly Total Precipitation as Snowfall and Rainfall for the Anticipated Area of the Project, 1979 to 2019



Annual Total Precipitation – Frequency Analysis

A frequency analysis was performed using annual precipitation values based on ERAI annual data for the anticipated area of the Project from 1979 to 2019 using a Weibull distribution. Other distributions (i.e., Log Pearson Type III, Three-Parameter Log Normal, and Generalized Extreme Value Distribution) were considered but screened out as the Weibull distribution had the best fit. Annual total precipitation is expected to range from 370 mm during a 200-year dry year to 763 mm during a 200-year wet year (Table 6). The mean annual precipitation is 531 mm, and the median annual precipitation is 527 mm.

Table 6: Frequency Analysis of Derived Annual Total Precipitation for the Anticipated Area of the Project, 1979 to 2019

Hydrological Condition	Average Return Period (Years)	Estimated Annual Precipitation (mm)
Wet	200	763
	100	740
	50	714
	20	676
	10	643
	5	602
Mean	n/a	531
Median	2	527
Dry	5	460
	10	430
	20	408
	50	389
	100	378
	200	370

Source: ECMWF 2019.
n/a = not applicable.

Short-Duration Rainfall

The rainfall intensities and durations associated with varying return periods of short-duration rainstorm events are available from IDF curves published by ECCC (2019b) for Cree Lake based on data from 1970 to 1993 (Table 7). Cree Lake s most representative of conditions for the anticipated area of the Project based on latitude, elevation, ERAI annual precipitation data, and isolines for the PMP (Hopkinson 1999). Cree Lake has an IDF record of 24 years, compared to 16 years for Cluff Lake and 41 years for Buffalo Narrows. The rainfall intensities associated with varying return periods are available from IDF curves published by ECCC (2019b) for Cree Lake and are presented in Table 8.

Table 7: Intensity-Duration-Frequency Rainfall Amounts for Cree Lake

Time Interval	Average Return Period Rainfall Amounts (mm)					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
5 minutes	5.2	9.0	11.4	14.6	16.9	19.2
10 minutes	7.5	12.6	15.9	20.1	23.2	26.3
15 minutes	9.6	17.2	22.3	28.6	33.4	38.1
30 minutes	12.3	21.2	27.2	34.6	40.2	45.7
1 hour	15.3	24.9	31.3	39.4	45.3	51.3
2 hours	18.0	29.2	36.6	45.9	52.9	59.8
6 hours	26.0	35.9	42.5	50.8	56.9	63.1
12 hours	32.9	45.7	54.2	64.9	72.8	80.6
24 hours	38.1	51.8	60.9	72.4	80.9	89.4

Source: ECCC 2019b.

Table 8: Intensity-Duration-Frequency Rainfall Intensities for Cree Lake

Time Interval	Average Return Period Rainfall Intensities (mm/h)					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
5 minutes	62.4	107.4	137.3	175	202.9	230.7
10 minutes	45.2	75.4	95.4	120.6	139.4	158
15 minutes	38.4	68.9	89.1	114.6	133.5	152.3
30 minutes	24.5	42.4	54.3	69.3	80.4	91.5
1 hour	15.3	24.9	31.3	39.4	45.3	51.3
2 hours	9.0	14.6	18.3	23	26.4	29.9
6 hours	4.3	6.0	7.1	8.5	9.5	10.5
12 hours	2.7	3.8	4.5	5.4	6.1	6.7
24 hours	1.6	2.2	2.5	3.0	3.4	3.7

Source: ECCC 2019b

Probable Maximum Precipitation

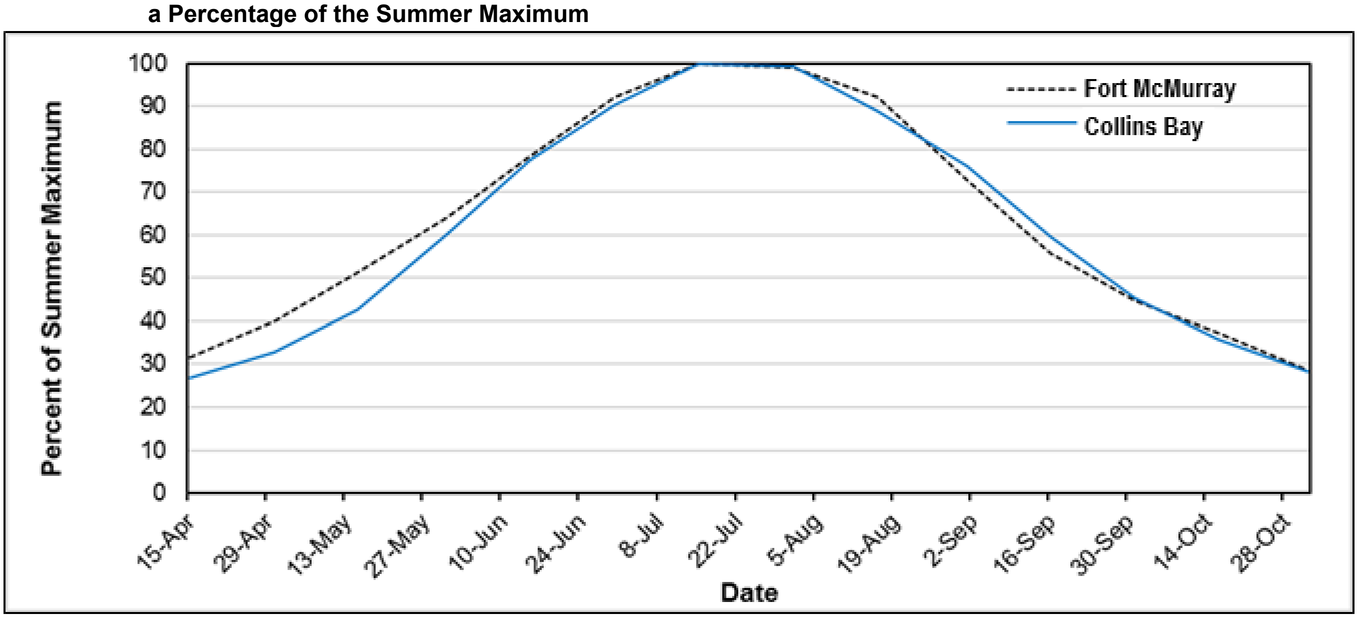
The magnitude of the PMP was derived based on isolines provided by Hopkinson (1999) that document estimates of PMP relative to a reference station located at a reference climate station at Collins Bay located at the Cameco Rabbit Lake operation. The anticipated area of the Project is expected to have 105% of the maximum precipitable water estimated for the reference climate station. The magnitude of the Point-PMP varies seasonally: The Point-PMP values listed in Table 9 are most likely to occur in July, when the persistent atmospheric dew-point temperature is highest; lower values are expected for other months. Seasonal variability of the Point-PMP was referenced for Fort McMurray, because of proximity to Rook I Meteorological Station, and checked against Collins Bay, because of it was the reference climate station. The The seasonal variation of the PMP for Collins Bay and Fort McMurray is similar, as shown in Figure 12 as a percentage of the July peak. The seasonal variation of the PMP for the anticipated area of the Project may be more like that at Fort McMurray than at Collins Bay due to its location. Point-PMP is recommended to be applied for small watersheds with an area of the order of 1 km^2 (Hopkinson 1994).

