Appendix 1.0-R SRK, Tenas Project Hydrometeorological Report

TELKWA COAL
LIMITED

Tenas Project – Hydrometeorological Baseline and Model Development Report

Prepared for

Telkwa Coal Ltd

Prepared by

SRK Consulting (Canada) Inc.
1CT027.003
August 2021

Tenas Project – Hydrometeorological Baseline and Model Development Report

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Prepared for

Telkwa Coal Ltd
Suite #1240 – 1140 West Pender Street
Vancouver, BC V6E 4G1

Prepared by

SRK Consulting (Canada) Inc.
2200 – 1066 West Hastings Street
Vancouver, BC V6E 3X2
Canada

Tel: +1 604 681 4196
Web: www.srk.com

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Executive Summary

As part of the Tenas Project Environmental Assessment, SRK Consulting (Canada) Inc. was retained by Allegiance Coal Limited (ACL) to complete a hydrometeorological analysis for the Tenas Project (the Project).

The Project is located approximately 25 km southwest of the town of Smithers, BC within the Telkwa River watershed and is composed of an open pit, backfill, external stockpiles, water management ponds, control ponds, process plant and rail infrastructure.

This report presents the hydrometeorological baseline of the Project. The key objective of this report is to to develop inputs to the Project water management plan and water and load balance model.

Site hydrometeorological conditions are monitored via a site weather station and five (5) hydrometric stations located on each of the major watercourses (Goathorn-Hydro, Telkwa-Hydro, Tenas-Hydro/Tenas-Hydro B, and Four-Hydro). The weather station and hydrometric stations at Goathorn, Telkwa and Tenas were operated from 2017 to 2019 and have two complete hydrologic years of data. The Four-Hydro hydrometric station was installed in 2020, and has no overlap between Project meteorological data or any of the other Project hydrometric stations. For this assessment, the local datasets are supplemented with regional datasets and climate re-analysis models.

Synthetic long-term Project climate datasets were developed based on transposing the regional datasets at Smithers Airport to the site and adjusting for observed orographic effects. These datasets were used to derive Project design parameters and water and load balance inputs, as well as to support development of a rainfall-runoff model. This model was developed and calibrated for each of the local hydrometric stations. A combination of the calibrated models from Goathorn Creek and Tenas Creek were applied to the Tenas Project area.

Selected climate parameters are summarized in Table 1-1 to Table 1-3.

Table 1-1: Derived Monthly and Annual Project Climate Normals

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Temperature (°C)	-9.2	-6.1	-2.7	2.1	6.8	10.7	13.0	12.5	8.4	2.6	-3.8	-7.9	2.2
Rainfall (mm)	8.0	9.7	10.4	21.5	35.9	45.7	48.1	43.1	50.8	58.6	20.0	8.0	359.9
Snowfall (mm)	61.8	35.9	22.0	4.9	0.7	0.0	0.0	0.0	0.3	13.6	49.4	59.7	248.1
Total Precipitation (mm)	69.7	45.6	32.4	26.4	36.6	45.7	48.1	43.1	51.1	72.2	69.4	67.7	608.0
Evaporation (mm)	0	0	0	60	97	108	116	99	50	0	0	0	529

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Evaporation_rev02.Rmd

Table 1-2: Extreme Precipitation

Return Period	24-hour Precipitation [mm]	72-hour Precipitation [mm]
2	37.3	56.2
5	50.7	78.4
10	60.8	95.9
25	74.9	121.4
50	86.6	143.2
100	99.3	167.5
200	113.1	194.6
500	133.3	235.6
1000	150.3	271.0
PMP (Spring)	234.0	-
PMP (Summer/Autumn)	283.0	-

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Precipitation_1CT027.003_rev01.Rmd

Table 1-3: Extreme Snowmelt

Return Period	24-hour Snowmelt [mm SWE]	72-hour Snowmelt [mm SWE]
2	23	59
5	27	68
10	29	74
25	31	80
50	32	81
100	33	85
200	35	89
500	36	93
1000	38	97

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\ \Telkwa Coal\1CT027.003_2020 EA Water Management\500_Water_Balance\Model\SnowmeltModel\SWE_ModelledOutput_09172020.xlsx

Mean annual runoff for the Project was determined to be 219 mm/year with an annual runoff coefficient of 0.36 with the highest flows occurring in May and June due to freshet, and low flows occurring during the winter.

Climate change scenarios for RCP4.5, RCP6.5 and RCP8.5 were evaluated for the Project Area. The effects of the RCP4.5 scenario were used to generate mean annual and monthly temperature and precipitation correction factors, which also affect runoff and evaporation rates, as summarized in Table 1-4.

Table 1-4: Projected Climate Change Impacts on Selected Climate Parameters

Timeframe	Mean Annual Temperature (°C)	Mean Annual Precipitation (mm)	Mean Annual Evaporation (mm)
2011-2040	1.2°C	+5%	+2%
2041-2070	2.4°C	+12%	+4%
2071-2100	3.0°C	+15%	+5%

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Extreme precipitation magnitudes are expected to increase. Monthly streamflow is expected to experience an overall increase in flow magnitude and a shift to an earlier spring freshet. No significant trend in peak flows is projected.The short duration of the Project meteorological and hydrometric datasets is a limitation of this hydrometeorological baseline report. SRK recommends ongoing monitoring of Project meteorologic conditions, and continued hydrometric station monitoring at Four-Hydro and Tenas-Hydro B as a minimum.This report should be updated when additional data become available. In particular, the Four-Hydro discharge record requires additional flow measurements to characterize baseline conditions for effects assessments and to support predictive modelling.

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Attachments

1 Introduction

SRK Consulting (Canada) Inc. has been tasked with updating the meteorological and hydrological characterization to develop inputs required for the Tenas Project (the Project) in support of the Environmental Assessment (EA). The EA has been prepared in accordance with the BC Environmental Assessment Office (BC EAO) Guidelines for Preparing Environmental Assessments (BC EAO 2016).

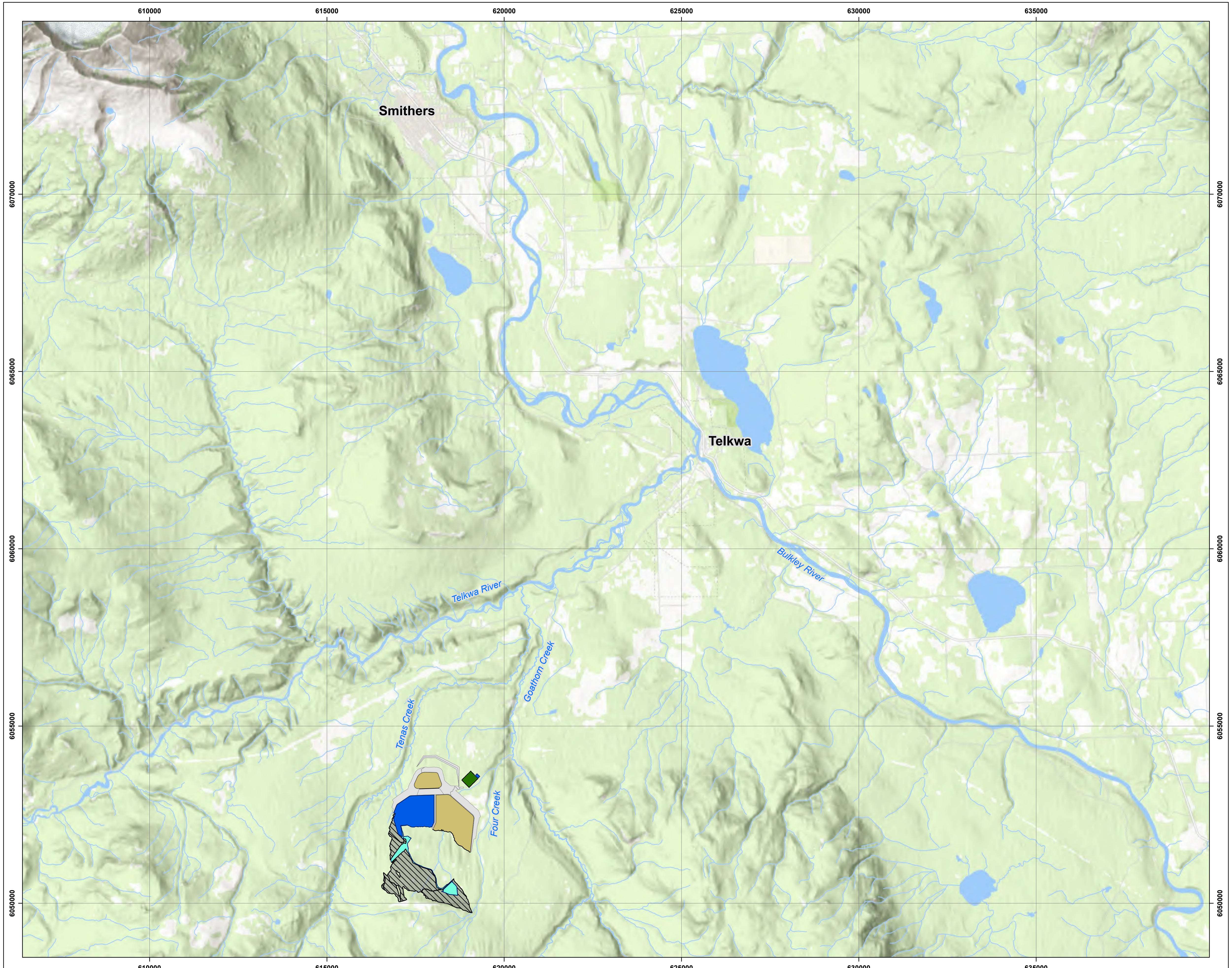
The following report provides a summary of baseline meteorology and hydrology data collected over the past 3 years for the Project. Regional records were used to extend the local records in order to develop statistical climate and hydrologic parameters that will be used to support various technical studies for the EA, including water management designs, groundwater modeling, and the water and load balance model.

1.1 Project Setting

The Tenas Coal Project is a proposed coal mine located in the Coast Mountains of the Cordilleran Region near the Town of Telkwa approximately 25 km southwest of Smithers, British Columbia. The coal preparation plant, maintenance facilities and service facilities would be located approximately 6 km southwest of Telkwa. The Project footprint elevation ranges from 750 to 1050 meters above sea level (masl) with a median elevation of 800 masl. The Ministry of Environment and Climate Change Strategy (MECCS) have published hydrological zones that represent areas of homogeneous hydrologic and geomorphic characteristics. The Tenas Project is within Zone 8 – Nechako Plateau.

The Project encompasses the lower reaches of the Telkwa River, Tenas Creek, Goathorn Creek and Four Creek. The Telkwa River is a major tributary to the Bulkley River near the village of Telkwa, British Columbia, which ultimately flows into the Skeena River. Four Creek is a tributary of Goathorn Creek, and Goathorn Creek and Tenas Creek are tributaries of the Telkwa River.

Figure 1-1 shows the Project location.



Tenas Project

Site Location

Legend

- Backfill
- Core Footprint
- Pit Lake
- Plant and Maintenance Area
- Pond
- Rock Cover
- Watercourse

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Project Features: Allegiance Coal, 2020
- Basedata: Government of British Columbia
- Basemap: World Topo Base

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Kilometers

NAD 1983 UTM Zone 9N

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1.2 Scope of Report

Meteorology and hydrology studies conducted as part of the Telkwa Coal Project Prefeasibility studies (SRK 2017a, 2017b) identified gaps in the existing meteorological and hydrological datasets. Subsequent collection of hydrometeorological data from 2018 to 2019 led to improved comparisons between Project Area datasets with regional records.

This report summarizes the baseline Project climate and hydrology and generates projections of future climate conditions.

- Section 2 presents the available meteorological datasets.
- Section 3 presents the available hydrometric datasets.
- Section 4 describes how available datasets were used to develop the Project Area meteorology and hydrometric synthetic time series.
- Section 5 outlines how climate change impacts on Project air temperature and precipitation were generated and applied on a monthly basis.

2 Baseline Meteorology

2.1 Section Overview

Meteorological characteristics are typically assessed by integrating Project-specific and regional meteorology records as well as comparing previous studies related to the Project and regional indices. Placing the Project-specific parameters in context using regional analyses is important to be able to provide meteorological inputs to the Project based on extended periods of record.

2.2 Available Meteorological Data

Baseline meteorological monitoring was initiated at the Telkwa Coal Project site in September 2017 by ERM Consultants.

This section summarizes the available monitoring data for the Telkwa Coal Project. Regional climate data from the surrounding area has also been assessed to place the Telkwa Coal Project climate into context.

2.2.1 Project Data

Baseline climate data for the Project Area was collected at the Tenas Deposit automatic weather station (54.59° N, 127.19° W), installed on 29 September 2017 and operated through December 2019. No meteorological data was collected in 2020. No snow surveys were conducted during the monitoring period. Figure 2-1 illustrates the location of the Tenas Deposit Station and Table 2-1 provides the metadata.

The monitoring record from the Tenas Deposit Station was compiled, reviewed, and validated by ERM (ERM 2019). The following data is recorded at the weather station:

- Hourly average wind speed
- Hourly wind direction and standard deviation of wind direction for 2017
- Hourly average air temperature
- Hourly average relative humidity
- Hourly average solar radiation
- Hourly average barometric pressure
- Hourly sampled snow depth
- 5-minute and hourly accumulated total precipitation

Details concerning the meteorological station configuration, data collection and preliminary gap-filling procedures are outlined in Section 4 of The Tenas Project 2017 to 2019 Baseline Report (ERM 2019).

2.2.2 Regional Data

Regional meteorological data for British Columbia is available from private as well as provincial and federal government sources. Regional re-analysis products for historical climate and future scenarios are available as gridded products developed by third parties based on government datasets. Within the Nechako Plateau hydrological zone, there are over 90 regional meteorological stations monitored by the Meteorological Service of Canada (MSC). This division of Environment and Climate Change Canada provides public historical meteorological data and information.

Figure 2-1 illustrates the locations of selected regional meteorological stations with respect to the Project. Three stations have historically operated in the town of Smithers. Smithers Airport Auto and Smithers A are understood to be the same station, after an upgrade in 2018. Table 2-1 presents the metadata for the selected regional stations.

Table 2-1: Regional Meteorological Station Selections.

Station Name	Climate Identifier	Latitude [° N]	Longitude [° W]	Elevation [masl]	Record Start	Record End	Distance from Project [km]
QUICK	1076638	54.62	126.90	533	1962	1995	19.1
SMITHERS AIRPORT AUTO	1077501	54.82	127.19	518	2013	2020	25.2
SMITHERS A	1077500	54.82	127.18	522	1942	2018	25.2
SMITHERS	1077499	54.83	127.18	523	2010	2020	26.3
HOUSTON	1073615	54.40	126.67	610	1957	2019	40.0
TOPLEY LANDING	1078209	54.82	126.16	722	1962	2017	71.0
EQUITY SILVER	1072692	54.2	126.28	1280	1981	2018	73.6
SUSKWA VALLEY	107G879	55.29	127.17	534	1982	2019	77.5
BURNS LAKE DECKER LAKE	1091174	54.38	125.96	713	1990	2019	83.1

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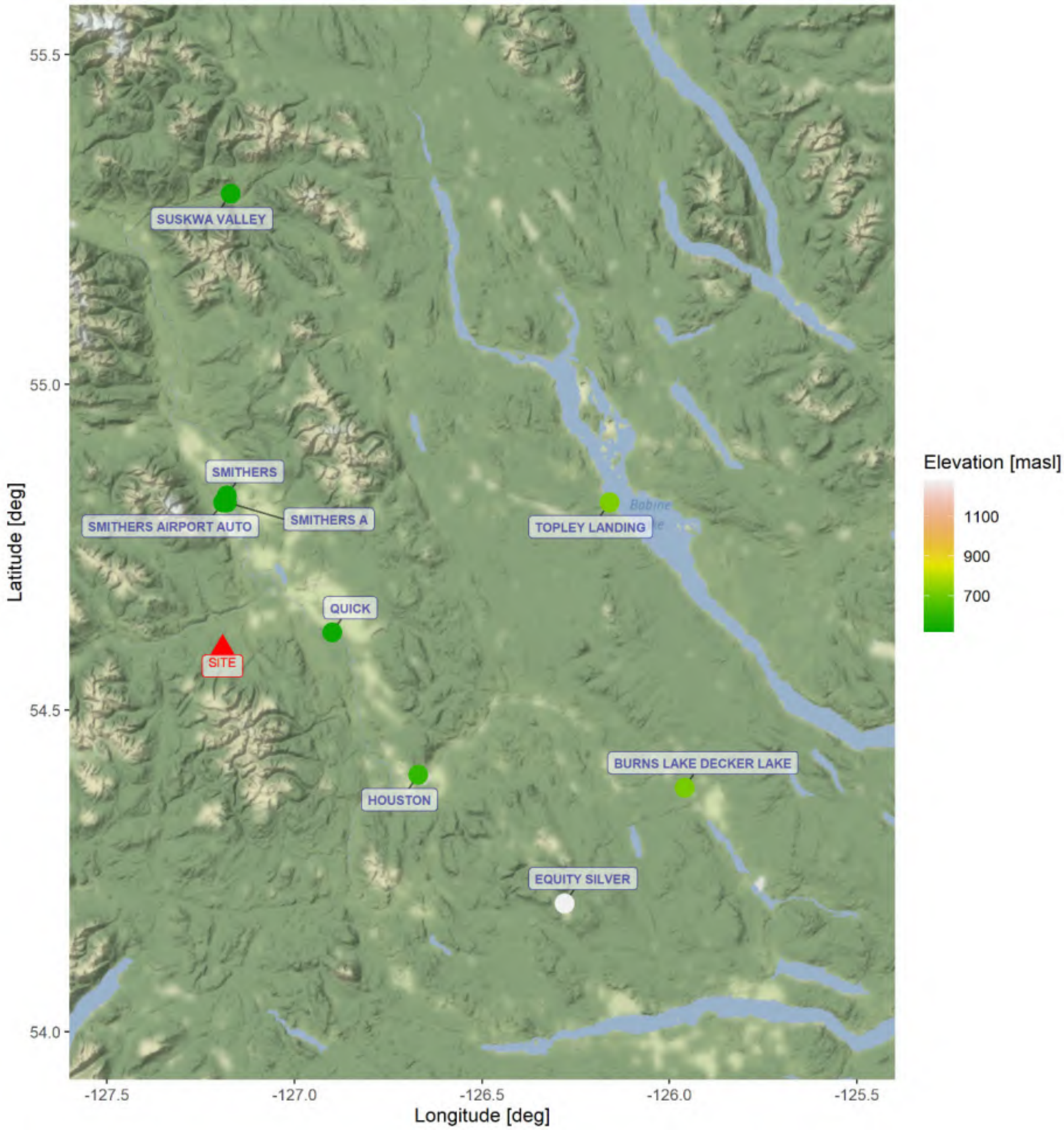

Figure 2-1: Meteorological Stations Used in Project ("Site") and Regional Assessment

Note: Smithers A and Smithers Airport Auto are located at the same geographic location.