Table 9: Probable Maximum Precipitation for the Anticipated Area of the Project

Location	1-Hour PMP (mm)	6-Hour PMP (mm)	24-Hour PMP (mm)
Rook I Project	346.3	347.6	489.2
Collins Bay	329.8	331.0	465.9

Source: Estimated from Hopkinson 1999.
PMP = probable maximum precipitation.

Figure 12: Seasonal Distribution of Point Probable Maximum Precipitation for Fort McMurray and Collins Bay as a Percentage of the Summer Maximum



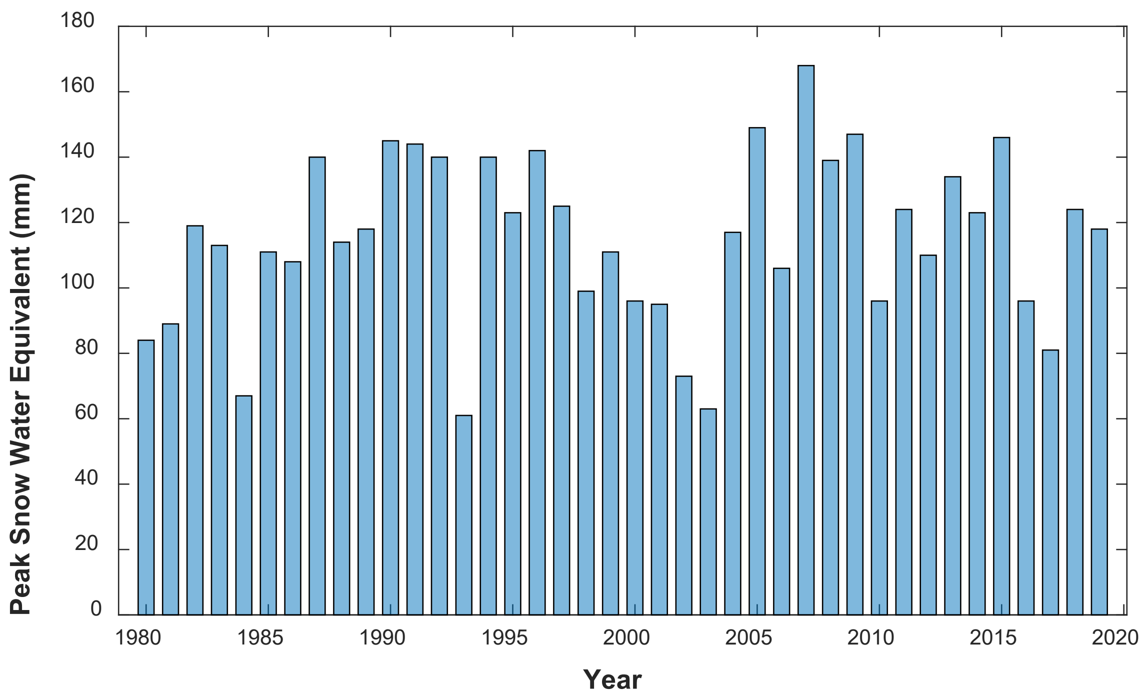
5.1.2 Snow Water Equivalent

The peak SWE estimates for the anticipated area of the Project are presented in Figure 13 based on the GlobSnow data and statistical summary provided in Table 10. A large inter-annual variability for snow accumulation was estimated over the period 1980 to 2019. The SWE ranged from 61 mm to 168 mm with an average of 115 mm.

Table 10: Statistics of Peak Snow Water Equivalent for the Anticipated Area of the Project

Summary Statistic	Minimum	25th Percentile	Median	75th Percentile	Maximum	Mean	Standard Deviation
Peak annual snow water equivalent (mm)	61	96	117	139	168	115	26

Figure 13: GlobSnow Peak Annual Snow Water Equivalent Estimate for the Anticipated Area of the Project, 1980 to 2019



5.1.3 Air Temperature

Monthly and annual statistics of air temperature (measured 2 m from the surface) for the anticipated area of the Project based on ERAI data from 1979 to 2019 are summarized in Table 11. The annual average air temperature was -1.3°C, with the coldest month, January, having an average temperature of -19.8°C and the warmest month, July, having an average temperature of 15.9°C.

Table 11: Monthly and Annual Air Temperature Statistics for the Anticipated Area of the Project, 1979 to 2019

Daily Air Temperature (°C)							
Month	**Extreme Minimum**	**25th Percentile**	**Median**	**75th Percentile**	**Extreme Maximum**	**Mean**	**Standard Deviation**
January	-41.0	-27.8	-19.3	-12.6	7.7	-19.8	9.7
February	-39.2	-24.1	-17.2	-10.0	4.3	-17.3	9.1
March	-35.1	-16.7	-9.7	-3.7	7.1	-10.7	8.5
April	-24.5	-4.7	0.1	3.5	19.8	-1.0	6.7
May	-11.7	3.7	7.3	11.0	21.7	7.3	5.3
June	1.3	11.0	13.5	16.1	26.1	13.4	3.8
July	3.0	13.9	15.8	18.0	24.7	15.9	3.0
August	2.7	11.4	14.1	16.7	24.6	14.0	3.8
September	-3.4	5.0	8.0	11.1	20.4	8.0	4.2
October	-20.3	-1.8	1.0	4.0	15.5	0.9	5.0
November	-34.7	-14.1	-8.1	-3.5	6.0	-9.2	7.2
December	-43.4	-24.5	-16.2	-10.0	4.0	-17.2	9.5
Annual Average	**-20.5**	**-5.7**	**-0.9**	**3.4**	**15.1**	**-1.3**	**6.3**

Source: ECMWF 2019.

5.1.4 Dew-Point Temperature

Monthly and annual dew-point temperature statistics for the anticipated area of the Project based on ERAI data from 1979 to 2019 are summarized in Table 12. The annual average dew-point temperature was -6.0°C with the coldest month, January, having an average dew-point temperature of -22.8°C and the warmest month, July, having an average dew-point temperature of 9.9°C.

Table 12: Monthly Dew-Point Temperature Statistics for the Anticipated Area of the Project, 1979 to 2019

Month	Daily Dew-Point Temperature (°C)						
	Minimum	25th Percentile	Median	75th Percentile	Maximum	Mean	Standard Deviation
January	-44.9	-31.4	-22.5	-14.8	0.8	-22.8	10.3
February	-43.1	-28.2	-20.5	-12.7	-0.7	-20.6	9.6
March	-40.2	-21.4	-14.0	-7.8	0.2	-15.1	8.9
April	-31.1	-11.1	-6.4	-2.9	7.1	-7.5	6.4
May	-18.9	-4.5	-0.6	3.1	13.2	-0.9	5.5
June	-7.5	3.5	6.4	9.4	18.5	6.3	4.1
July	-0.5	7.6	10.1	12.1	18.1	9.9	3.2
August	-4.2	6.7	9.1	11.4	18.3	9.0	3.5
September	-9.9	1.3	4.2	7.0	14.7	4.0	4.2
October	-24.7	-5.0	-1.6	0.9	9.4	-2.2	4.9
November	-38.3	-16.5	-10.3	-6.0	1.9	-11.7	7.5
December	-46.8	-27.7	-18.6	-11.6	-0.3	-19.8	10.1
Annual Average	**-25.9**	**-10.6**	**-5.4**	**-1.0**	**8.4**	**-6.0**	**6.5**

Source: ECMWF 2019.

5.1.5 Solar Radiation

Solar radiation is an important input to energy balance-driven hydrological processes such as snow melt and evapotranspiration. Monthly and annual statistics of solar radiation for the anticipated area of the Project based on ERAI data from 1979 to 2019 are summarized in Table 13. Average daily solar radiation ranged from 19.7 W/m^2 in December to 346.7 W/m^2 in June.

Table 13: Monthly Solar Radiation Statistics for the Anticipated Area of the Project, 1979 to 2019

Month	Daily Net Solar Radiation (W/m^2)						
	Minimum	25th Percentile	Median	75th Percentile	Maximum	Mean	Standard Deviation
January	0.9	18.2	31.0	42.6	76.6	31.7	16.8
February	3.0	58.1	80.0	104.9	165.9	81.5	33.4
March	13.7	128.6	173.3	210.7	284.1	167.1	56.9
April	8.2	222.1	280.8	321.3	405.4	264.6	78.8
May	6.4	299.3	375.3	417.7	479.5	344.9	100.0
June	11.2	291.4	373.3	427.3	490.1	346.7	108.2
July	10.2	273.4	342.4	391.1	476.2	321.4	94.7
August	1.5	215.9	284.1	329.5	416.9	267.9	85.2
September	0.6	127.1	184.5	230.3	319.5	177.8	70.8
October	4.3	57.7	92.2	129.4	210.8	94.3	47.7
November	1.3	20.6	35.5	50.7	100.8	37.6	21.1
December	0.6	11.8	19.4	28.2	43.7	19.7	9.8
Annual Average	**5.2**	**143.7**	**189.3**	**223.6**	**289.1**	**179.6**	**60.3**

Source: ECMWF 2019.

5.1.6 Atmospheric Losses

Evaporation, evapotranspiration, and sublimation are important losses in water balance calculations. Mean monthly lake evaporation and actual evapotranspiration and sublimation for the anticipated area of the Project based on ERAI data from 1979 to 2019 are summarized in Table 14. Annual precipitation and loss totals and statistics are provided in Appendix A, Meteorological Annual Totals and Statistics. The highest mean monthly lake evaporation tended to occur in July, while the highest evapotranspiration from the terrestrial environment occurred in June and July. The highest sublimation losses were usually observed in November. Snow evaporation or sublimation was estimated to remove 25% of mean annual snowfall in the anticipated area of the Project.

Table 14: Mean Monthly Lake Evaporation, Actual Evapotranspiration and Sublimation Statistics for the Anticipated Area of the Project, 1979 to 2019

Month	Lake Evaporation (mm)	Actual Evapotranspiration (mm)	Sublimation (mm)
January	0	0	5
February	0	0	4
March	0	0	4
April	0	0	2
May	86	24	0
June	107	75	0
July	130	75	0
August	106	59	0
September	60	29	0
October	21	7	6
November	0	0	9
December	0	0	6
Annual	**510**	**269**	**36**