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2.2.3 Missing Data

Some data gaps were identified during the 27 months of records available from the Tenas Deposit Station. Wind speed measurements were absent from the records for 21 days, representing 2.6% of the time. Similarly, solar radiation was not recorded for 126 days, representing 15.8% of downtime, mostly during the winter, presumably because of snow cover.

In terms of regional datasets, most stations also present some gaps in their records. Based on the correlations between stations these gaps could be patched appropriately as described in the sections below. Figure 2-2 and Figure 2-3 present the number of days with mean temperature and precipitation records respectively available at each regional station from 1942 to early 2020. The color ramp on the right-hand side indicates 0 days of data (white) to a full 365 days (dark blue).

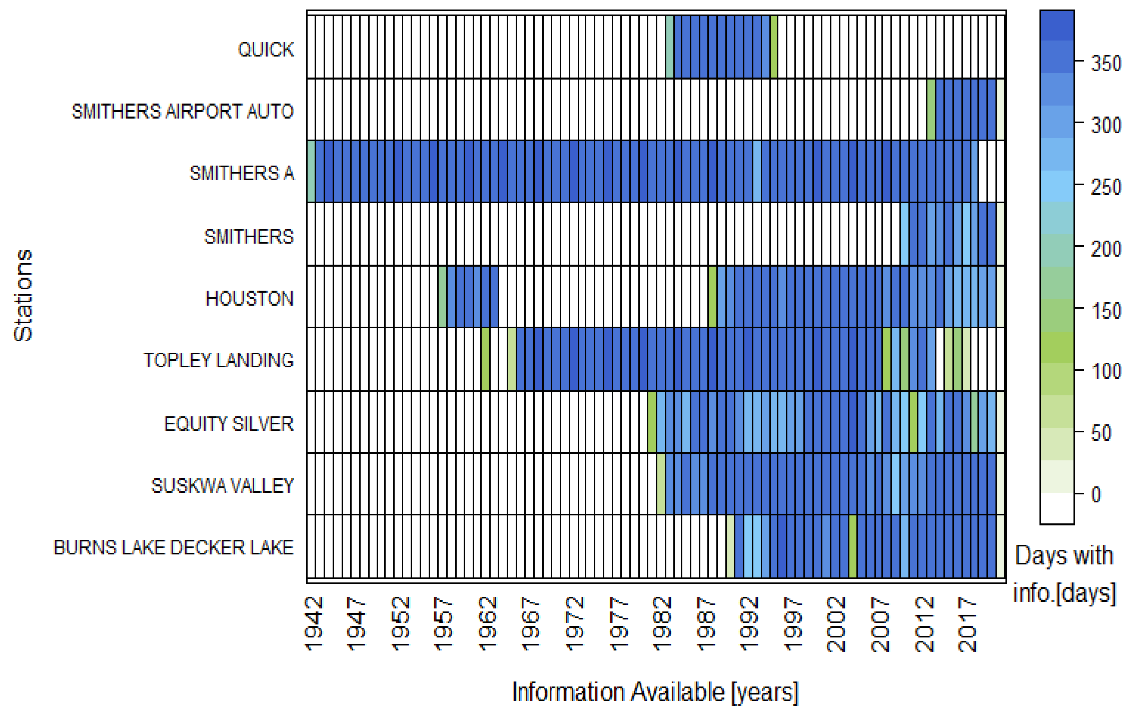

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Figure 2-2: Number of Days with Mean Temperature Data Available Every Year from Regional Stations

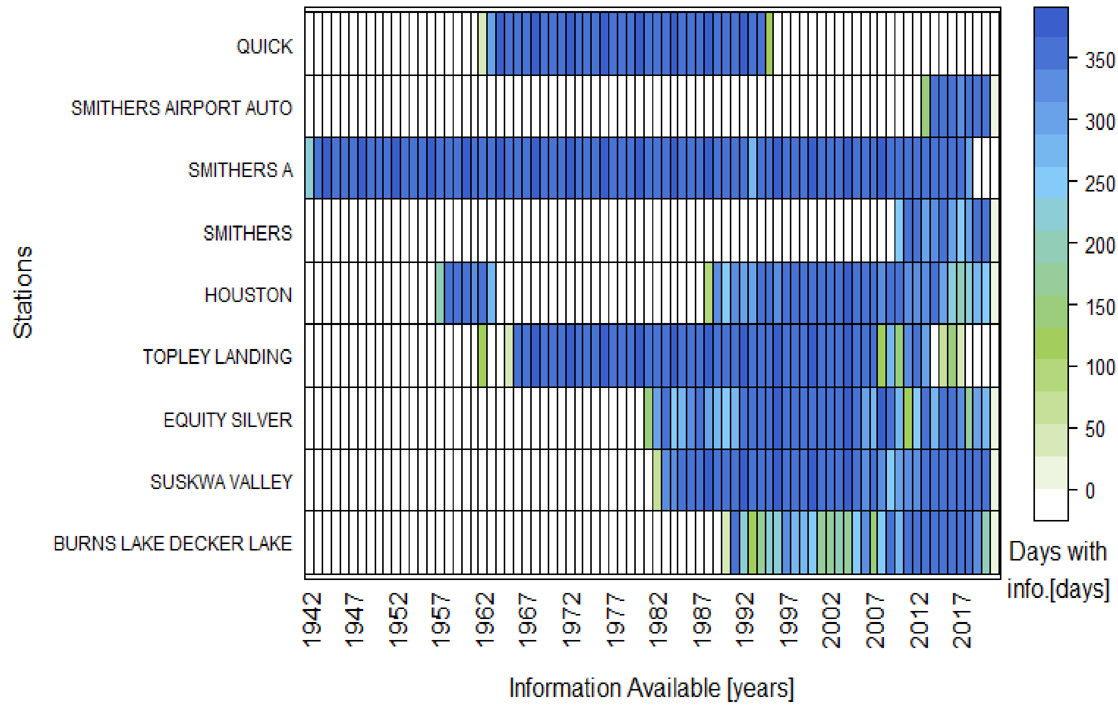

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Figure 2-3: Number of Days with Precipitation Data Available Every Year from Regional Stations

2.2.4 Regional Snow Datasets

The British Columbia Snow Survey Data includes datasets from two regional networks:

The Automated Snow Weather Station (ASWS) network is comprised of stations operated by the Ministry of Environment, BC Hydro and others. These stations collect hourly snow water equivalent, snow depth, air temperature, and precipitation. Data is available in near-real-time. Tsai Creek Station is the closest station of this type to the Project and is published by the Ministry of Environment and Climate Change Strategy (MECCS).

The Manual Snow Survey Sites network is operated by the province of British Columbia and manually measures snow depth and snow water equivalent. Measurements are taken monthly when snow is present, providing a record of snowpack across the province. Hudson Bay is the closest manual survey site to the Project. This data is also published by MECCS.

Figure 2-4 illustrates the locations of Tsai Creek and Hudson Bay snow survey stations, and Table 2-2 presents details pertaining to these stations.

Table 2-2: Regional Snow Survey Stations

Station Name	Station Identifier	Latitude [°]	Longitude [°]	Elevation [masl]	Record Start	Record End	Distance from Project [km]
Tsai Creek	4B17P	54.64	-127.68	1360	2003	Current	31.8
Hudson Bay	4B03A	54.76	-127.27	1480	1972	Current	19.4

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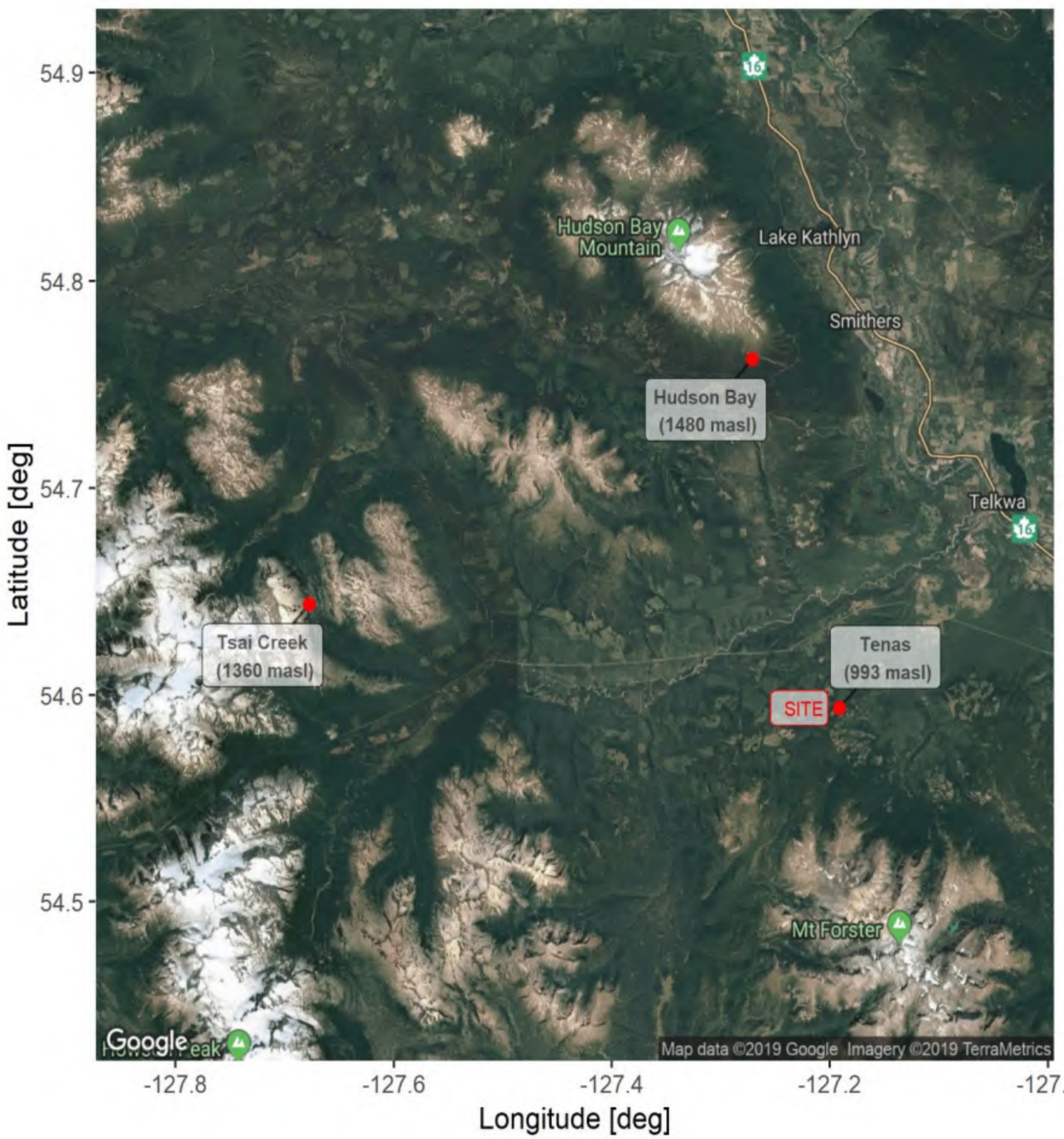

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Figure 2-4: Regional Snow Pillow Stations Hudson Bay and Tsai Creek Shown in Relation to Tenas Deposit Station

2.2.5 Reanalysis Meteorological Datasets

Reanalysis products were used to calculate regional orographic trends for precipitation and temperature. The regional stations could not account for these orographic trends, particularly in winter due to inversions present at some stations, and Project data did not produce a meaningful relationship to regional stations due to its relatively short duration of record.

Climate reanalysis combines gridded global models with observed historical data to produce historical climate and to incorporate adjustments based on developed relationships. Multiple reanalysis datasets are available in different spatiotemporal resolutions. Table 2-3 presents the three reanalysis datasets examined for this study.

Table 2-3: Overview of reanalysis datasets examined in this study

Reanalysis	Institution	Period of Record
ERA-5	European Centre for Medium-Range Weather Forecast (ECMWF)	1979-current
MERRA-2 Modern-Era Retrospective Analysis for research and applications	US National Aeronautics and Space Administration (NASA)	1980- current
PRISM	Pacific Climate Impact Consortium (PCIC)	1950-2007

Source: Compiled in text.

ERA-5 and MERRA-2 are global datasets that provide sub-daily values for multiple meteorological parameters. PRISM is a climate-elevation regression model, used to generate a reanalysis dataset that provides precipitation and maximum and minimum temperature averages on a monthly timestep for the Pacific Region of Canada and the northwestern USA.

2.3 Summary of Available Data

This section presents a summary of the Project Area and regional meteorological datasets.

Meteorological parameters were summarized for the three years of Project data using monthly averages of daily minimum, mean and maximum air temperatures. Monthly average sums of the minimum, mean and maximum total precipitation were calculated. Annual maximum snow water equivalent (SWE) was computed for the Project based on regional snow survey data, transposed to the Project Area.

Other parameters measured at the Tenas Deposit Station include: Wind speed and direction, solar radiation, relative humidity, and barometric/atmospheric pressure. Evaporation rates were calculated based on thes parameters. Measured and calculated parameters are summarized for the Project Area and the long-term regional records in the following sections.

2.3.1 Air Temperature

Project

Temperature is used to estimate snowmelt, evaporation, evapotranspiration, and other inputs such as pond freeze depths. Air temperatures recorded at the Tenas Deposit Station ranged from -24.5°C (January 11, 2018) to 31.4°C (July 29, 2018). Figure 2-5 presents the daily maximum, average and minimum temperature at the Tenas Deposit Station. During the period of record, the coldest month was the month of February 2019 with a mean temperature of -12.7°C, and the hottest month was the month of July 2018 at 15.5°C. The summary of monthly maximum, average and minimum daily temperatures is presented in Table 2-4.

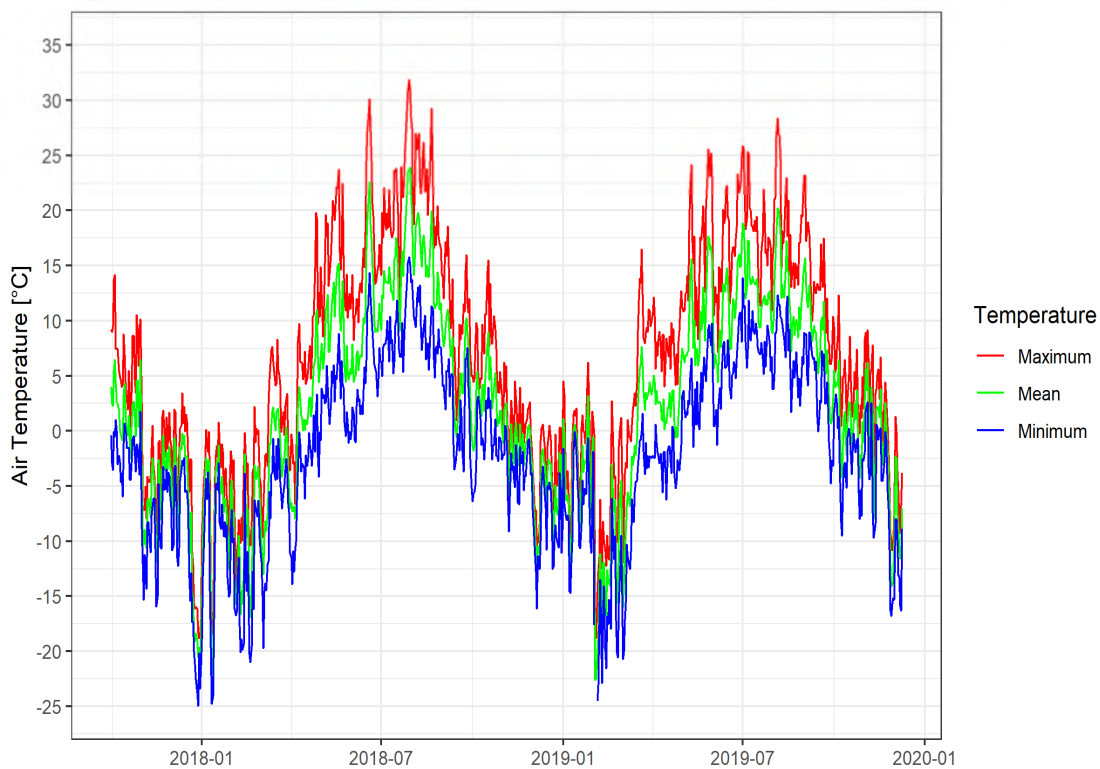

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Figure 2-5: Tenas Deposit Meteorological Station Temperature Record.

Table 2-4: Tenas Deposit Meteorological Station Daily Air Temperature [°C] for October 2017-2019.

Year	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2017	Max.										14.2	2.5	3.4	14.2
	Mean										1.9	-5.6	-8.9	-4.2
	Min.										-5.9	-15.9	-24.9	-24.9
2018	Max.	0.8	2.2	8.3	19.8	23.7	30.1	31.8	29.3	18.5	15.5	6.2	0.6	31.8
	Mean	-7.6	-9.8	-3.3	1.1	9.4	10.6	15.5	15.3	5.9	3.0	-1.0	-6.1	2.8
	Min.	-24.7	-21.0	-19.7	-13.9	-1.1	-1.0	5.0	4.9	-5.2	-6.3	-9.1	-16.1	-24.7
2019	Max.	6.2	2.7	16.5	12.7	25.6	24.8	25.9	28.4	23.2	12.3	9.1	1.3	28.4
	Mean	-3.8	-12.7	-1.3	2.4	10.5	10.9	12.9	12.9	8.2	0.7	-1.9	-7.9	2.6
	Min.	-14.7	-26.5	-20.7	-6.2	-1.4	-1.3	3.8	1.7	-4.8	-9.5	-16.8	-16.3	-26.5

*Light grey denotes no measurements.

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Regional

Temperature records for the Smithers Airport station were extended and patched using data from the Houston station. Figure 2-6 shows the annual distribution of regional temperatures, where the coldest and warmest months are typically January and July, respectively. Regional stations show similar temperature behaviour throughout the year except for Tsai Creek and Equity Silver. These two regional stations appear to show milder winters suggesting a temperature inversion for higher elevations. This suggests monthly correction factors are more appropriate to account for the potential of temperature inversions during the winter months.