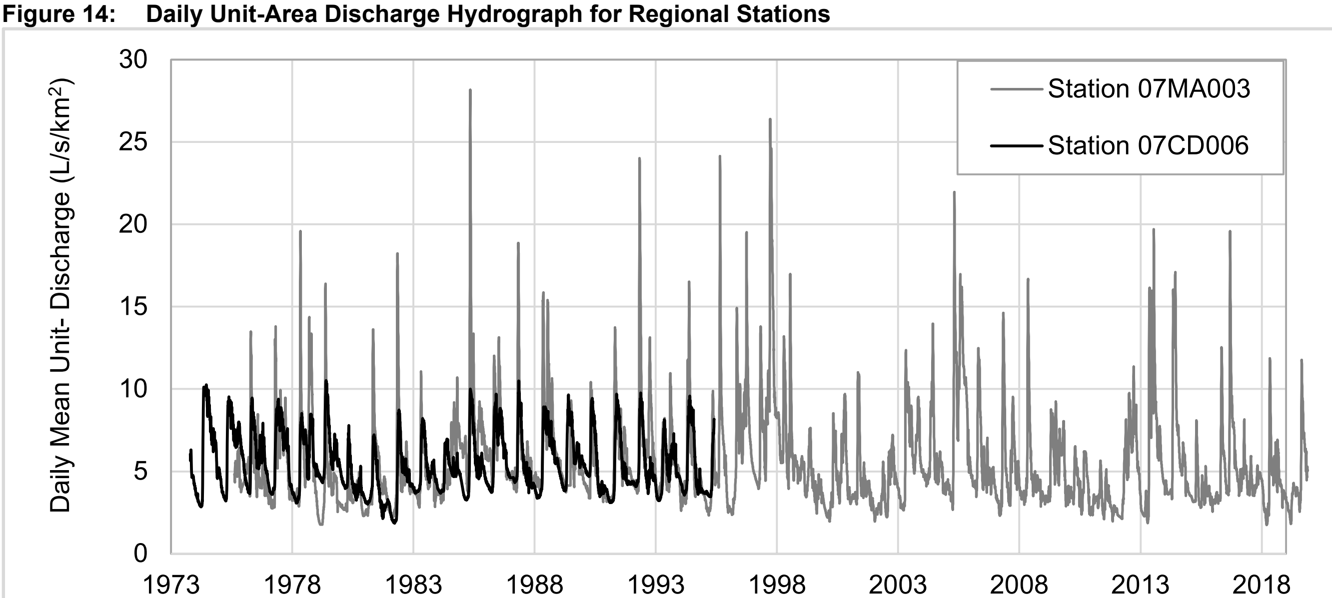
Source: ECMWF 2019.

5.2 Historical Hydrometric Data

5.2.1 Unit-Area Discharge

Historical daily mean discharge records were converted to unit-area discharge for the Douglas River near Cluff Lake (WSC Station 07MA003) and Clearwater River below Lloyd Lake (WSC Station 07CD006). Average unit-area discharge was similar for the two stations; however, peak flows were usually much higher for the Douglas River (Figure 14). Detailed annual discharge statistics for these two stations are provided in Appendix B, Table B-1 (Douglas River) and Table B-2 (Clearwater River).

Figure 14: Daily Unit-Area Discharge Hydrograph for Regional Stations



Mean monthly and annual unit-area discharge statistics for the Douglas River (WSC Station 07MA003) and Clearwater River below Lloyd Lake (WSC Station 07CD006) are provided in Table 15**.**

Table 15: Long-Term Unit-Area Discharge Statistics for the Hydrology Study Areas

Month	Hydrology RSA (Clearwater River above the Mirror River confluence) [(a)]			Downstream Far-Field Stations on the Clearwater River in Saskatchewan (below the Mirror River confluence) [(b)]		
	Mean (standard deviation) ($L/s/km^2$)	25th Percentile ($L/s/km^2$)	75th Percentile ($L/s/km^2$)	Mean (standard deviation) ($L/s/km^2$)	25th Percentile ($L/s/km^2$)	75th Percentile ($L/s/km^2$)
January	3.89 (1.2)	3.18	4.49	4.13 (0.66)	3.67	4.62
February	3.67 (1.1)	2.85	4.23	3.78 (0.64)	3.38	4.24
March	3.54 (0.90)	2.93	4.10	3.65 (0.60)	3.34	3.92
April	5.41 (1.9)	4.05	6.31	4.53 (0.86)	3.99	5.09
May	9.35 (3.4)	6.91	11.63	8.12 (0.99)	7.50	8.71
June	6.25 (2.1)	4.86	7.13	7.81 (1.3)	7.52	8.68
July	6.06 (2.6)	4.20	7.27	6.69 (1.4)	5.75	7.91
August	5.85 (2.4)	4.33	6.73	5.69 (1.3)	4.91	6.21
September	6.58 (2.7)	4.54	7.72	5.32 (1.2)	4.51	6.40
October	6.56 (3.0)	4.67	7.33	5.55 (1.3)	4.65	6.36
November	5.06 (1.7)	3.92	5.80	5.01 (0.96)	4.29	5.60
December	4.31 (1.2)	3.48	4.99	4.58 (0.72)	4.15	4.93
Annual [(c)]	**5.55 (1.3)**	**4.72**	**6.21**	**5.42 (0.67)**	**5.09**	**5.96**

a) Derived from long-term records for the Douglas River at Water Survey of Canada (WSC) Station 07MA003 (1975 to 2018).
b) Derived from long-term records for the Clearwater River WSC Station 07CD006 (1973 to 1995).
c) Annual statistics were calculated using data for complete years; partial years were excluded.
RSA = regional study area.

5.2.2 Annual Basin Yield

Annual water yield is the sum of annual discharge from a watershed distributed over the watershed's drainage area. Annual water yield data are available for the Douglas River near Cluff Lake between 1975 and 2018 (WSC 2019), which serves as a proxy for the RSA. Over this period, the annual basin yield ranged from 103 mm to 292 mm, with an average of 175 mm. Annual water yield data are available for the Clearwater River at the outlet of Lloyd Lake, which serves as a proxy for the far-field station watersheds between 1977 and 1995. Over this period, the annual basin yield ranged from 120 mm to 199 mm, with an average of 171 mm.

A frequency analysis was performed using annual water yield values based on ERAI annual data from 1979 to 2017 using a Log Pearson III distribution. Other distributions (i.e., Generalized Extreme Value, Three-Parameter Log Normal, and Weibull) were considered, but screened out as the Log Pearson III distribution had the best fit. Annual water yield in the RSA is expected to range from 96 mm during a 200-year dry year to 324 mm during a 200-year wet year (Table 16). Annual water yield in the far-field station watersheds is expected to range from 100 mm during the 200-year dry year to 200 mm during the 200-year wet year (Table 16).

Table 16: Frequency Analysis of Annual Water Yield for the Hydrology Study Areas

Hydrological Condition	Average Return Period (years)	Estimated Annual Water Yield (mm)	
		Regional Study Area[a]	Far-Field Watersheds[b]
Wet	200	324	200
	100	303	199
	50	282	198
	20	254	196
	10	231	194
	5	207	189
Average (Mean)	n/a	175	171
Median	2	169	170
Dry	5	139	156
	10	126	143
	20	117	132
	50	107	118
	100	101	109
	200	96	100

Note: Log Pearson III distribution used for frequency analyses.
a) Derived from long-term records for the Douglas River at WSC Station 07MA003 (1975 to 2018).
b) Derived from long-term records for the Clearwater River WSC Station 07CD006 (1973 to 1995).
n/a = not applicable.

5.2.3 Flood and Low Flow Frequency Analysis

The flood and low flow magnitude and frequency results for the Douglas River station are shown in Table 17. These results are based on daily mean flows for the period of record from 1975 to 2018. These Douglas River unit-area runoff results may be applied to the hydrology baseline monitoring stations in the upper Clearwater watershed above the Mirror River confluence. In this region, most small watersheds have relatively large coverage with lakes and permeable overburden, both of which moderate peak flows. As a result, daily mean flood peaks do not need to be adjusted upward from the unit-area flood values generated from the Douglas River with its larger watershed area.

Table 17: Flood and Low Flow Magnitude and Frequency Results for the Douglas River (WSC Station 07MA003)

Return Period (Years)	Probability of Exceedance (%)	Annual Flood Peak		Annual Minimum Flow		Annual 7-Day Average Flow	
		m^3/s	$L/s/km^2$	m^3/s	$L/s/km^2$	m^3/s	$L/s/km^2$
2	0.5	23.2	13.7	4.81	2.85	4.94	2.93
5	0.2	32.0	18.9	3.85	2.28	3.95	2.34
10	0.1	37.0	21.9	3.37	2.00	3.47	2.05
20	0.05	41.3	24.4	3.01	1.78	3.10	1.83
50	0.02	46.2	27.3	2.65	1.57	2.73	1.61

Flood and low flow magnitude and frequency results for the Clearwater River below Lloyd Lake, based on the years 1974 to 1995, are provided in Table 18. Unit-area runoff values estimated from this station provide a good representation of flows in larger watersheds. For example, these results may be applied to locations on the Clearwater River below the Mirror River confluence.

Table 18: Flood and Low Flow Magnitude and Frequency Results for the Clearwater River (WSC Station 07CD006)

Return Period (Years)	Probability of Exceedance (%)	Annual Flood Peak		Annual Minimum Flow		Annual 7-Day Average Flow	
		m^3/s	$L/s/km^2$	m^3/s	$L/s/km^2$	m^3/s	$L/s/km^2$
2	0.5	39.2	9.23	15.0	3.53	15.2	3.58
5	0.2	42.3	9.96	12.8	3.02	13.1	3.08
10	0.1	43.6	10.3	11.2	2.64	11.5	2.71
20	0.05	44.5	10.5	9.72	2.29	10.0	2.36
50	0.02	45.3	10.7	7.92	1.86	8.27	1.95
100	0.01	45.7	10.8	6.73	1.58	7.09	1.67

5.2.4 Historical Floods

Notable annual flood peaks are present in the historical record for the Douglas River near Cluff Lake (WSC Station 07MA003). The five highest annual peak daily flows with return periods exceeding 10 years are presented in Table 19. For the purposes of this study, a flood is an event with a daily peak discharge and an associated return period exceeding two years. However, for brevity, only floods with return periods exceeding 10 years are presented in Table 19. Although the flood peak is typically expected to occur in early May, extreme floods have occurred later in the year, such as in September of 1997 and August of 1995.

Table 19: Notable Flood Peaks in the Historical Record for the Douglas River near Cluff Lake (WSC Station 07MA003, 1976 to 2018)

Return Period (Years)	Annual Flood Peak		Year	Date
	m^3/s	$L/s/km^2$		
61	47.6	28.2	1985	8 May
39	44.6	26.4	1997	21 September
21	40.8	24.1	1995	28 August
21	40.6	24.0	1992	3 May
12	37.1	22.0	2005	28 April

5.2.5 Comparison with 2018 to 2019 Hydrometric Data

Figure 15 shows the unit-area discharge hydrographs for Douglas River near Cluff Lake (WSC Station 07MA003) for various flow statistics over the period of record (i.e., 1975 to 2019) compared with 2018 and 2019 unit-area discharge data. The 2018 and 2019 data are based on provisional daily mean discharge records (WSC 2019). Discharge at this station was near-normal during the open-water period in 2018, with four rainfall-runoff events spaced out regularly through the summer. Discharge was below normal from fall 2018 through the winter of 2018/2019 until August 2019. The hydrograph shows that discharge increased above the 75th percentile in late August to September 2019 due to rainfall events. In 2018, the peak daily mean discharge of 20.0 m^3/s occurred on 3 May 2018 during spring freshet. In 2019, the rainfall-runoff peak of 19.9 m^3/s occurred 25 August 2019. Both peaks were just below the 1-in-2-year flood event of 23.2 m^3/s for this station (Section 5.2.3).

Figure 15 also includes unit-area discharge hydrographs for the Patterson Lake outflow (Station CR-WC-MS-03) from August 2018 to September 2019. Similar to the Douglas River, flows at Patterson Lake outflow were below normal from August 2018 onward except for a period during early spring freshet and August 2019. However, unit-area discharge was lower at the Patterson Lake outflow than the Douglas River for 2018 until spring 2019 and did not experience a high peak flow in August 2019.

Figure 15: Unit-Area Discharge Hydrographs for the Douglas River near Cluff Lake (1975 to 2019) Compared with 2018 and 2019 Observations (WSC Station 07MA003, Station CR-WC-MS-03)