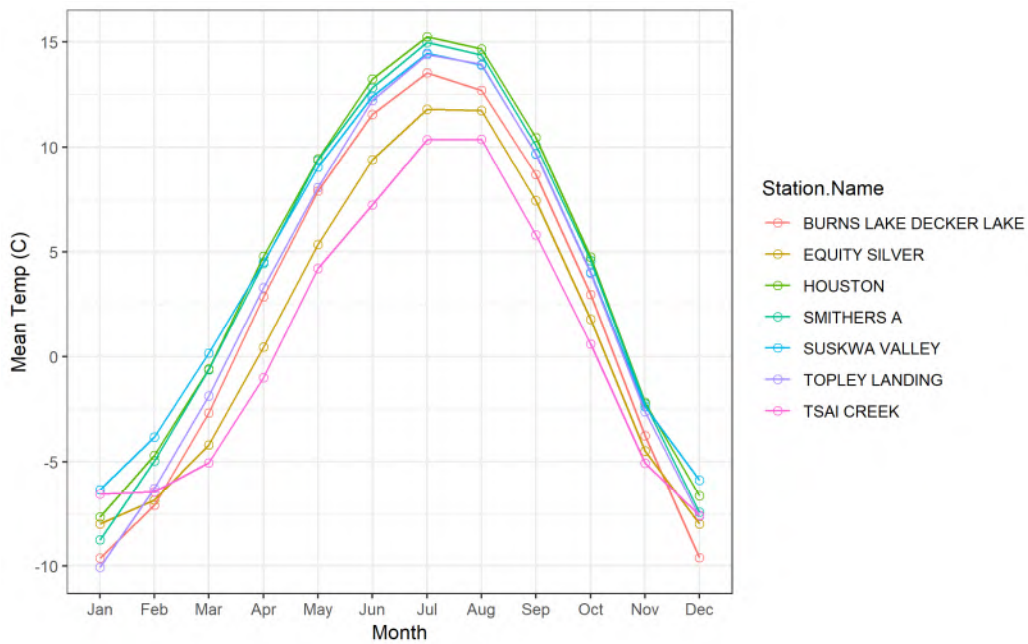

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Figure 2-6: Monthly Average Temperatures at Regional Meteorological Stations

Regionally, mean annual temperature decreases with increasing elevation. For a Project site elevation of 993 m (corresponding to the location of the Tenas Deposit Station), the mean annual temperature is approximately 2°C colder than temperatures recorded at the Smithers Airport Station (Figure 2-7).

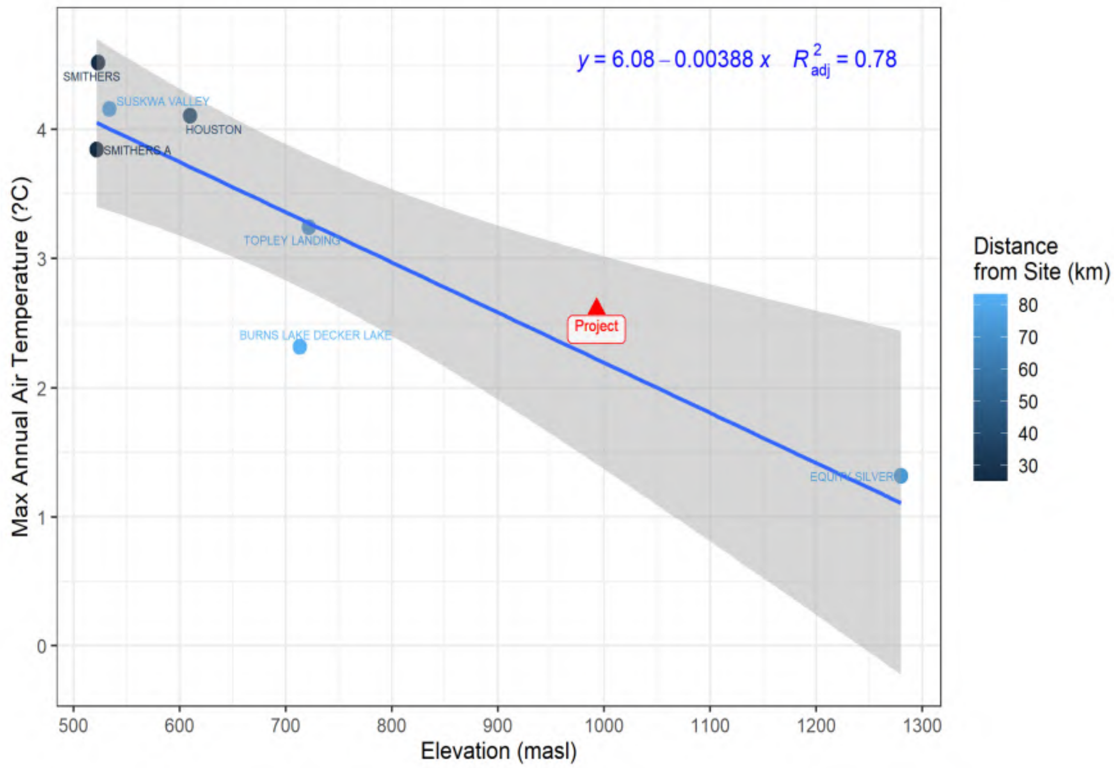

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Figure 2-7: Regional Mean Annual Temperature – Elevation Trend

2.3.2 Precipitation

Project

The Tenas Deposit Station recorded 672 mm and 502 mm of total precipitation in 2018 and 2019, respectively. Figure 2-8 presents the recorded daily precipitation from October 2017 to December 2019. The largest single-day precipitation events occurred on 24 October 2017 for rainfall (73 mm) and on 7 February 2018 for snowfall (65 mm). The 24 October 2017 event corresponds to an exceptional runoff event that exceeded historical streamflow records for regional stations in the area (ERM 2019).

The recorded total precipitation at the Tenas Deposit Station (Figure 2-8) was divided into rainfall (mm) and snowfall (mm SWE) components if the Project air temperature record was less than 0 degrees Celsius. Using this estimation, snow comprises 71% and 31% in 2018 and 2019, respectively (see Table 2-8 for regional comparison). Monthly cumulative values of measured total precipitation and estimated rainfall and snowfall are summarized in Table 2-5.

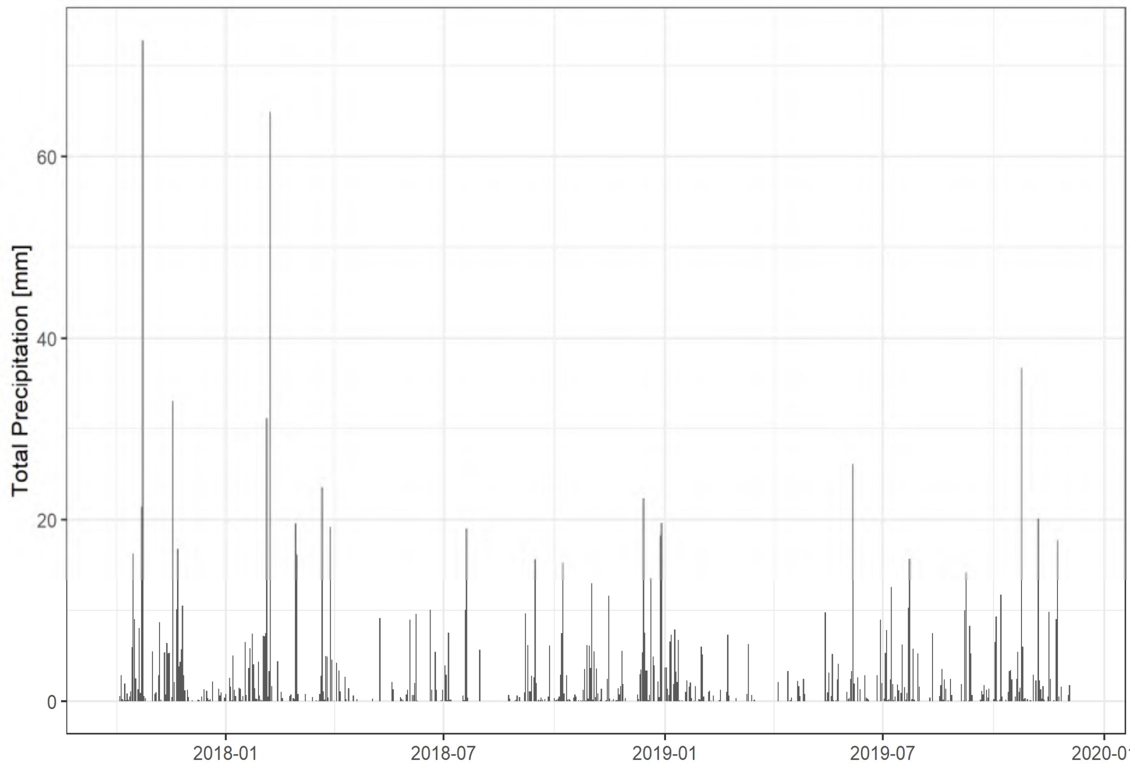

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Figure 2-8: Tenas Deposit Meteorological Station Measured Total Precipitation for October 2017-2019

Table 2-5: Tenas Deposit Meteorological Station Total Precipitation (measured), Rain (estimated), Snow (estimated)

Year	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
2017	Total Precipitation [mm]										147	134	10	--
	Rainfall [mm]										114	0	0	--
	Snowfall [mm SWE]										33	134	10	--
2018	Total Precipitation [mm]	50	150	81	14	14	42	50	2	50	54	51	113	672
	Rainfall [mm]	0	0	1	3	14	42	50	2	30	42	9	0	195
	Snowfall [mm SWE]	50	150	80	10	0	0	0	0	20	11	42	113	477
2019	Total Precipitation [mm]	60	19	8	13	26	57	83	21	47	93	73	2	502
	Rainfall [mm]	5	0	0	7	26	57	83	21	46.5	69	32	0	346
	Snowfall [mm SWE]	55	19	8	6	0	0	0	0	0.5	24	41	2	156

*Light grey denotes no measurements.

Source: compiled in text from \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_hydrology_summary.xlsx

Regional

A regional precipitation analysis was carried out to identify trends and elevation correlations. The Smithers Airport Auto and Smithers A stations (10775001 and 1077500) were merged to generate a long-term record. Remaining gaps in this record were patched with Quick as well as ERA-5, using quantile mapping methods. The resulting patched Smithers A record provides 73 years of complete data.

Average yearly precipitation, rainfall and snowfall for regional stations are presented in Table 2-6 for their corresponding period of record. Regional stations present varying mean annual precipitation (MAP) in the range of 390 mm to 760 mm with precipitation occurring mainly as rainfall except for Equity Silver where more snow is observed due to its higher elevation.

Table 2-6: Regional Stations Annual Precipitation, Rain, Snow and Corresponding Proportions

Station	Mean Annual Precipitation [mm]	Mean Annual Rainfall [mm]	Mean Annual Rainfall [%]	Mean Annual Snowfall [SWE mm]	Mean Annual Snowfall [%]
SMITHERS A (patched)	508	322	63%	186	37%
QUICK	461	298	65%	163	35%
HOUSTON	423	291	69%	132	31%
TOPLEY LANDING	539	312	58%	227	42%
EQUITY SILVER	660	344	52%	316	48%
SUSKWA VALLEY	760	554	73%	205	27%
BURNS LAKE DECKER LAKE	389	186	48%	203	52%

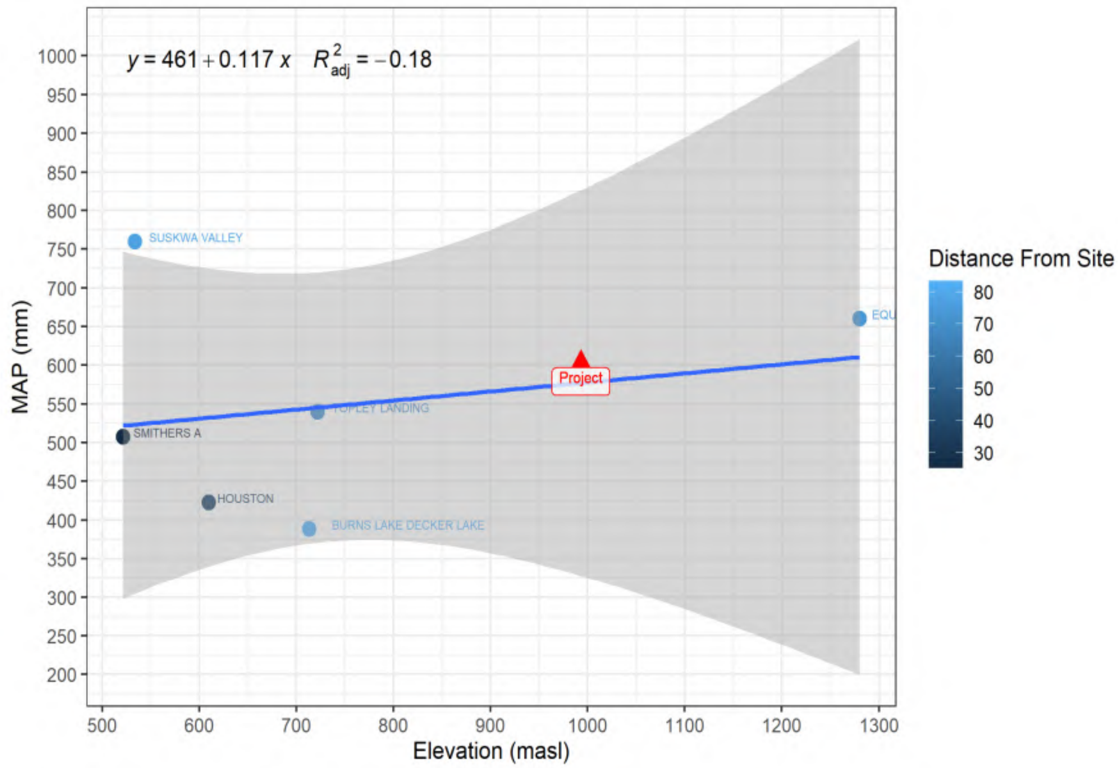
Notes:

1. Rainfall and snowfall proportions as percentages of the mean annual precipitation.
2. Smithers A patched with Smithers Airport Auto, Quick and ERA-5.

Source: Compiled in text from R code: code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\ Telkwa_EA_Precipitation_1CT027.003_rev01.Rmd and Canadian Climate Normals https://climate.weather.gc.ca/climate_normals/index_e.html

Figure 2-9 illustrates the regional correlation between MAP and elevation. A negative value for the determination coefficient (R^2 presented in Figure 2-9) indicates the correlation between elevation and MAP using only the regional meteorological datasets is very poor.

The relationship between MAP and elevation is likely less significant at this location due to the more dominant effects of topography and the Pacific Ocean as a moisture source. The west-east gradient and proximity to mountain range with rain shadow effects are the most important factors affecting precipitation in this area. Orographic gradients were further evaluated using Reanalysis datasets and are discussed in Section 4.1.2.



Note: Quick station data not included due to differing timelines
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Figure 2-9: Regional Mean Annual Precipitation – Elevation Trend

Monthly precipitation was also reviewed and compared to site data over the concurrent period of record. Figure 2-10 shows a box plot with the range of monthly precipitation registered at the regional stations during the period of record for the Project. Monthly precipitation registered at the Tenas Deposit Station is represented by the red circles. During the period of record, Project precipitation has usually been within the range of values observed in the region in the corresponding month, with the most significant anomalies occurring during the winter months mainly with higher precipitation for site relative to regional stations. During the 2017-2018 winter season in particular the Project location registered higher precipitation relative to other locations in the region. Monthly precipitation data for the regional stations is presented in Table 2-7.

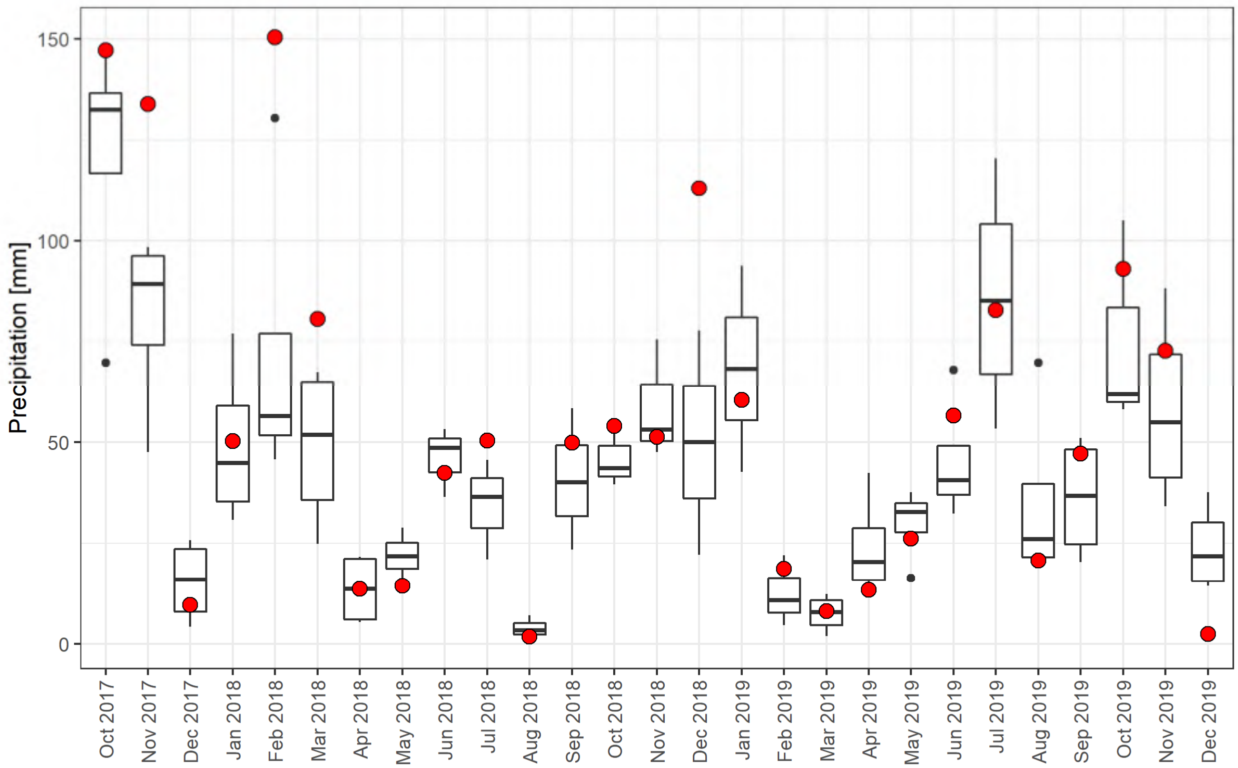

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Figure 2-10: Regional Monthly Precipitation (boxplots) compared to Project (red circles)

Table 2-7: Regional Stations Monthly Precipitation Records

Year	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
2017	SMITHERS A (patched)	33	10	7	11	90	57	31	17	83	132	99	9	--
	HOUSTON	0[1]	10[1]	1[1]	6[1]	83[1]	34[1]	7[1]	1[1]	3[1]	81[1]	17[1]	4[1]	--
	TOPLEY LANDING				24[1]	62[1]								--
	EQUITY SILVER	52	50	44		116	74	30	26	50	133	95	23	--
	SUSKWA VALLEY	38	17	36	32	120	69[1]	75	55	104	149	83	26	--
	BURNS LAKE DECKER LAKE	21	12	13	23	68	38	30	11	48	70	48	4	--
2018	SMITHERS A (patched)	31	59	39	5	24	53	21	1	23	40	24[1]		--
	HOUSTON	14[1]	34[1]	4[1]	2[1]	12[1]	23[1]	41.2[1]	0[1]	31[1]	28[1]	36[1]	20[1]	--
	TOPLEY LANDING													--
	EQUITY SILVER	77	130	64	21	29	24[1]							--
	SUSKWA VALLEY	53	46[1]	67	22	20	49	46	7	58	55	76	78	575
	BURNS LAKE DECKER LAKE	37	54	25	6	15	36	37	3	40	44	48	0.1[1]	--
2019	SMITHERS A (patched)													--
	HOUSTON	23[1]	1[1]	0[1]	0[1]	16.8[1]	40[1]	42[1]	26	49.4	73[1]	12[1]	13[1]	--
	TOPLEY LANDING													--
	EQUITY SILVER	0[1]	5[1]	10	24	37.6	68	121	40	41[1]	24[1]	44[1]	38	--
	SUSKWA VALLEY	94	22	12	42	31	43	99	70	51	105	88	28	685
	BURNS LAKE DECKER LAKE	8[1]	11	2	14	34	39	72	20	26	58	34	16	--

[1]Incomplete month. More than 5 days missing from record.