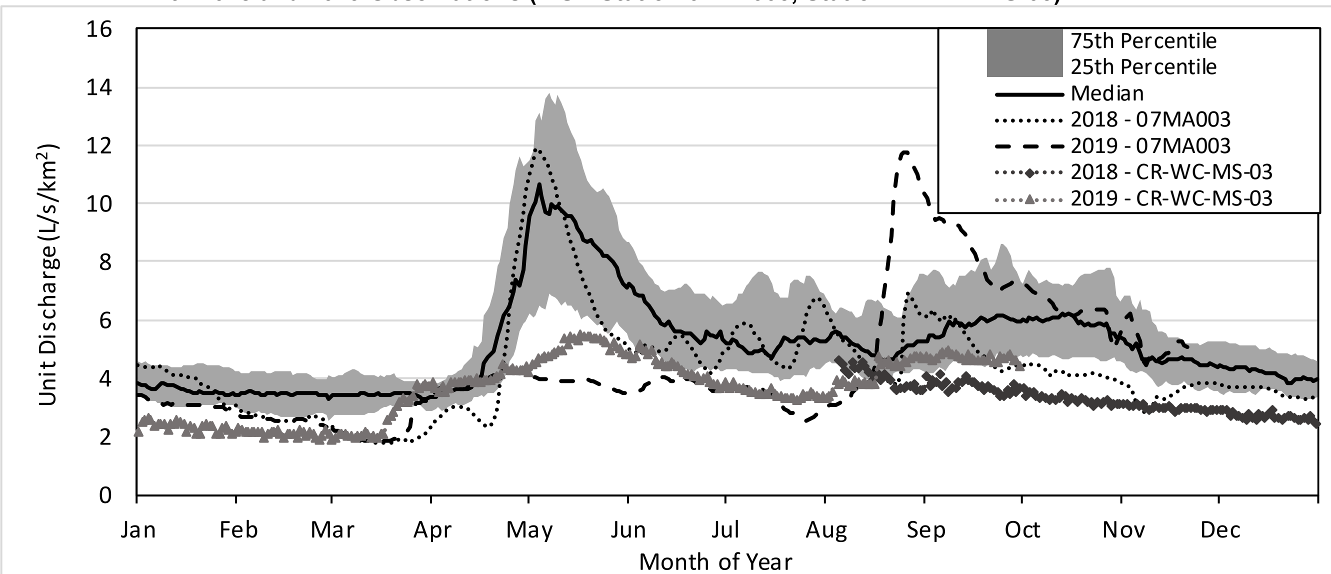
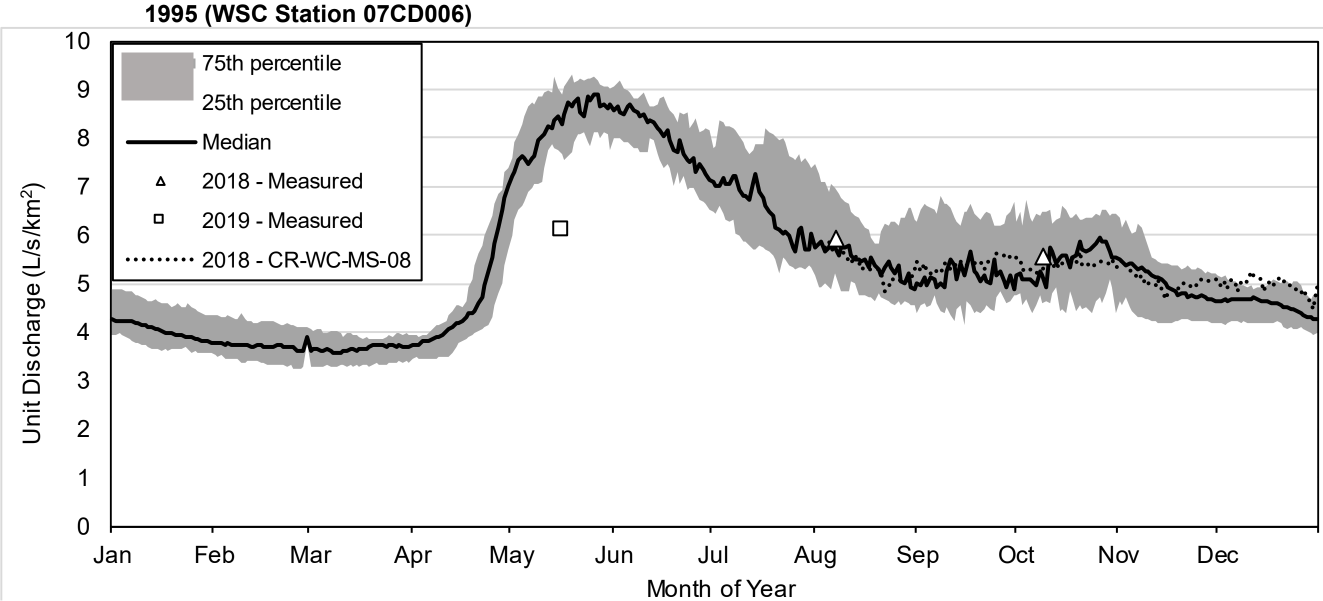


Figure 16 shows the unit-area discharge hydrographs for the Clearwater River at the outlet of Lloyd Lake (WSC Station 07CD006) for various flow statistics over the period of record from 1973 to 1995. These historical results are compared to observations at the hydrometric station CR-WC-MS-08, which was established near the WSC station in August 2018. Discharge observations in 2018 were close to median historical flows for WSC Station 07CD006 for the same time of year; however, the discharge measurement in mid-May 2019 was well below normal.

Figure 16: Comparison of 2018 and 2019 Observations at the Clearwater River below Lloyd Lake (Station CR-WC-MS-08) to Historical Observations at the Clearwater River at the Outlet of Lloyd Lake from 1974 to 1995 (WSC Station 07CD006)



6.0 SUMMARY

Long-term meteorological records were compiled from a combination of publicly available meteorological stations near the Project, as well as global re-analysis products including European Re-analysis Interim (ERAI). Publicly available meteorological station data were used to test the validity of global reanalysis data for representing local conditions. The ERAI data compiled for the locations of regional meteorological stations were compared to concurrent historical observations near the anticipated area of the Project made by Environment and Climate Change Canada (ECCC) and determined that ERAI global re-analysis provides an acceptable estimate of the meteorology in the region. Based on this conclusion, a 40-year record (i.e., 1979 to 2019) was compiled for the anticipated area of the Project.

Over the 40-year record, ERAI annual total precipitation ranged from 399 mm to 695 mm with a mean of 531 mm. In an average year, the total precipitation consisted of 144 mm falling as snow and 387 mm falling as rain. The annual snowfall was observed to range from 83 mm to 209 mm in the historical record. Annual lake evaporation loss was estimated to be 514 mm and terrestrial evapotranspiration was estimated to be 262 mm. The long-term meteorological records provide an understanding of historical climatic variability for the anticipated area of the Project and will support the Environmental Assessment (EA) and related studies such as water or lake water balance modelling. The long-term records account for a wide range of climatic variability, and in turn, hydrological variability, and allow for the assessment of routine conditions as well as extreme runoff events.

The Douglas River (Water Survey of Canada [WSC] Station 07MA003) hydrometric station was used to represent the hydrology for smaller watersheds near the anticipated area of the Project (i.e., upstream of the confluence with the Mirror River), while the discontinued station on the Clearwater River at the Lloyd Lake outlet (WSC Station 07CD006) was used to represent larger watersheds farther downstream along the Clearwater River (i.e., downstream of the confluence with the Mirror River). Annual water yield in the Clearwater River at the outlet of Lloyd Lake ranged from 120 mm to 199 mm and averaged 171 mm. Annual water yield in the Douglas River ranged from 103 mm to 292 mm and averaged 175 mm. On average, the annual runoff ratio (i.e., water yield/total precipitation) is expected to be approximately 34%. The mean annual water yield for these two stations was very similar: 171 mm for the Clearwater River and 175 mm for the Douglas River. Peak flows were much higher for the Douglas River on a unit-area basis compared to the Clearwater River at the outlet of Lloyd Lake, as peak flows were greatly attenuated downstream of Lloyd Lake.

Based on the provisional data at the Douglas River, 2018 was a near-normal flow year with a peak snowmelt runoff just above the median value. Discharge was below normal from fall 2018 through the winter of 2018/2019 until August 2019. Flows at Patterson Lake outflow were also below normal from August 2018 onward except for a period during early spring freshet in 2019 and August 2019. However, unit-area discharge was lower at the Patterson Lake outflow than the Douglas River for 2018 until spring 2019, and Patterson Lake outflow did not experience as high a peak flow response in August 2019.

The baseline meteorological and hydrological characterization study achieved the objective of describing the existing regional meteorological and hydrological conditions in the baseline study area to support the EA. Long-term meteorological and hydrological records were required to support detailed hydrological modelling and model calibration for the waterbodies and watercourses near the proposed Project.

CLOSING

Golder is pleased to submit this report to NexGen in support of the environmental assessment for the Rook I Project. For details on the limitations and use of information presented in this report, please refer to the Study Limitations section following this page. If you have any questions or require additional details related to this study, please contact the undersigned.

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APPENDIX A

Meteorological Annual Totals and Statistics

Table A-1: Annual Summary and Statistics of Precipitation and Atmospheric Losses at the Project

Year	Precipitation (mm)	Rain (mm)	Snow (mm)	Lake Evaporation (mm)	Evapotranspiration (mm)	Sublimation (mm)
1979	457	329	128	527	281	36
1980	425	297	129	528	264	31
1981	454	315	139	569	297	42
1982	429	273	156	495	263	27
1983	399	285	114	494	262	34
1984	632	468	164	492	267	33
1985	515	350	165	503	260	36
1986	456	322	134	483	255	36
1987	483	300	183	512	269	51
1988	692	530	162	493	257	37
1989	500	344	156	509	269	28
1990	435	259	176	517	274	39
1991	548	391	157	499	260	32
1992	467	328	139	494	261	42
1993	521	380	141	476	250	36
1994	523	391	132	552	290	32
1995	628	475	153	503	262	33
1996	628	504	124	476	260	26
1997	695	523	172	464	250	45
1998	413	329	83	570	290	37
1999	494	360	134	518	275	37
2000	559	459	100	467	249	36
2001	530	421	108	533	285	43
2002	601	468	134	454	249	45
2003	659	530	129	489	262	30
2004	479	270	209	463	260	36
2005	629	463	166	492	257	46
2006	544	410	134	532	283	41
2007	523	393	130	509	270	31
2008	520	351	169	544	287	31
2009	595	427	168	487	264	36
2010	510	414	96	512	268	37
2011	438	316	122	559	283	33
2012	658	468	190	525	280	39
2013	548	384	164	550	285	32
2014	506	366	140	511	279	35
2015	495	363	132	537	277	35
2016	653	505	147	520	270	41
2017	552	401	152	539	280	40
2018	447	319	128	492	256	36
Min	**399**	**259**	**83**	**454**	**249**	**26**
25th Percentile	**465**	**326**	**129**	**492**	**260**	**32**
Median	**521**	**382**	**140**	**509**	**267**	**36**
75th Percentile	**597**	**460**	**164**	**529**	**279**	**39**
Max	**695**	**530**	**209**	**571**	**297**	**51**
Mean	**531**	**387**	**144**	**510**	**269**	**36**

APPENDIX B

Hydrological Annual Summary and Statistics

Table B-1: Annual Discharge Statistics for the Douglas River Hydrometric Station (07MA003)