*Light grey denotes no measurements.

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\Telkwa_1CT027.003_MSC_Summaries.xlsx

2.3.3 Snow Depth

Project

The winter snowpack in 2017-2018 began accumulating at the Tenas Deposit October 16, 2017 and finished melting in May 2018. During this period, the snow depth peaked at 149 cm on March 30, 2018. Table 2-8 presents the daily mean snow depth data recorded at the Tenas Deposit Station. Snowpack at the Project does not have a large potential of being redistributed by wind as the general surrounding area is heavily forested and recorded wind speeds are low (see Section 2.3.4). Snow depth measurements recorded at the Tenas Deposit Station are believed to be representative of the Project (ERM 2019). Snow depths are measured continuously at the Project while snowpack snow water equivalent measurements are not available.

Table 2-8: Snow Depth Summary at Tenas Deposit Station for October 2017 to 2019

Year	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	Maximum Snow Depth [cm]										16	60	51
	Average Snow Depth [cm]										4	28	47
	Minimum Snow Depth [cm]										0	3	44
2018	Maximum Snow Depth [cm]	78	122	149	140	64	0	0	0	8	4	16	75
	Average Snow Depth [cm]	63	101	119	110	12	0	0	0	1	0	9	38
	Minimum Snow Depth [cm]	51	76	97	68	0	0	0	0	0	0	3	13
2019	Maximum Snow Depth [cm]	76	83	83	55	6	0	0	0	0	29	19	15
	Average Snow Depth [cm]	66	75	74	32	0	0	0	0	0	5	5	14
	Minimum Snow Depth [cm]	56	72	56	10	0	0	0	0	0	0	0	12

*Light grey denotes no measurements.

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Snowpack_Update_rev02.Rmd

Regional

The Tenas Deposit Station records total precipitation and snow depth but does not measure the snow water equivalent. The automated regional snow pillow station operated by environment Canada at Tsai Creek measures precipitation, temperature, snow depth and hourly snow water equivalent. The snow depth record at Tsai Creek is much higher than the snow depth record at the Tenas Deposit Station although the accumulation pattern is similar. However, melt timing occurs later at Tsai Creek due to the elevation difference between the two stations as well as other physiographic characteristics such as aspect. At Tsai Creek, snowmelt typically begins in April, peaks in May and then is finished by early June.

Hudson Bay manual survey station also offers records near the Project. Figure 2-11 illustrates snow depth records at these regional stations compared to the project records, and Table 2-9 presents monthly average snow depth at Tsai Creek together with monthly survey results carried out at Hudson Bay.

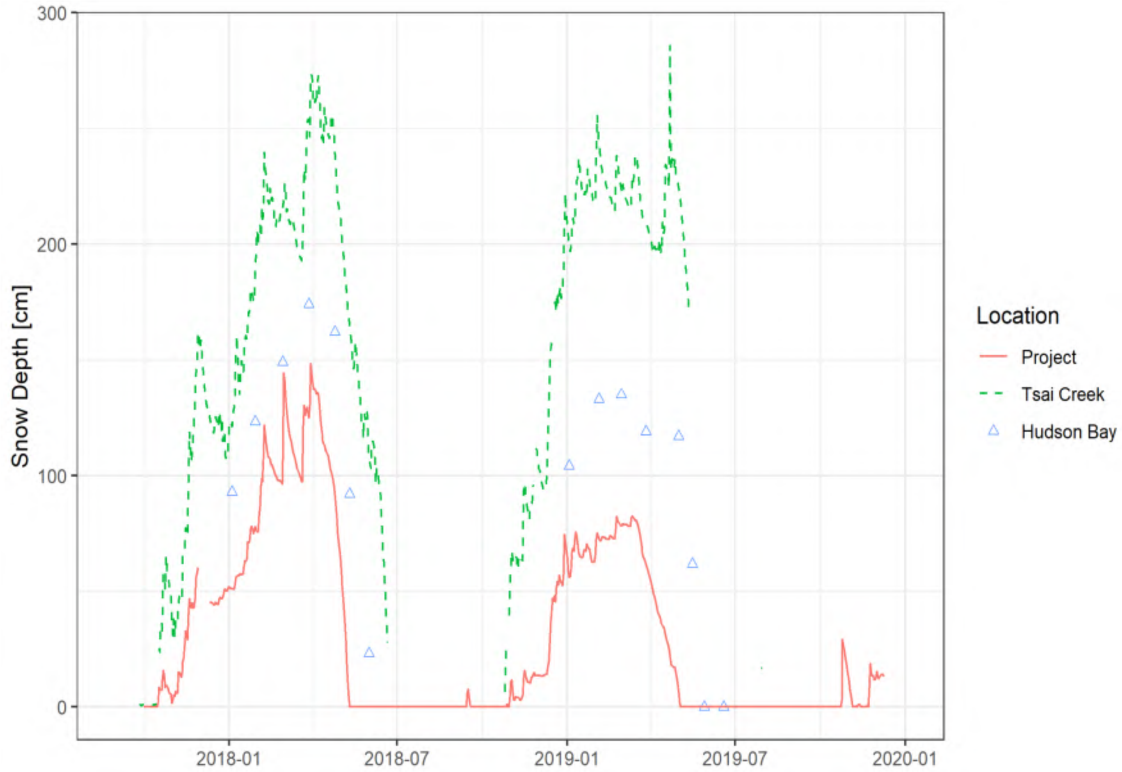

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Figure 2-11: Snow Depth Records at Tsai Creek, Hudson Bay and Tenas Deposit

Table 2-9: Average Snow Depth at Tsai Creek and Hudson Bay Stations for October 2017 to 2019

Year	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	Average Snow Depth at Tsai Creek [cm]										33	85	126
	Hudson Bay monthly Snow Depth Survey [cm]												
2018	Average Snow Depth at Tsai Creek [cm]	155	215	219	249	155	86				30	80	155
	Hudson Bay monthly Snow Depth Survey [cm]	108	149	174	162	92	23						108
2019	Average Snow Depth at Tsai Creek [cm]	148	219	229	220	217	190	18	17	0	29	19	15
	Hudson Bay monthly Snow Depth Survey [cm]		104	134	119		60	0		0	5	5	14

*Light grey denotes no measurements.

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Snowpack_Update_rev02.Rmd

2.3.4 Wind

Project

Wind speeds at the Project are generally low (less than 2 m/s) and are predominantly from the southwest (i.e., travelling down the Tenas Creek watershed). Figure 2-12 illustrates the wind rose representing wind speed data for the hydrologic year from October 2017 to September 2018. Table 2-10 presents the monthly average wind speed for each year of record from the Project station. No additional wind direction records were available so wind data from October 2018 to 2019 is not represented in the wind rose. The maximum hourly mean wind speed recorded at the Tenas Deposit Station between October 2017 to December 2019 was 5.4 m/s and the maximum wind gust speed was 14.9 m/s.

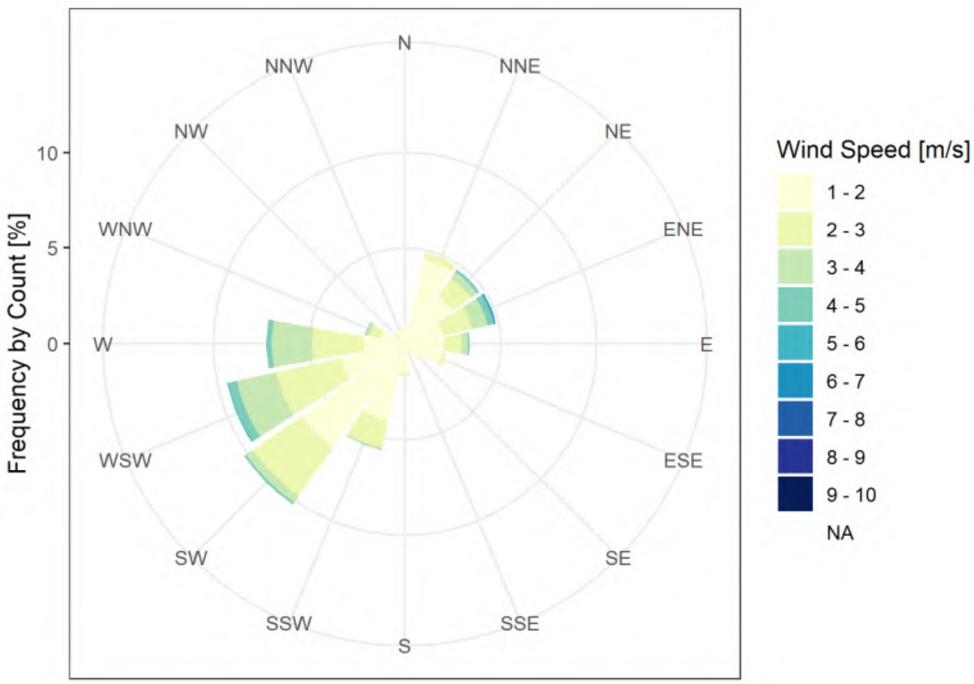

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Figure 2-12: Wind Rose at Project for 2017-2018 Hydrologic Year

Table 2-10: Project Daily Average Wind Speed Summary [m/s]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017										1.2	1.1	0.9
2018	0.7	1.2	1.5	2.0	2.5	2.9	3.3	2.3	1.4	1.1	0.9	1.1
2019	1.0	1.4	1.3	1.6	1.8	1.7	1.4	1.5	1.3	1.1	1.2	0.7

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\ Wind_and_Freeboard_EA_rev00.Rmd

Regional

Winds at the Smithers Airport station were found to be predominantly from the southeast and slightly higher than the Project Area. Wind speeds are typically used to evaluate evaporation and wave run-up and setup for freeboard estimates. Given the short period of record overlap, it was determined that higher wind speed measured at the Smithers Airport station is conservative and appropriate for application to the Project.

Figure 2-13 illustrates the wind roses based on wind speeds recorded from October 2017 to December 2019 at Smithers Airport station.

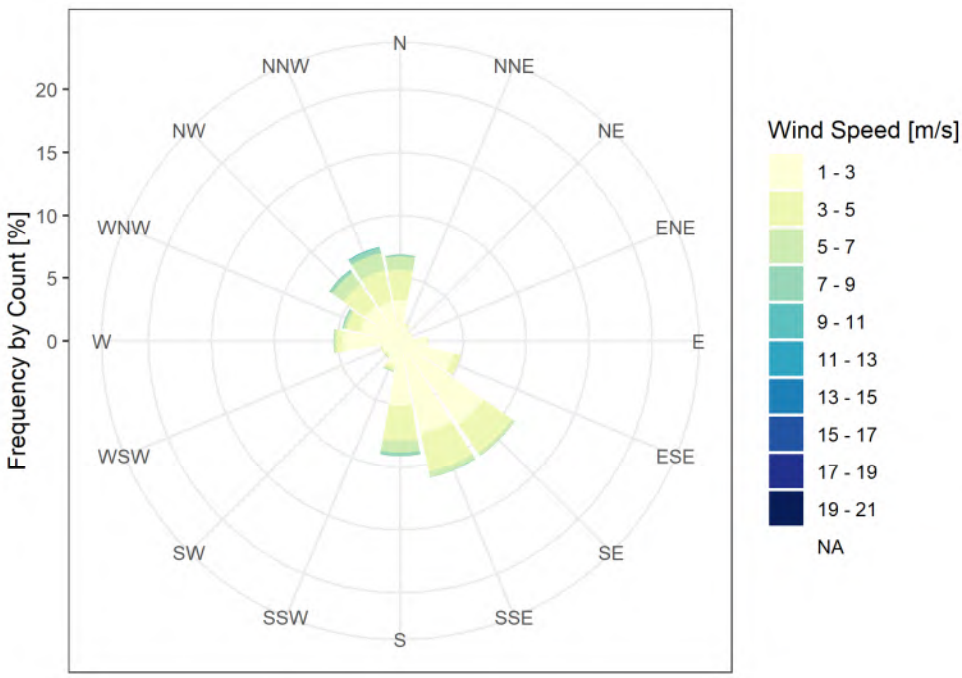

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Figure 2-13: Wind Rose for Smithers A – October 2017 to December 2019

Smithers A values have been adapted to the Project for design purposes but should be replaced with Project-specific data when it becomes available. Wind speeds are typically not transposable across large distances and due to physiographic characteristics unique to each location. Table 2-11 summarizes the monthly average wind speeds and Table 2-12 presents the frequency analysis for sustained wind speeds adopted for the Project.

Table 2-11: Average Monthly Wind Speed [m/s] at Smithers A Regional Station

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average (m/s)	2.0	1.9	2.0	2.2	2.1	1.9	1.7	1.5	1.5	1.9	1.9	2.0	1.9

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Wind_and_Freeboard_EA_rev00.Rmd

Table 2-12: Sustained Wind Speed Frequency Analysis for Smithers Airport Station

Return Period	Wind Speed [m/s]
2	12.6
5	14.8
10	16.3
25	18.2
50	19.5
100	20.9
200	22.3
500	24.1
1000	25.5

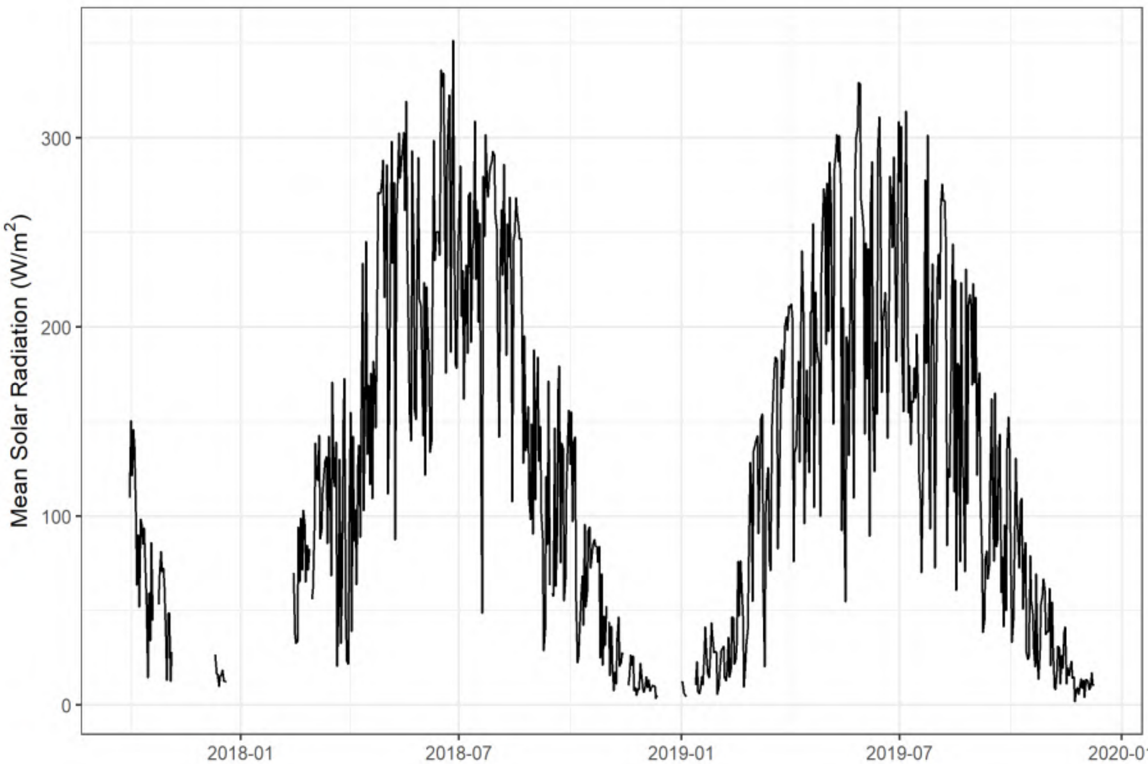
Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\ Wind_and_Freeboard_EA_rev00.Rmd

2.3.5 Solar Radiation

Project

The amount and intensity of solar radiation is a function of elevation, latitude, catchment orientation (slope and aspect) and shadows cast by topographic features and the atmosphere (i.e., cloud cover). Solar radiation at the Tenas Deposit Station is measured in power density units of W/m^2. Many periods of erroneous data were removed from the dataset due to snow accumulation on top of the sensor. Figure 2-14 illustrates daily solar radiation measured at the Tenas Deposit Station from October 2017 to December 2019.

Average daily solar radiation ranged from 4 W/m^2 to 351 W/m^2. As illustrated, incoming solar radiation has both seasonal and annual cycles. Diurnal variation in the sub-daily record (not shown) demonstrate typically higher values at midday and during summer while lower values typically occur between late evening to morning, and in winter. Table 2-13 presents the average monthly solar radiation at the Tenas Deposit Station.



Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Evaporation_1CT027.003_rev01.Rmd

Figure 2-14: Average Daily Solar Radiation at the Tenas Deposit Station for October 2017 to 2019

Table 2-13: Average Monthly Solar Radiation at the Tenas Deposit Station for October 2017 to 2019 [W/m^2]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017										79.8	30.2	15.7
2018		72.0	99.3	165.2	233.0	237.6	242.2	202.3	112.5	73.1	20.1	9.2
2019	18.4	40.8	137.3	181.4	230.5	219.5	182.3	183.6	108.5	58.4	20.9	11.1

*Light grey denotes no measurements.