Year	Min	7-Day Average Annual Minimum	Mean	Max	Water Yield	Min	7-Day Average Annual Minimum	Mean	Max
	Discharge (m^3/s)				mm	Unit-Area Discharge ((L/s)/km^2)			
1976	5.83	5.92	9.02	22.8	169	3.45	3.51	5.34	13.5
1977	4.64	4.72	9.61	23.3	179	2.75	2.79	5.68	13.8
1978	4.84	4.91	10.6	33.1	197	2.86	2.91	6.25	19.6
1979	3.00	3.00	6.99	27.7	130	1.78	1.78	4.14	16.4
1980	3.87	3.87	5.80	11.8	109	2.29	2.29	3.43	6.98
1981	3.90	3.97	7.98	23.0	149	2.31	2.35	4.72	13.6
1982	3.80	3.80	8.27	30.8	154	2.25	2.25	4.90	18.2
1983	4.74	4.81	8.02	18.7	150	2.80	2.84	4.74	11.1
1984	5.17	5.28	9.42	18.1	176	3.06	3.12	5.58	10.7
1985	6.20	6.30	13.5	47.6	251	3.67	3.73	7.96	28.2
1986	6.76	7.06	11.7	22.2	219	4.00	4.18	6.95	13.1
1987	6.30	6.34	10.1	31.9	188	3.73	3.75	5.97	18.9
1988	6.16	6.27	12.4	26.8	232	3.64	3.71	7.34	15.9
1989	6.30	6.38	9.11	15.7	144	3.73	3.77	5.39	9.29
1990	5.32	5.49	8.04	17.6	150	3.15	3.25	4.76	10.4
1991	5.57	5.64	9.95	23.2	186	3.30	3.34	5.89	13.7
1992	6.19	6.36	12.2	40.6	229	3.66	3.76	7.23	24.0
1993	5.57	5.73	9.22	18.5	172	3.30	3.39	5.46	11.0
1994	4.43	4.56	9.03	27.9	168	2.62	2.70	5.34	16.5
1995	3.92	4.06	9.61	40.8	179	2.32	2.40	5.69	24.1
1996	4.00	4.04	11.8	33.0	220	2.37	2.39	6.96	19.5
1997	6.66	6.73	15.6	44.6	292	3.94	3.98	9.25	26.4
1998	6.67	7.04	11.7	28.7	217	3.95	4.17	6.89	17.0
1999	4.12	4.24	7.39	12.9	138	2.44	2.51	4.37	7.63
2000	3.32	3.39	8.05	16.4	151	1.96	2.01	4.76	9.70
2001	4.33	4.22	7.28	18.6	136	2.56	2.50	4.31	11.0
2002	3.33	3.39	6.64	12.2	124	1.97	2.00	3.93	7.22
2003	4.46	4.59	10.5	20.9	196	2.64	2.71	6.21	12.4
2004	6.06	6.20	9.48	23.6	177	3.59	3.67	5.61	14.0
2005	4.53	4.75	15.0	37.1	280	2.68	2.81	8.88	22.0
2006	5.84	6.20	9.28	21.1	173	3.46	3.67	5.49	12.5
2007	3.89	3.98	8.99	24.7	168	2.30	2.35	5.32	14.6
2008	4.86	5.19	8.25	28.2	154	2.88	3.07	4.88	16.7
2009	4.87	5.12	9.03	15.6	168	2.88	3.03	5.34	9.23
2010	3.96	4.04	6.93	11.0	129	2.34	2.39	4.10	6.51
2011	3.30	3.59	5.51	9.6	103	1.95	2.13	3.26	5.65
2012	3.58	3.59	9.06	19.2	169	2.12	2.12	5.36	11.4
2013	3.16	3.23	11.2	33.3	208	1.87	1.91	6.61	19.7
2014	5.60	5.75	10.7	28.9	199	3.31	3.40	6.32	17.1
2015	4.31	4.69	6.39	13.7	119	2.55	2.78	3.78	8.11
2016	5.13	5.25	10.1	33.1	189	3.04	3.11	5.99	19.6
2017	5.95	6.04	7.71	13.8	144	3.52	3.58	4.56	8.17
2018	3.11	3.37	7.59	19.8	129	1.84	1.99	4.49	11.7
Mean	**4.83**	**4.96**	**9.41**	**24.2**	**175**	**2.86**	**2.93**	**5.57**	**14.3**
Minimum	**3.00**	**3.00**	**5.51**	**9.55**	**103**	**1.78**	**1.78**	**3.26**	**5.65**
25th Percentile	**3.91**	**4.01**	**8.00**	**17.8**	**147**	**2.31**	**2.37**	**4.73**	**10.6**
Median	**4.74**	**4.81**	**9.11**	**23.0**	**169**	**2.80**	**2.84**	**5.39**	**13.6**
75th Percentile	**5.84**	**5.98**	**10.5**	**29.8**	**196**	**3.45**	**3.54**	**6.23**	**17.7**
Maximum	**6.76**	**7.06**	**15.6**	**47.6**	**292**	**4.00**	**4.18**	**9.25**	**28.2**

Table B-2: Annual Discharge Statistics for the Clearwater River below Lloyd Lake (07CD003)

Year	Minimum	7-Day Average Annual Minimum	Mean	Maximum	Annual Water Yield	Minimum	7-Day Average Annual Minimum	Mean	Maximum
	Discharge (m^3/s)				mm	Unit-Area Discharge ((L/s)/km^2)			
1974	12.1	12.16	26.86	43.6	198	2.85	2.86	6.28	10.3
1975	13.6	13.70	25.05	40.5	199	3.20	3.22	6.32	9.5
1976	15.5	15.53	25.65	40.2	186	3.65	3.65	5.89	9.5
1977	15.3	15.30	24.03	39.9	190	3.60	3.60	6.04	9.4
1978	13.1	13.31	25.91	36.2	178	3.08	3.13	5.65	8.5
1979	18.3	18.46	18.59	44.7	192	4.31	4.34	6.10	10.5
1980	13.8	14.04	16.12	33.1	138	3.25	3.30	4.38	7.8
1981	9.07	10.02	18.65	30.7	120	2.13	2.36	3.79	7.2
1982	7.86	8.00	21.64	37.1	138	1.85	1.88	4.39	8.7
1983	15.6	15.69	20.98	34.9	161	3.67	3.69	5.09	8.2
1984	15.6	15.64	23.12	29.6	156	3.67	3.68	4.94	7.0
1985	13.9	13.96	25.62	42.5	172	3.27	3.28	5.44	10.0
1986	15.8	15.94	22.91	41.2	190	3.72	3.75	6.03	9.7
1987	15.7	17.06	25.01	44.6	170	3.69	4.01	5.39	10.5
1988	14.3	14.53	25.33	37.9	186	3.36	3.42	5.89	8.9
1989	16.2	16.27	22.73	41.0	188	3.81	3.83	5.96	9.6
1990	14.7	15.40	22.07	40.1	169	3.46	3.62	5.35	9.4
1991	13.2	13.30	22.77	41.2	164	3.11	3.13	5.19	9.7
1992	15.5	16.14	21.65	41.5	169	3.65	3.80	5.36	9.8
1993	13.7	13.81	22.62	34.6	161	3.22	3.25	5.09	8.1
1994	15.1	15.34	18.38	40.7	168	3.55	3.61	5.32	9.6
1995	14.7	14.79	26.71	34.7	56	3.46	3.48	4.32	8.2
Mean	**14.21**	**14.47**	**22.84**	**38.7**	**171**	**3.34**	**3.41**	**5.37**	**9.1**
Minimum	**7.86**	**8.00**	**16.12**	**29.6**	**120**	**1.85**	**1.88**	**3.79**	**7.0**
25th Percentile	**13.63**	**13.73**	**21.64**	**35.2**	**161**	**3.21**	**3.23**	**5.09**	**8.3**
Median	**14.7**	**15.04**	**22.84**	**40.2**	**170**	**3.46**	**3.54**	**5.37**	**9.4**
75th Percentile	**15.58**	**15.68**	**25.26**	**41.2**	**188**	**3.66**	**3.69**	**5.94**	**9.7**
Maximum	**18.3**	**18.46**	**26.86**	**44.7**	**199**	**4.31**	**4.34**	**6.32**	**10.5**