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Evaporation_1CT027.003_rev01.Rmd

Regional

The Smithers Airport Station does not record solar radiation. The Canadian Weather Energy and Engineering Dataset (CWEEDS) dataset is available for the location of Smithers Airport and was compared to incoming solar radiation recorded at the Tenas Deposit Station. Table 2-14 presents the average monthly solar radiation at the Smithers Airport station from the CWEEDS dataset.

Table 2-14: Average Monthly Solar Radiation [W/m^2] at Smithers Airport Location

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average	67	133	249	366	465	485	425	327	232	147	77	48	196

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Evaporation_1CT027.003_rev01.Rmd

Based on available data, incoming solar radiation at the Project was found to be lower than the solar radiation from the CWEEDS dataset for the Smithers Airport location, understood to be due to the former being located in the north face of a mountain while the latter is located in an open, flat location and receives greater insolation.

2.3.6 Relative Humidity

Relative humidity refers to the ratio of the amount of moisture in the air to the relative maximum potential amount that air could hold at a given temperature and atmospheric pressure. As relative humidity approaches 100%, the likelihood of precipitation increases. On a monthly basis, the average relative humidity was typically greatest from November to January, remaining consistently above 85%, and was the lowest overall during the months of July and August (Figure 2-16). The monthly maximum, average and minimum daily relative humidity values are summarized in Table 2-15.

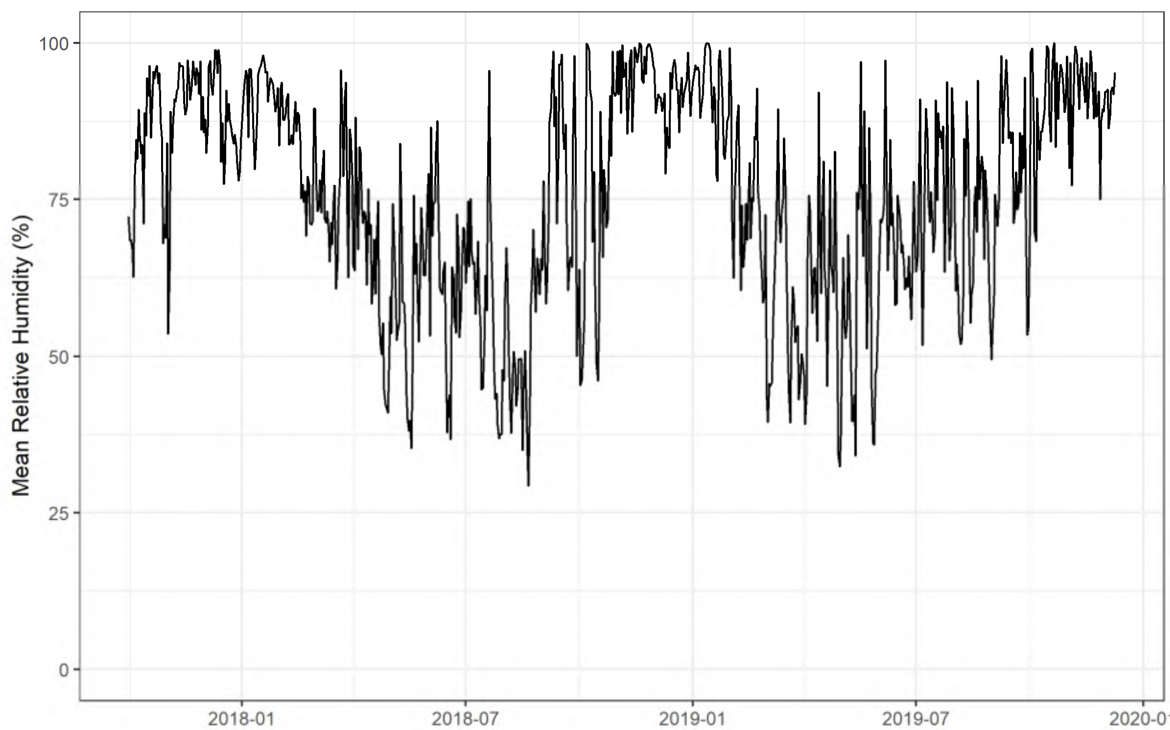


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Figure 2-15: Average Daily Relative Humidity at the Tenas Deposit Station for October 2017 to December 2019

Table 2-15: Tenas Deposit Monthly Average Relative Humidity [%]

Year	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2017	Max										96.4	97.2	98.9	98.0
	Avg										83.2	90.0	88.3	87.1
	Min										62.7	53.6	77.5	53.6
2018	Max	98.0	93.7	95.7	88.1	84.0	87.6	95.6	70.2	98.6	99.9	100.0	98.5	100.0
	Avg	92.0	83.2	76.8	63.9	59.6	63.2	58.3	51.5	78.3	75.5	96.0	91.3	74.1
	Min	79.9	69.2	60.8	41.0	35.3	36.7	36.9	29.4	50.1	45.3	85.5	79.1	29.4
2019	Max	100.0	92.8	89.5	92.1	97.0	97.3	93.8	94.1	97.9	100.0	99.5	95.3	100.0
	Avg	92.4	74.3	58.6	61.6	58.9	69.2	77.0	69.4	78.9	89.7	91.4	91.6	76.1
	Min	78.0	58.6	39.4	32.4	34.2	55.9	51.8	49.6	53.5	68.3	75.0	86.4	32.4

*Light grey denotes no measurements.

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Evaporation_1CT027.003_rev01.Rmd

Regional

Hourly relative humidity recorded at the Smithers Airport station was evaluated for the period of record (1953-2019) and the monthly average values are presented in Table 2-16. Patterns in relative humidity were similar to what was observed at the Tenas Deposit Station.

Table 2-16: Average Monthly Relative Humidity [%] at Smithers A Location

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average (%)	83.6	79.3	71.2	63.3	61.3	65.7	68.8	72.1	79.5	82.1	85.9	85.4	74.8

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Evaporation_1CT027.003_rev01.Rmd

Monthly relative humidity values were compared between October 2017 and December 2019 and are shown in Figure 2-16, where the red line represents the identity function. Based on these records, the Smithers Airport station relative humidity is generally lower than at the Tenas Deposit Station.

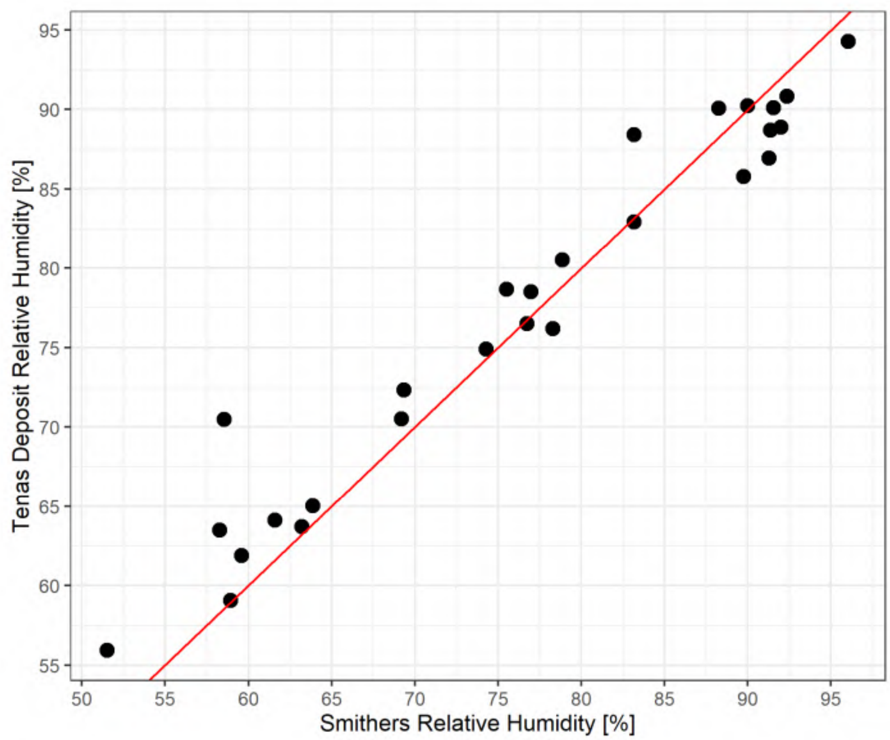

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Figure 2-16: Monthly Average Relative Humidity at Smithers Airport Station and Tenas Deposit Station for October 2017 to December 2019

2.3.7 Evaporation

Project and Regional

Open water evaporation is an important component of the water balance for the Project area. Two approaches were used in order to evaluate open water evaporation: (1) Penman (Penman, 1948) and (2) Morton CRWE (Morton, 1983b) approaches. The Penman and Morton CRWE approaches were applied to three datasets to estimate mean daily potential evaporation and then subsequently compared to the Topley Landing pan evaporation measurements (adjusted to represent lake evaporation). The three datasets are: (1) patched regional data (Smithers Airport Station), (2) patched Project data (Tenas Deposit Station) and (3) derived Project data based on reanalysis and regional datasets. Monthly average lake evaporation results are presented in Figure 2-17.

The Penman formula is a semi-empirical equation that incorporates energy budget and mass transfer approaches to estimate daily potential evapotranspiration or open water evaporation. Open water evaporation E_0 (in mm/day) is calculated according to the formula:

$$E_o = \frac{\left(\frac{\Delta}{\gamma} H + E_a\right)}{\frac{\Delta}{\gamma} + 1}$$

Where $\frac{\Delta}{\gamma}$ is an empirical parameter dependent on temperature, H is calculated based on incoming solar radiation, outgoing radiation, albedo of the open water surface and the proportion of cloudiness.

E_a is calculated semi-empirically as well using windspeed, and vapour pressure.

The Morton CRWE formula generates an estimate of monthly potential evaporation using the input parameters in Table 2-17.

Table 2-17: Morton CRWE Evaporation Formulation Input Parameters

Parameter	Description	Value
T_{max}, T_{min}	Timeseries of daily maximum and minimum project temperatures	See Section 2.3.1, 4.2.2
RH_{max}, RH_{min}	Timeseries of daily maximum and minimum project relative humidity	See Section 2.3.6, 4.1.5
T_{dew}	Timeseries of daily project dew point temperature.	Computed with the Magnus Formula (Magnus, 1844)
Rs	Timeseries of daily project solar irradiance	See Section 2.3.5, 4.2.5
epsilon	Surface emissivity (Morton, 1986)	0.92

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Evaporation_1CT027.003_rev01.Rmd

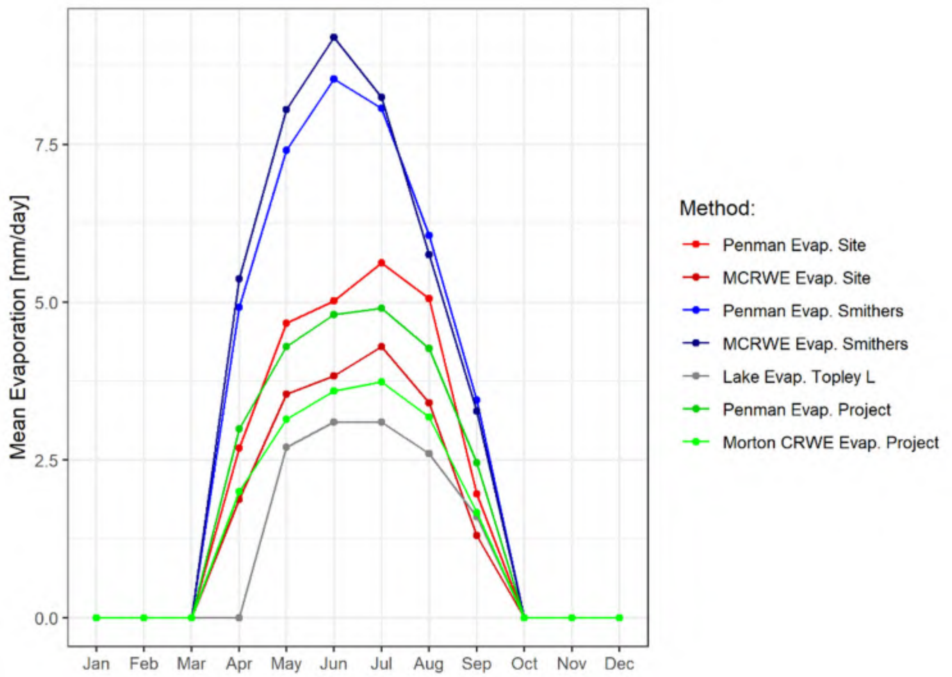


Figure 2-17: Estimated Monthly Average Lake Evaporation

The only regional station with evaporation measurements is Topley Landing, located 71 km northeast of the Project at an elevation of 722 masl. Mean annual lake evaporation at Topley Landing was 401 mm based on the 1981-2010 Canadian Climate Normals published by Environment Canada. Note that relative humidity and solar radiation are not measured at Topley Landing so the methods listed above could not be directly compared for Topley Landing.

3 Baseline Hydrology

3.1 Section Overview

The baseline characterization incorporates historical flow records from selected long-term Water Survey of Canada (WSC) stations as well as available data from local Project hydrometric stations.

Local data has been collected as part of the Tenas Project baseline monitoring program. Information from September 2017 to September 2018 is synthesized in the Tenas Project 2017 to 2018 Baseline Report (ERM 2019) with more recent information provided by ERM in the form of field reports. Additional data collected by AGRA Earth and Environmental Ltd in 1997-1998 is presented in Attachment C.

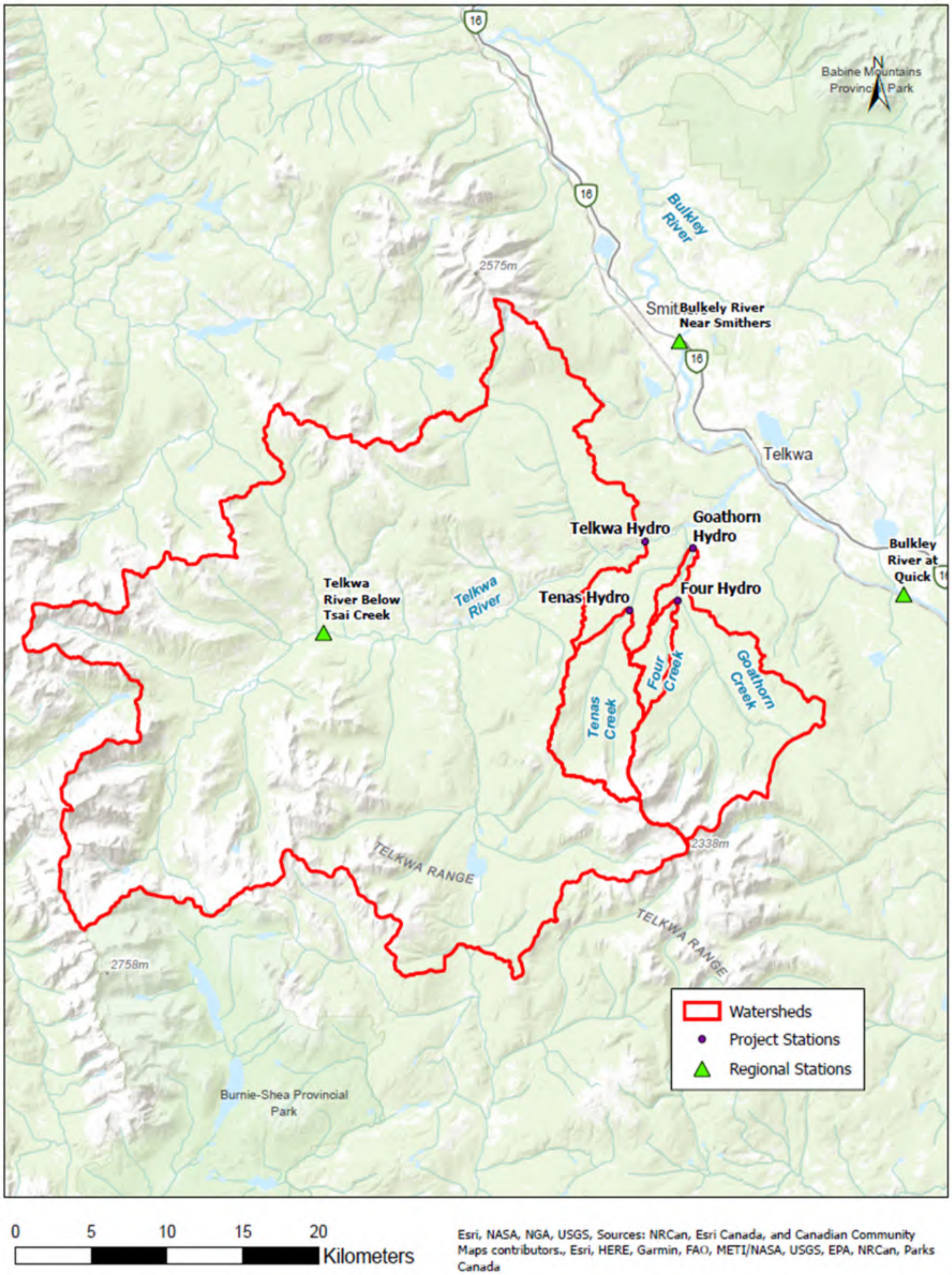
Hydrometric records generated for the Project Area spanning 2017 to 2020 are shown in Section 3.2 for the open water period. Regional data for each Water Survey of Canada station are discussed in Section 3.2 and summarized in Section 3.3.

3.2 Available Hydrometric Data

3.2.1 Project Data

Catchment Delineations

Catchment areas were defined by ERM (ERM 2019) and verified by SRK. Project Area hydrometric stations as well as regional Water Survey of Canada stations are shown in Figure 3-1.



Source: \\srk.ad\dfs\na\van\Projects \01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\!080_Deliverables\Hydromet Baseline Update\040_Figures\ Figure3.1_Hydrometric_Stations_20201023.jpg

Figure 3-1: Map of Project Area With Project Hydrometric Station Catchments Delineated

Hydrometric Data

Historical hydrometric data was collected in 1997-1998 by AGRA Earth and Environmental Ltd for development of the Project Area by Luscar Ltd. Hydrometric spot measurements were collected at Four Creek and Tenas Creek and converted to continuous discharge for a subset of each open-water season. Four Creek data from this period was assessed in more detail than Tenas Creek records due to the short duration of data collect in 2020 by ERM.

Table 3-1 summarizes relevant information for each Project hydrometric station.

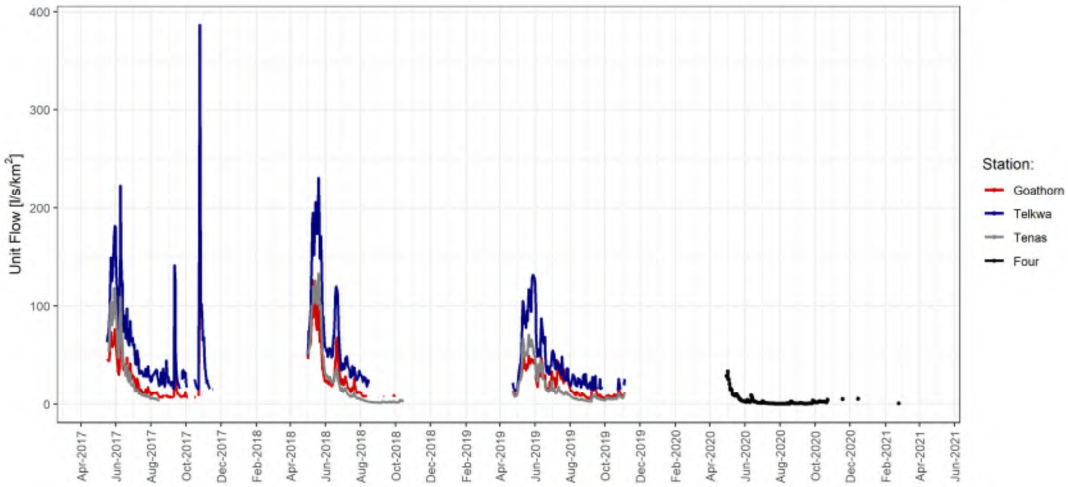
Recent rating curves and continuous discharge were developed for each hydrometric station by ERM (Figure 3-2). Additional details on the instrumentation and rating curve development is summarized in the 2017-2018 Baseline Report (ERM 2019). The Tenas-Hydro station was moved approximately 200 m upstream in 2018. Additional monitoring, rating curve development and analysis for 2019 hydrometric data was completed by ERM.

The Four-Hydro station was installed in April 2020 and a rating curve was developed based on six discharge measurements with two additional measurements completed in late 2020. Monitoring of other local hydrometric stations in 2020 was not completed. A discharge measurement was completed at Four-Hydro in February 2021 to obtain some understanding of winter low flows in Four Creek.

Table 3-1: Summary of Project Area Hydrometric Stations Location and Measurement Information

Station Name	Longitude	Latitude	Average Catchment Elevation (masl)	Area (km^2)	Period of Measurement	Rating Curve Equation (March 2020) Q = C(h-a)b	# of Manual Measurements
Telkwa-Hydro	54.65	-127.17	1243	997.2	May 2017 – November 2019	C: 56.634 a: 97.955 b: 2.113	8 (2017) 10 (2018) 6 (2019)
Tenas-Hydro & Tenas-Hydro B	54.62	-127.19	1181	47.6 46.8	May 2017 – November 2019	C: 13.233 a: 97.21 b: 2.278	5 (2017) 10 (2018) 6 (2019) 1 (2021)
Goathorn-Hydro	54.65	-127.12	1243	123.5	May 2017 – November 2019	C: 9.383 a: 98.18 b: 2.361	9 (2017) 10 (2018) 6 (2019)
Four-Hydro	54.62	-127.14	985	11.0	Established 30 April 2020	C: 15.007 a: 99.239 b: 2.810	8 (2020) 1 (2021)

Source: Compiled in text. \\srk.ad\dfs\na\van\Projects \01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\!020_Project_Data\020_Client\20200312_HydrologyData_DFarmer\2.0 Rating Curves and Hydrographs



Source: Compiled in text from R code \\srk.ad\dfs\na\van\Projects \01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Figures Flows_update_rev10.Rmd

Figure 3-2: Available Continuous Streamflow Data Recorded at the Project Hydrometric Stations

3.2.2 Regional Data

Water Survey of Canada (WSC) is the national authority responsible for the collection, interpretation and dissemination of standardized water resource data in Canada. Stations within the same BC hydrological zone were evaluated and additional selection criteria were subsequently applied.

Figure 3-1 illustrates the four regional WSC stations selected based on proximity to the Project hydrometric stations as well as for having similar flow regimes. These stations have more than 10 years of data and catchment areas ranging between 125 km^2 to 8,940 km^2. Table 3-2 summaries the metadata for these stations and the length of published historical record. Additional provisional data was downloaded from the WSC website where the archived record did not extend to 2020. The provisional data records may change slightly as Water Survey of Canada evaluates data and adjusts rating curves to account for any changes that may have occurred between years.

Table 3-2: Summary of Regional Hydrometric Stations

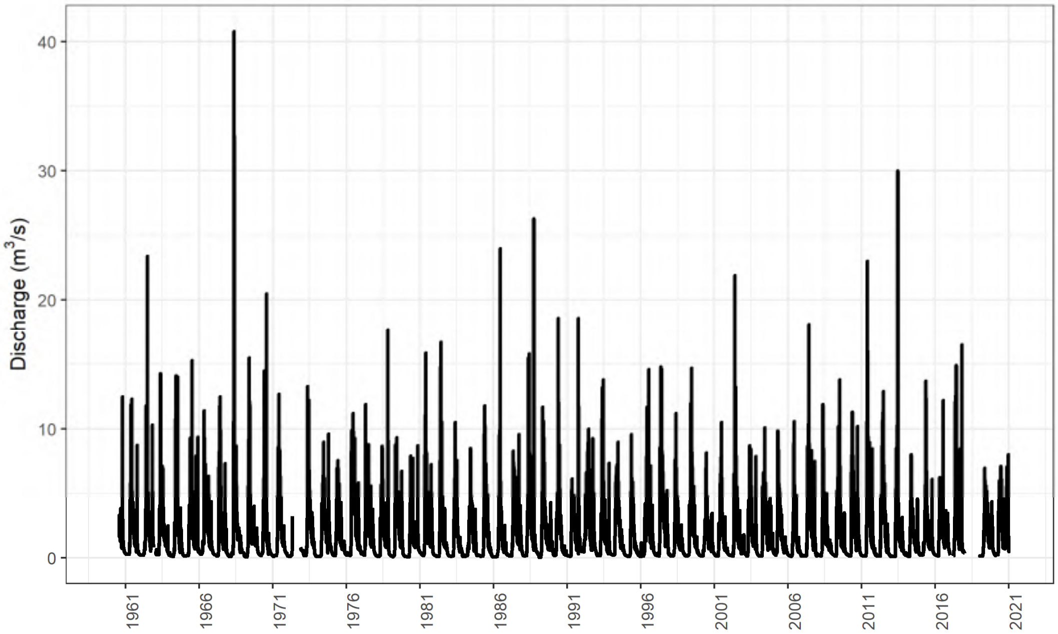
Station ID	Station Name	Longitude	Latitude	Area [km^2]	First Year	Last Year
08EE008	Goathorn Creek near Telkwa	54.65	-127.12	125	1960	2020[1]
08EE020	Telkwa River below Tsai Creek	54.61	-127.50	367	1975	2020
08EE004	Bulkley River at Quick	54.62	-126.90	7340	1930	2020
08EE005	Bulkley River near Smithers	54.77	-127.13	8940	1945	2020

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.002 2017-18 permitting Support (Phase 2)\0200_SurfaceWater\Hydrology\R files\Flows_update_rev02.Rmd

Notes:

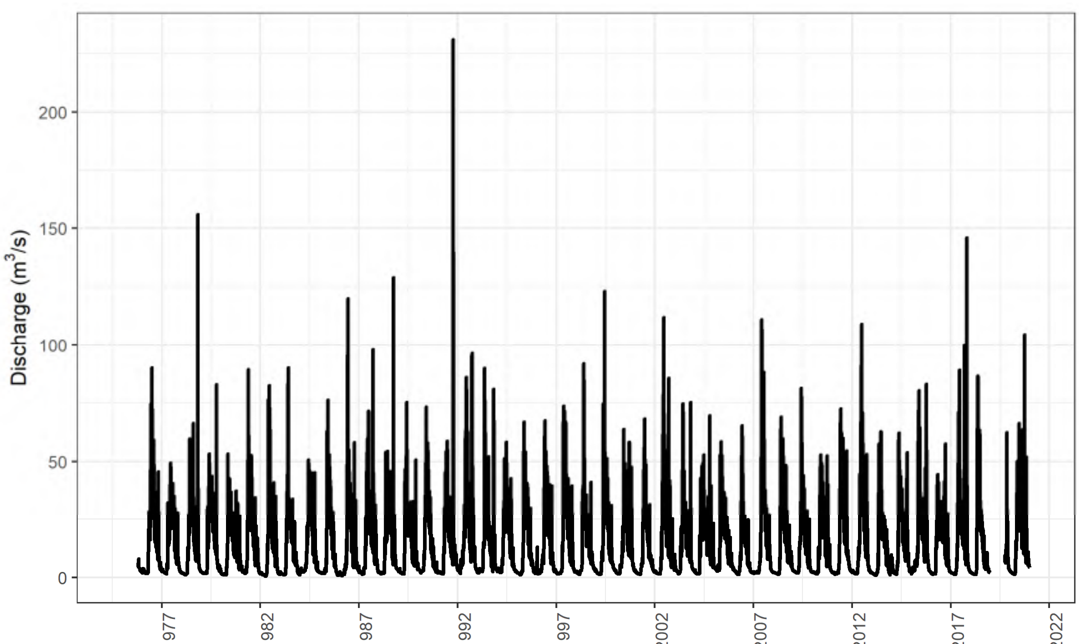
1. Goathorn Creek near Telkwa (08EE008) was decommissioned in January 2018 and re-installed in October 2019.

Discharge from all four Water Survey of Canada regional stations (Table 3-2) followed a nival regime with an initial increase in discharge observed in April followed by annual maximum in response to snowmelt during May. Discharge responded to rainfall events throughout the summer and a recession to annual low flows was observable in the late fall and winter. The time series of each regional hydrometric station are shown in Figure 3-3, Figure 3-4 , Figure 3-5, Figure 3-6.



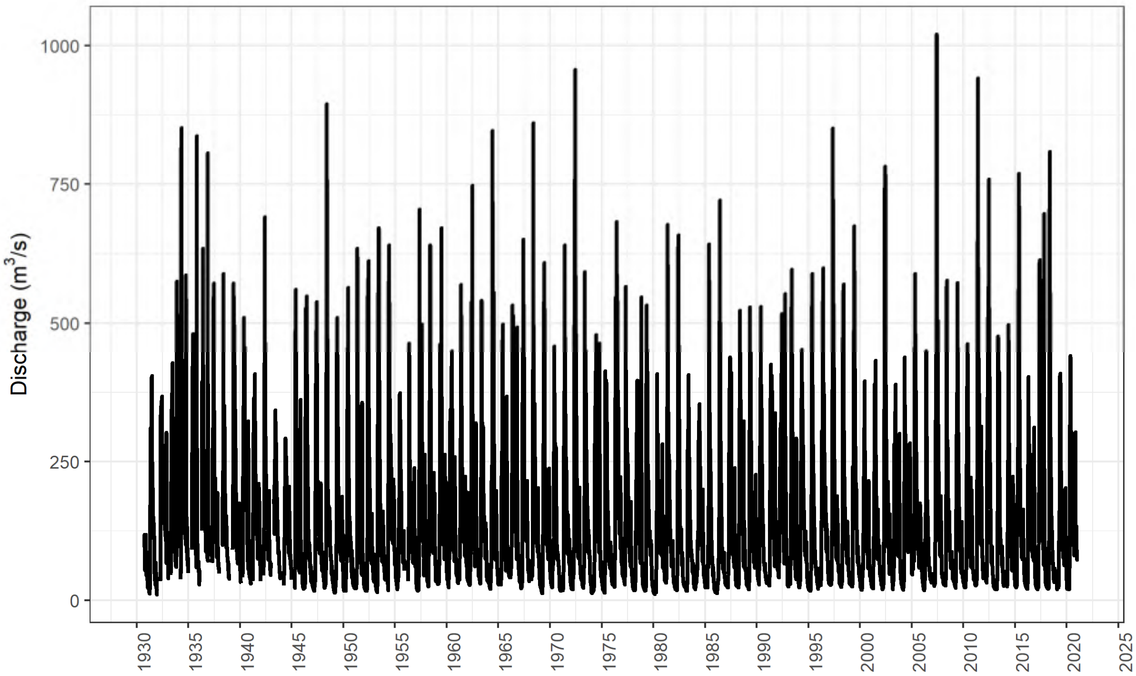
Source: Compiled in R \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\RegionalFlows\Telkwa_flows_1CT027003_Plots_njs.R

Figure 3-3: Goathorn Creek Near Telkwa (08EE008) Discharge data from 1960-2020.



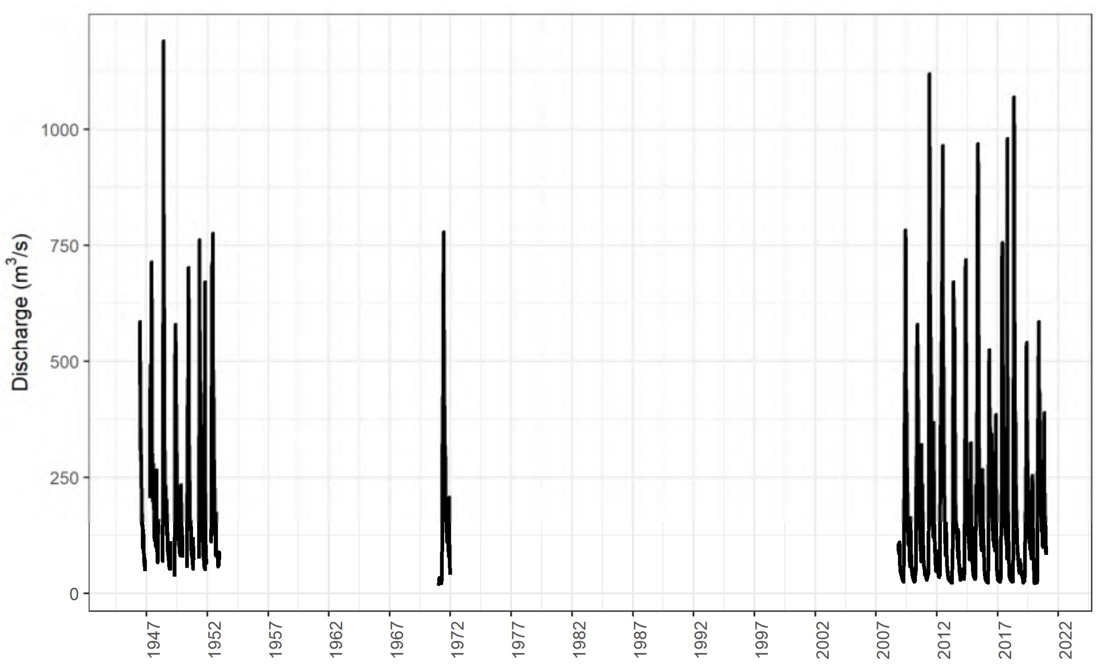
Source: Compiled in R \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\RegionalFlows\Telkwa_flows_1CT027003_Plots_njs.R

Figure 3-4: Telkwa River Below Tsai Creek (08EE020) Discharge from 1975-2020



Source: Compiled in R \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\RegionalFlows\Telkwa_flows_1CT027003_Plots_njs.R

Figure 3-5: Bulkley River At Quick (08EE004) Discharge for 1930-2020



Source: Compiled in R \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\RegionalFlows\Telkwa_flows_1CT027003_Plots_njs.R

Figure 3-6: Bulkley River Near Smithers (08EE005) Discharge for 1945-2020

3.3 Summary of Available Data

3.3.1 Project Hydrometric Monitoring Data

Discharge

Historical discharge data for 1997-1998 will not be presented in this section but is summarized in Attachment C. Continuous discharge was generated from water level measurements and rating curves developed for each Project Area hydrometric station for the open water period. Unit discharge values are presented for each station in Table 3-4 and were calculated by dividing monthly average flow by the associated catchment area (Table 3-1). Note that Four-Hydro was installed in April 2020 and is the only station with data for 2020.

Table 3-3: Average Monthly Discharge for the Open-Water Period (m^3/s)

Station Name	Year	April [1]	May[1]	June	July	Aug	Sept	October	November[1]
Telkwa-Hydro	2017		121.1	93.9	37.7	28.3	33.5	73.1	27.4
	2018		135.5	66.1	34.7	24.2	22.3		
	2019	16.1	84.9	56.1	36.3	23.2	19.4	18.6	22.7
Tenas-Hydro	2017		4.0	2.4	0.5	0.2			
Tenas-Hydro B	2018		4.0	1.2	0.5	0.1	0.1	0.1	
	2019	0.4	2.2	1.2	0.6	0.2	0.3	0.3	0.4
Goathorn-Hydro	2017		7.3	5.1	2.0	1.1	1.6	6.0	
	2018		8.7	3.7	2.2	1.1	1.0		
	2019	1.3	4.6	3.3	3.4	1.3	1.3	1.1	1.2
Four-Hydro	2020		0.131	0.031	0.009	0.008	0.010	0.026	

*Light grey denotes no measurements.

Source: \\srk.ad\dfs\na\van\Projects \01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_summaries\Telkwa_1CT027.003_FlowSummaries_Collated_njs_cog.xlsx

Notes:

1. Measurements in April, May and November were conducted on differing days per month between years and stations.

Table 3-4: Average Monthly Unit Discharge ($L/s/km^2$) for the Open-Water Period

Station Name	Catchment Area (km^2)	Year	April	May	June	July	Aug	Sept	October	November
Telkwa-Hydro	966.9	2017		125.2	97.1	38.9	29.3	34.7	75.6	28.3
		2018		140.1	68.4	35.9	25.0	23.1		
		2019	16.6	87.8	58.0	37.6	24.0	20.0	19.3	23.5
Tenas-Hydro	47.6	2017		84.2	49.7	11.3	5.2			
Tenas-Hydro B	46.75	2018		85.7	25.3	9.7	2.8	2.0	2.7	
		2019	9.4	47.8	26.1	12.7	5.3	5.4	6.2	8.4
Goathorn-Hydro	123.5	2017		59.0	41.3	16.3	8.5	12.6	48.4	
		2018		70.4	30.0	17.5	8.7	8.0		
		2019	10.8	37.2	26.9	27.3	10.5	10.3	9.0	9.9
Four-Hydro	11.0	2020		11.9	2.8	0.9	0.7	0.9	2.3	

*Light grey denotes no measurements.

Source: \\srk.ad\dfs\na\van\Projects \01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_summaries\Telkwa_1CT027.003_FlowSummaries_Collated_njs_cog.xlsx

Low Flows

Low flows are critically important parameters due to their low dilution capacity as well the implications for biological organisms. Low flow statistics are based on available records to estimate the lowest flow within a watercourse over some period of time. Low flow statistics are expressed as an averaging period (e.g., 7 day average) over a recurrence interval where 10 years is common for hydrologically-based flows (7Q10). A low flow calculation requires several years of record as a distribution model (i.e, Log Pearson Type III) is applied to the collected lowest flow event from each year of record. The short length of the Project Area hydrometric records does not allow for a 7Q10 calculation. Low flows were therefore conservatively estimated as the minimum daily average flow for each month for each station (Table 3-5).

Low flow data for Four-Hydro was limited to the open water season in 2020 with additional low flow measurements captured on 24-25 February 2021 at three locations along Four Creek. The low flows measurements were 0.008 m^3/s at Four-Hydro with 0.006 m^3/s (E 619344, N 6052005) and 0.007 m^3/s (E 619269, N 6051447) at separate locations. Historical spot measurements and continuous discharge records were consulted and revealed no reliable low flow measurements of as stated in AGRA (1999) in Attachment A.

Table 3-5: Minimum Instantaneous Discharge (m^3/s)

Station Name	Year	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Telkwa-Hydro	2017					61.8	56.1	21.8	16.6	14.6	14.8	9.8	7.5	7.5
	2018	6.5	2.5	1.7		45.0	32.5	22.4	15.3	5.6	7.7	5.9	4.1	1.7
	2019	3.2	3.4	2.4	13.1	14.6	29.3	18.9	14.2	12.7	12.8	13.0		2.4
Tenas-Hydro	2017					2.4	0.8	0.3	0.2	0.3	0.3	0.3	0.2	0.2
Tenas-Hydro B	2018	0.1	0.1	0.1	1.4	0.6	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	2019	0.1	0.0	0.0	0.3	0.5	0.6	0.4	0.1	0.1	0.2	0.3		0.0
	2020													
Goathorn-Hydro	2017					4.7	2.7	1.2	0.8	0.8	0.7	0.7	0.5	0.5
	2018					2.7	2.1	1.3	0.9	0.9	0.7	0.3	0.2	0.2
	2019	0.2	0.2	0.1	1.1	1.2	1.7	1.9	0.7	0.6	0.7	1.0		0.1
Four-Hydro	2020					0.03	0.01	0.002	0.002	0.004	0.02[1]	0.06[2]	0.06[2]	
	2021		0.008[2]											

[1]Record is only until 17 October 2020. Incomplete month.

[2]Single measurement.

*Light grey denotes no measurements.

Source: \\srk.ad\dfs\na\van\Projects \01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_summaries\Telkwa_1CT027.003_FlowSummaries_Collated_njs_cog.xlsx

3.3.2 Regional Hydrometric Records

Discharge

Discharge data from Water Survey of Canada compiled for each station was summarized as average monthly and annual discharge for the four regional hydrometric stations (Table 3-6).

Table 3-6: Average Monthly and Mean Annual Discharge (m^3/s)

Station Name	Year	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Goathorn Creek near Telkwa (08EE008)	1960-2020	0.2	0.2	0.2	1.2	5.0	5.3	3.2	1.7	1.3	1.4	0.9	0.4	1.8
Telkwa River below Tsai Creek (08EE020)	1975-2020	2.6	2.1	2.1	5.3	27.2	40.7	30.9	21.4	15.6	12.8	7.2	3.5	14.3
Bulkley River at Quick (08EE004)	1930-2020	38.3	31.1	29.2	87.6	315.5	365.1	230.2	142.4	101.4	110.0	102.7	59.3	139.2
Bulkley River near Smithers (08EE005)	1946-2020	37.3	31.2	35.7	134.7	447.4	455.2	265.5	158.1	118.7	126.9	115.5	64.8	179.8

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\RegionalFlows\Telkwa_1CT027.003_WSC_FlowSummaries_20201130_njs.xlsx

Unit Discharge

The monthly average discharge for each regional station was converted to unit discharge, which normalizes discharge per unit area of the catchment (Table 3-7).

Table 3-7: Average Monthly and Annual Unit Discharge ($L/s/km^2$)

Station Name	Years of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Goathorn Creek near Telkwa (08EE008)	1960-2020	1.8	1.5	1.6	9.3	40.3	42.0	25.9	13.9	10.3	11.2	7.5	3.1	14.1
Telkwa River below Tsai Creek (08EE020)	1975-2020	7.1	5.8	5.7	14.5	74.0	110.8	84.3	58.2	42.5	35.0	19.7	9.4	38.9
Bulkley River at Quick (08EE004)	1930-2020	5.2	4.2	4.0	11.9	43.0	49.7	31.4	19.4	13.8	15.0	14.0	8.1	19.0
Bulkley River near Smithers (08EE005)	1946-2020	4.2	3.5	4.0	15.1	50.0	50.9	29.7	17.7	13.3	14.2	12.9	7.2	20.1

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\RegionalFlows\Telkwa_1CT027.003_WSC_FlowSummaries_20201130_njs.xlsx

Lowest 7-Day Average Flow (7Q10)

For the regional records, the 7-day average flow that occurred (on average) once every 10 years was calculated for each regional hydrometric station (Table 3-8).

Table 3-8: 7Q10 Values for Regional Stations (m^3/s)

Station Name	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Goathorn Creek near Telkwa (08EE008)	0.1	0.1	0.1	0.1	1.0	2.1	1.2	0.7	0.5	0.4	0.2	0.1	0.1
Telkwa River below Tsai Creek (08EE020)	1.6	1.4	1.2	1.4	4.9	19.7	17.4	11.6	5.9	4.2	2.3	1.7	1.2
Bulkley River at Quick (08EE004)	19.1	17.2	16.2	18.2	77.0	196.9	127.9	84.6	59.3	48.8	36.4	24.7	15.1
Bulkley River near Smithers (08EE005)	26.1	23.5	22.4	23.7	129.8	214.2	141.4	90.0	65.2	50.2	39.5	30.5	22.9

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Flows_update_rev09.Rmd

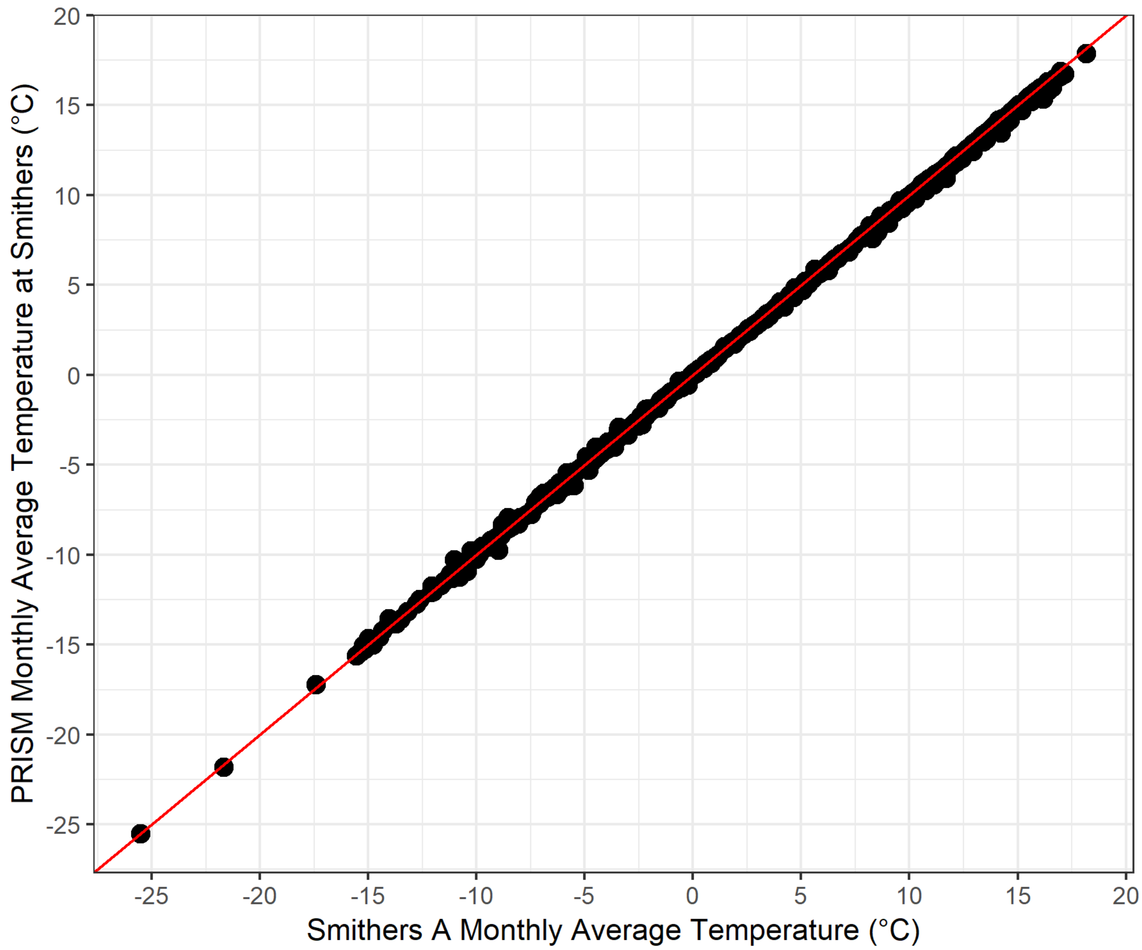
4 Derived Project Parameters

4.1 Derived Meteorological Parameters

Due the the relatively short record of Tenas Deposit Station data, meteorological parameters for the Project are derived by adjusting the patched long-term datasets at Stewart Airport to the site, based on spatial and orographic gradients. Adjustment factors are derived based on trends in regional stations, or when these are not adequate, reanalysis datasets, as described in the following sections.

4.1.1 Air Temperature

Historical Smithers Airport monthly temperatures were compared to the reanalysis datasets for the same location. Of the reanalysis datasets investigated, the PRISM model was determined to provide the best fit for precipitation as described in Section 4.1.2. Figure 4-1 illustrates the monthly temperature regression between measured and modelled PRISM temperatures at the Smithers Airport Station. Given the good correlation, PRISM data for the Project at the Tenas Deposit Station was obtained and monthly correction factors relative to the Smithers Airport station were developed to account for orographic gradients and temperature inversion effects (Table 4-1).



Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Temperature_1CT027.003_rev01.Rmd

Figure 4-1: Smithers Airport vs PRISM Reanalysis

Correction Factors and Expected Project Air Temperature

The correction factors presented in Table 4-1 were applied to the patched Smithers Airport Station temperature record to create a Project-adjusted long-term temperature record for design and modelling.

Table 4-1: Temperature Correction Factors

Month	Minimum Temperature			Average Temperature			Maximum Temperature		
	Smithers Airport (°C)	PRISM at Project (°C)	Absolute Temp. Ratio	Smithers Airport (°C)	PRISM at Project (°C)	Absolute Temp. Ratio	Smithers Airport (°C)	PRISM at Project (°C)	Absolute Temp. Ratio
January	-13.6	-13.5	1.000	-9.5	-9.9	0.998	-5.5	-6.3	0.997
February	-9.5	-10.2	0.997	-4.9	-6.0	0.996	-0.2	-1.7	0.994
March	-5.9	-7.6	0.993	-0.7	-2.8	0.992	4.5	2.0	0.991
April	-1.6	-3.3	0.994	4.3	1.9	0.991	10.1	7.1	0.989
May	2.5	0.3	0.992	8.9	6.3	0.991	15.4	12.3	0.989
June	6.0	4.4	0.994	12.5	10.4	0.992	19.0	16.3	0.991
July	8.1	6.5	0.994	14.7	12.6	0.993	21.1	18.6	0.991
August	7.5	6.1	0.995	14.1	12.1	0.993	20.6	18.1	0.991
September	3.9	2.9	0.996	9.8	8.1	0.994	15.7	13.4	0.992
October	0.1	-1.6	0.994	4.4	2.4	0.993	8.7	6.4	0.992
November	-5.6	-7.2	0.994	-2.5	-4.1	0.994	0.7	-1.1	0.994
December	-10.8	-11.2	0.998	-7.2	-7.9	0.998	-3.7	-4.5	0.997

Source compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Temperature_1CT027.003_rev01.Rmd

Table 4-2 summarizes the expected monthly air temperatures at the Project and Figure 4-2 illustrates the modelled average monthly temperature compared to measured temperature at the Tenas Deposit Station.

Table 4-2: Expected Project Temperature Summary [°C] From Derived Long-term Time Series

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
Maximum	-5.8	-1.8	2.2	7.4	12.9	16.5	19.0	18.6	13.7	6.5	-0.8	-4.6	7.0
Average	-9.2	-6.1	-2.7	2.1	6.8	10.7	13.0	12.5	8.4	2.6	-3.8	-7.9	2.2
Minimum	-12.6	-10.4	-7.5	-3.1	0.8	4.7	6.9	6.4	3.1	-1.4	-6.8	-11.2	-2.6

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Temperature_1CT027.003_rev01.Rmd

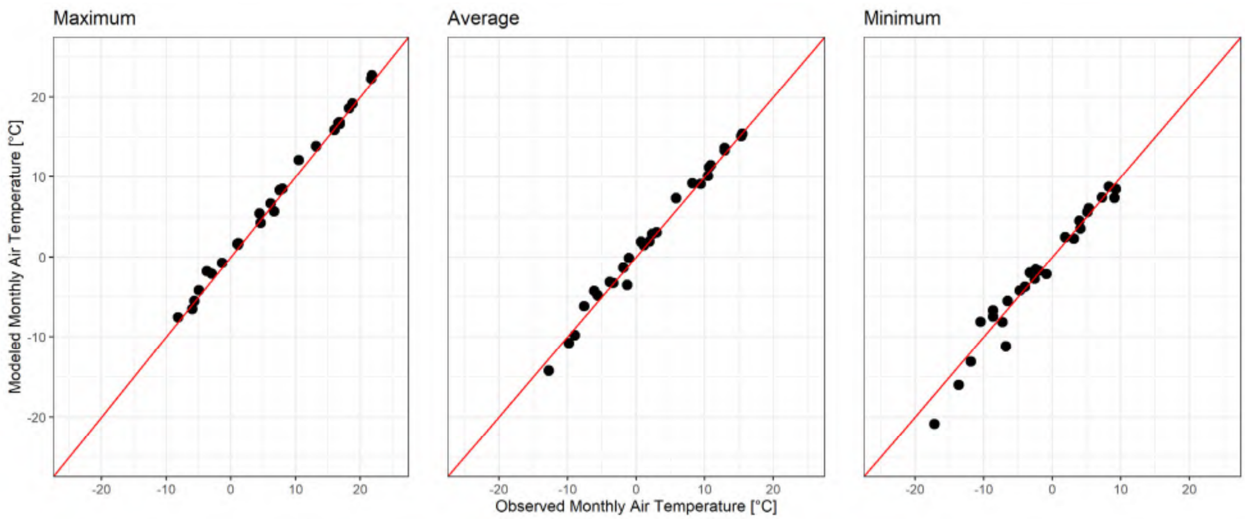


Figure 4-2: Comparison between Observed and Modelled Monthly Average Temperatures for October 2017 to December 2019

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Temperature_1CT027.003_rev01.Rmd

4.1.2 Precipitation

Figure 4-3 illustrates the monthly precipitation correlation between the 27 months of measured Project precipitation and patched precipitation records at Smithers for the overlapping period from September 2017 to December 2019. The total measured precipitation at the Tenas Deposit Station was approximately 50% greater than that at Stewart A over this period. The monthly precipitation difference ranged between -0 mm to +91 mm for Project data over the 27 months and suggests monthly correction factors are more appropriate to account for seasonality.

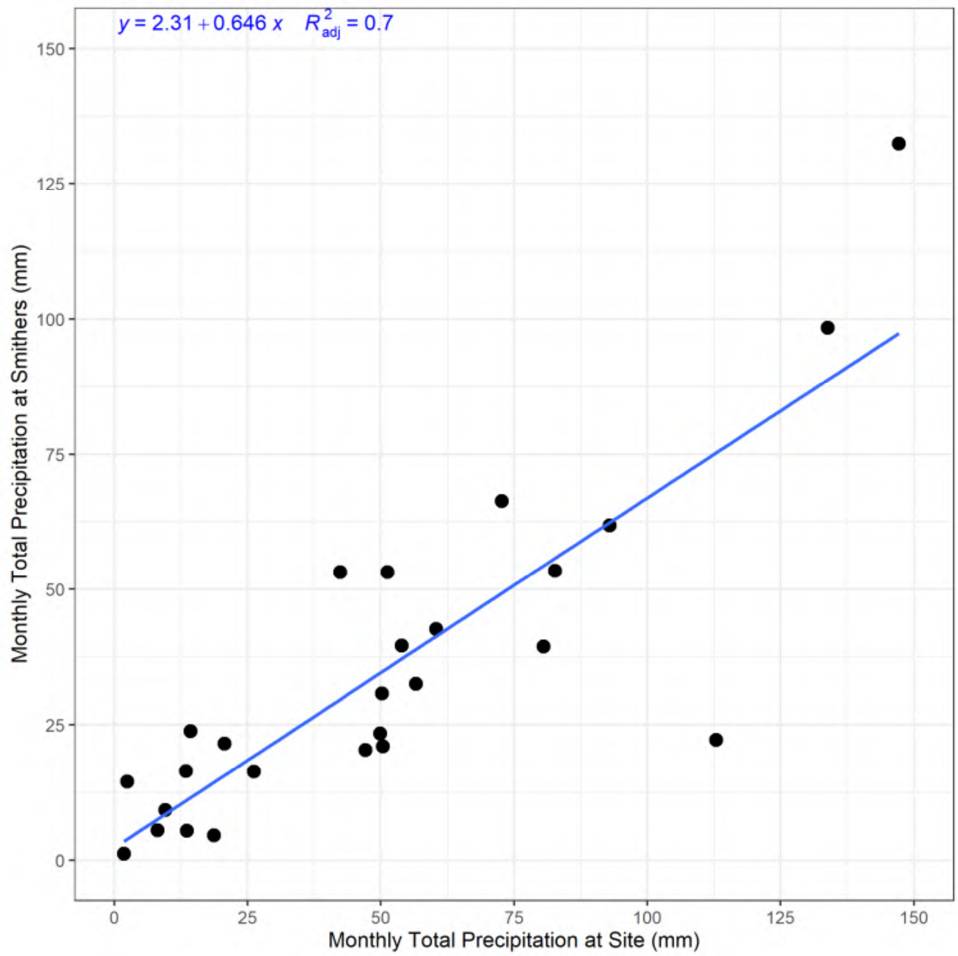


Figure 4-3: Comparison between Observed Total Precipitation at Tenas Deposit Station and Smithers A

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Precipitation_1CT027.003_rev01.html

Typically, precipitation depths are expected to be greater at higher elevations. However, as previously demonstrated in Figure 2-9, there is a poor regional correlation between mean annual precipitation and elevation at the regional stations. Therefore, Reanalysis datasets were evaluated against the patched Smithers A record to develop transposition factors to adjust the longer-term dataset to site (Table 4-3).

Table 4-3: Smithers A and Reanalysis Mean Monthly and Annual Precipitation Comparison [mm]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Smithers A (patched)	51	28	22	22	35	46	45	41	51	62	54	50	508
ERA 5	62	41	45	45	59	79	70	65	69	86	79	59	760
Merra 2	92	60	76	60	72	101	97	94	94	117	105	92	1059
PRISM	48	23	24	24	34	55	46	46	49	66	54	49	517

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Precipitation_1CT027.003_rev01.Rmd

The PRISM reanalysis data was found to best fit the recorded mean at Smithers A and was chosen to derive monthly correction factors to adjust the Smithers A timeseries to the Project location. The PRISM mean annual precipitation for the region surrounding the Project, shown in Figure 4-4, demonstrates the spatial and orographic variability of precipitation in the region.

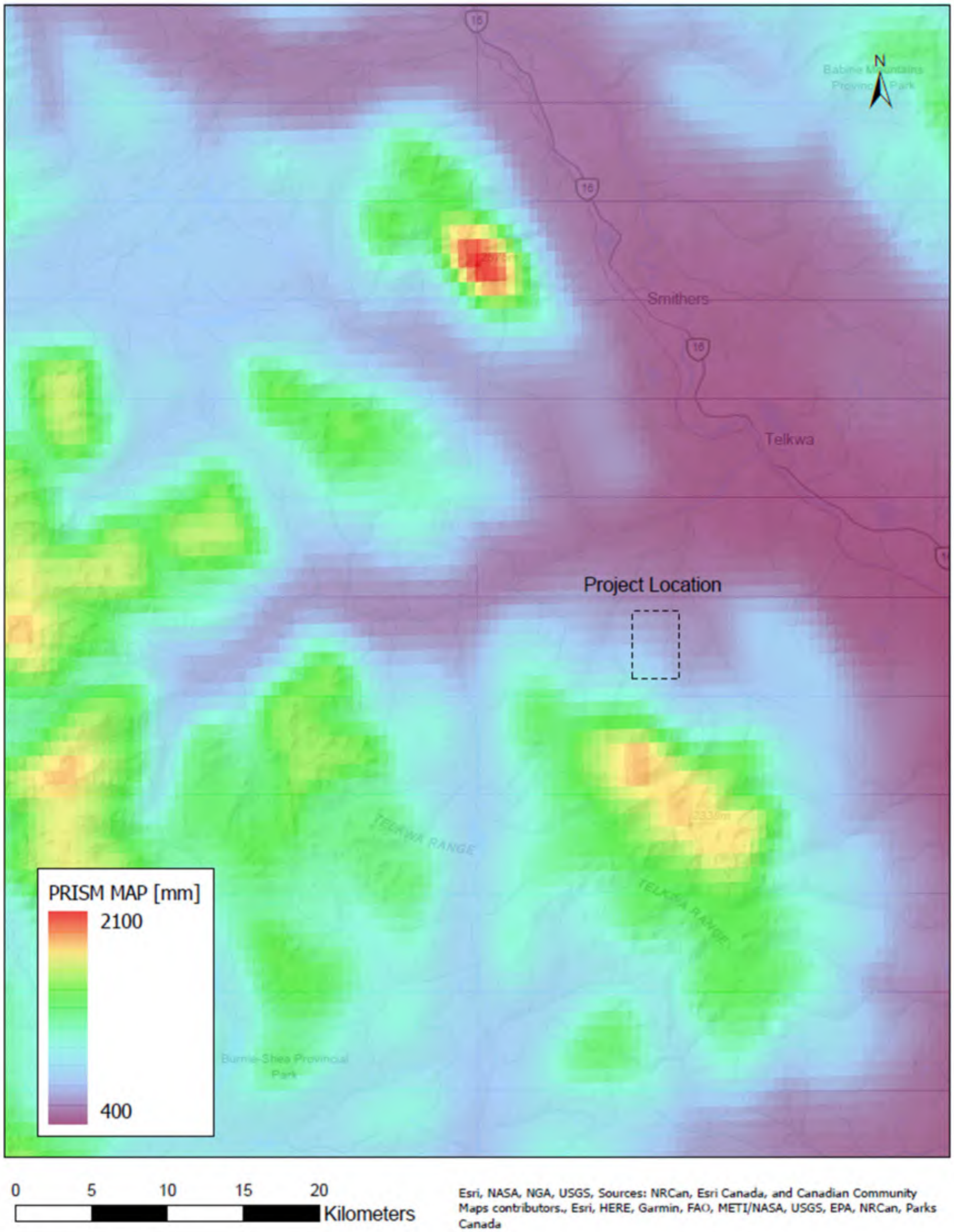


Figure 4-4: PRISM Mean Annual Precipitation in the project Area

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\!080_Deliverables\Hydromet Baseline Update\040_Figures\Figure4.4_PRISM_MAP.pdf

4.1.2.1 Correction Factors and Expected Project Precipitation

Table 4-4 illustrates the monthly precipitation correction factors developed to adjust monthly precipitation at the Smithers Airport station to the Project Area, based on PRISM reanalysis data.

Table 4-4: Precipitation Correction Factors

Month	Average Monthly Precipitation (mm)		PRISM Ratio (Smithers A: Project)
	PRISM Smithers Airport	PRISM at Project	
January	50.8	69.2	1.36
February	27.8	44.8	1.61
March	23.9	35.2	1.47
April	21.9	26.0	1.19
May	33.7	35.1	1.04
June	48.3	46.0	0.95
July	45.3	48.3	1.07
August	44.3	46.0	1.04
September	49.4	50.7	1.03
October	60.5	69.2	1.14
November	54.3	68.0	1.25
December	50.6	68.1	1.35

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Precipitation_1CT027.003_rev01.Rmd

A long-term modelled Project precipitation time series was developed by applying the monthly correction factors presented in Table 4-4 to the patched Smithers A time series. The modelled estimates are presented in comparison with the measured dataset from the Tenas Deposit Station in Figure 4-5 and Table 4-5. Results show that the modelled dataset fits the Project dataset reasonably well, but tends to under-estimate precipitation in some months. Project precipitation adjustment factors should be reviewed as additional Tenas Deposit Station data become available.

Table 4-6 summarizes expected average monthly precipitation at the Project based on the modelled time series. The mean annual precipitation (MAP) is estimated to be 608 mm which is approximately 19% greater than average precipitation recorded in the valley at the Smithers Airport station.

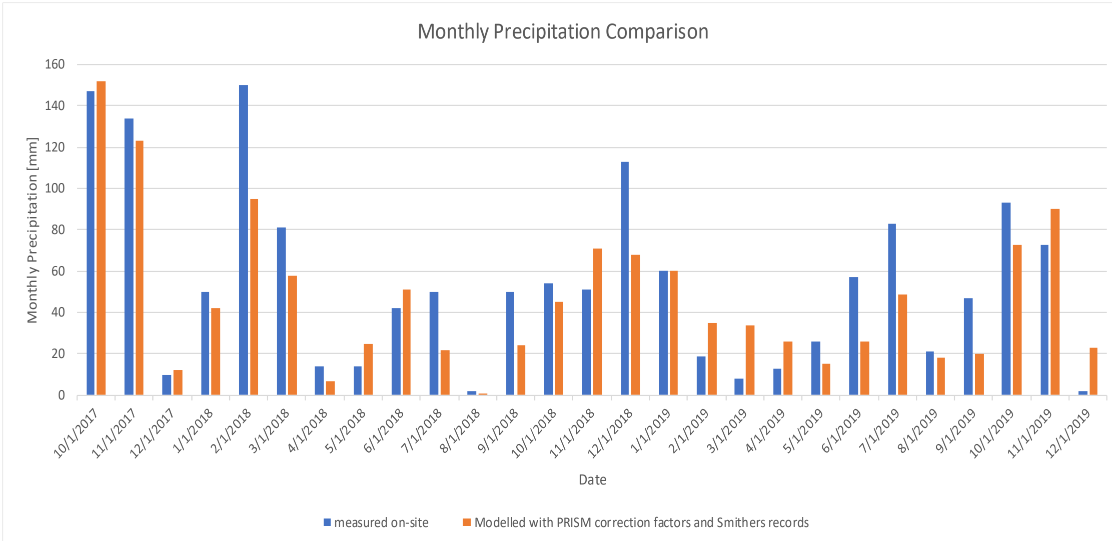


Figure 4-5: Comparison of Monthly Measured and Modelled Precipitation for Tenas Project

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Precipitation_1CT027.003_rev01.Rmd

Table 4-5: Monthly Tenas Deposit Meteorological Station Total Precipitation (measured) vs Total Precipitation using PRISM Correction Factors and the Smithers A record (modelled)

Year	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
2017	Total Measured Precipitation [mm]										147	134	10	291
	Total Modelled Precipitation [mm]										152	123	12	287
2018	Total Measured Precipitation [mm]	50	150	81	14	14	42	50	2	50	54	51	113	672
	Total Modelled Precipitation [mm]	42	95	58	7	25	51	22	1	24	45	71	68	509
2019	Total Measured Precipitation [mm]	60	19	8	13	26	57	83	21	47	93	73	2	502
	Total Modelled Precipitation [mm]	60	35	34	26	15	26	49	18	20	73	90	23	471

*Light grey denotes no measurements.

Source: compiled in text from \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Precipitation_1CT027.003_rev01.Rmd

Table 4-6: Project Precipitation Summary [mm]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall	8.0	9.7	10.4	21.5	35.9	45.7	48.1	43.1	50.8	58.6	20.0	8.0	359.9
Snowfall	61.8	35.9	22.0	4.9	0.7	0.0	0.0	0.0	0.3	13.6	49.4	59.7	248.1
Total	69.7	45.6	32.4	26.4	36.6	45.7	48.1	43.1	51.1	72.2	69.4	67.7	608.0

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_hydrology_summary.csv

Figure 4-6 illustrates the average monthly precipitation as rain and snow. Precipitation typically falls as snow during the months of November to March. Annually, the average snowfall (314 mm) is approximately 50% of mean annual precipitation.

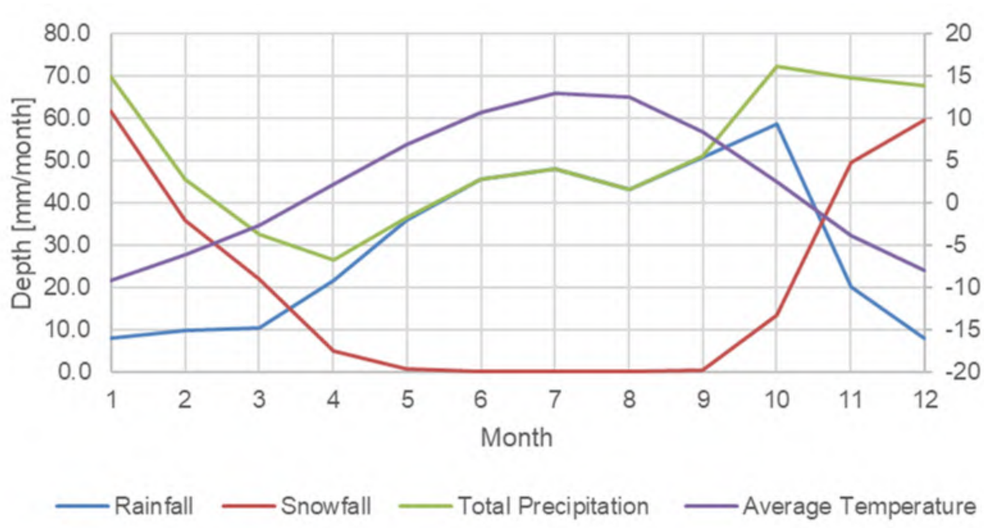


Figure 4-6: Monthly Precipitation as Snow and Rain

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Precipitation_1CT027.003_rev02.Rmd

4.1.2.2 Extreme Precipitation

Annual Frequency Analysis

A frequency analysis was performed using annual precipitation estimates derived from the long-term Project precipitation time series, developed using adjustments to Smithers Airport Station. The frequency analysis tested a range of probability distributions and found that a log normal distribution provides the best fit to the long-term annual precipitation data for the Project.

The results of the annual frequency precipitation analysis are presented in Table 4-7 for extreme conditions ranging from a 1,000-year dry to a 1,000-year wet return periods.

Table 4-7: Annual Precipitation Frequency Analysis

Hydrological Condition	Return Period [years]	Annual Precipitation [mm]
Wet	1000	997
	500	964
	200	918
	100	882
	50	843
	25	803
	20	789
	10	743
	5	690
Mean Annual Precipitation (MAP)		608
Dry	5	517
	10	479
	20	448
	25	440
	50	416
	100	396
	200	378
	500	357
	1000	343

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Precipitation_1CT027.003_rev01.Rmd

Extreme Precipitation

The annual maximum daily and 3-day precipitation depths were calculated from the long-term Project precipitation record. Annual maximum daily precipitations were converted to maximum 24-hour and 72-hour precipitation using a factor of 1.13 (United States Weather Bureau 1962; Bonnin et al. 2006).

A frequency analysis was performed on the annual maxima dataset for daily precipitation. The frequency analysis tested a range of probability distributions and found that a log Pearson type III distribution provided the best fit to both the 24-hour and 72-hour datasets.

Table 4-8 presents the 24-hour and 72-hour precipitation depths for a range of return periods based on the frequency analysis of the long-term Project precipitation record.

Table 4-8: Extreme Project Precipitation for 24-hour and 72-hour Events

Return Period	24-hour Precipitation [mm]	72-hour Precipitation [mm]
2	37.3	56.2
5	50.7	78.4
10	60.8	95.9
25	74.9	121.4
50	86.6	143.2
100	99.3	167.5
200	113.1	194.6
500	133.3	235.6
1000	150.3	271.0

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Precipitation_1CT027.003_rev01.Rmd

For durations less than 24-hours, the depth-duration-frequency curve data from the Smithers Airport station were obtained and modified to account for the 24-hour results presented in Table 4-8. Depth-duration-frequency data for Smithers Airport were obtained using the IDF_CC Tool (Version 3) (ICLR 2018) for return periods ranging from 2 to 100-years. Frequency and duration factors were calculated based on the 24-hour precipitation depths for Smithers Airport, and were applied to the Project 24-hour depths presented in Table 4-8. Table 4-9 summarizes the baseline depth-duration-frequency curve for the Project. Duration factors were extrapolated to generate the results for the 200-year return period event. The 72-hour return period results are also presented.

Table 4-9: Project Baseline Precipitation-Duration-Frequency Curve

Storm Duration		Precipitation (mm)						
		Return Period (years)						
min	hours	2	5	10	25	50	100	200
5	0.08	3.5	5.0	6.2	7.9	9.1	10.6	12.1
10	0.17	5.0	7.5	9.2	11.8	13.8	16.0	18.2
15	0.25	6.1	8.6	10.5	13.2	15.4	17.8	20.2
30	0.5	8.4	11.3	13.5	16.6	19.1	21.8	24.9
60	1	11.4	15.4	18.5	22.7	26.2	30.0	34.2
120	2	14.7	19.6	23.2	28.4	32.6	37.1	42.3
360	6	23.5	30.2	35.4	42.6	48.7	55.3	63.0
720	12	29.4	38.9	46.0	56.0	64.3	73.4	83.6
1440	24	37.3	50.7	60.8	74.9	86.6	99.3	113.1
4320	72	56.2	78.4	95.9	121.4	143.2	167.5	194.6

Source: Z:\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\400_Water_Management\Telkwa_IDF_AlternatingBlock.xlsm

Probable Maximum Precipitation

The probable maximum precipitation (PMP) was calculated using the Hershfield methodology (Hershfield 1965; WMO 2009), and the Project-adjusted precipitation record. The Canadian Dam Association Guidelines (2013) recommends evaluating two Probable Maximum Floods (PMF):

Summer/autumn PMF, which is generated by the summer/autumn PMP

Spring PMF is defined as the maximum of two cases:

1. PMF computed with Spring PMP and snow accumulation with frequency of 100 year (Rainfall Dominated)
2. PMF computed with the Probable Maximum Snow Accumulation (PMSA) and a rainstorm with a frequency of 100 year (Snowmelt Dominated)

Two separate PMFs are estimated for the Spring season as it is not reasonable to assume that the PMSA and a Spring PMP, which are two independent phenomena, would occur simultaneously.

Based on the typical hydrograph for the Project (see Section 3, snow at the Project is expected to be present until as late as June.

Table 4-10 presents the Spring and Summer/Autumn PMPs for the Project where Spring was defined as April to June and summer was defined as July through October.

Table 4-10: Project 24-hour Probable Maximum Precipitation

Season	PMP (mm)
Spring	234
Summer/Autumn	283

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Precipitation_1CT027.003_rev01.Rmd

Results were verified using the British Columbia MetStorm Probable Maximum Precipitation webtool (DTN, 2020), which was developed in support of the BC Extreme Flood Project. This web-based tool provides an indication of potential precipititaion depths based on regionally available datasets at select points across the province. The maximum point PMP estimated from the webtool within the Project vicinity is 218 mm. The results in Table 4-10 are based on Project-specific precipitation datasets and present a more conservative PMP estimate. For this reason, the Project data were used for the purpose of infrastructure design.

4.1.3 Snow Depth and Snowmelt

The SNOW-17 snow accumulation and ablation model developed by the National Weather Service River Forecast System (NWSRFS) was implemented to model snowmelt for the Project. The main processes included in this model are dividing precipitation into rain or snow, accumulation of snowpack, energy exchange, heat deficit in the snowpack, ground melt and snowmelt as a snow water equivalent (Anderson 2006). Model inputs are average temperature and precipitation and input parameters to model a column of snow. The Project weather station recorded an accumulated depth of snow. Data collection at the Project did not include snow courses or snow density to convert snow depth to snow water equivalent (SWE) but regional estimates were used to check the SNOW-17 model accuracy.

Table 4-11 summarizes the model input parameters based on guidelines of initial estimates (Anderson 2002) and validation against the snow water equivalent records at Tsai Creek. Temperature and precipitation time series for the Tsai Creek elevation were developed using PRISM corrections, similarly to the Project records. Figure 4-7 illustrates the measured and modelled snow water equivalent snow depths at Tsai Creek.

Table 4-11: SNOW-17 Model Input Parameters

Parameter	Description	Value
PXTEMP	Temperature threshold	1.5 °C
SCF	Loss coefficient during period of snow (i.e. sublimation)	1
UADJ	Average wind function during rain-on-snow events	0.04 mm/mbar/hr
MBASE	Temperature above which melt occurs	0 °C
MFMAX	Maximum melt factor	0.51 mm·°C·$6hr^{-1}$
MFMIN	Minimum melt factor	0.10 mm·°C·$6hr^{-1}$
TIPM	Antecedent temperature index factor	0.1
NMF	Maximum negative maximum factor	0.25 mm·°C·$6hr^{-1}$
PLWHC	Percent liquid water holding capacity. Maximum amount of liquid water as a fraction of the ice portion of the snow	4%

Source: from snowmelt calibration model for Tsai Creek. \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\500_Water_Balance\Model\SnowmeltModel \ TsaiCreek_Snow17.gsm

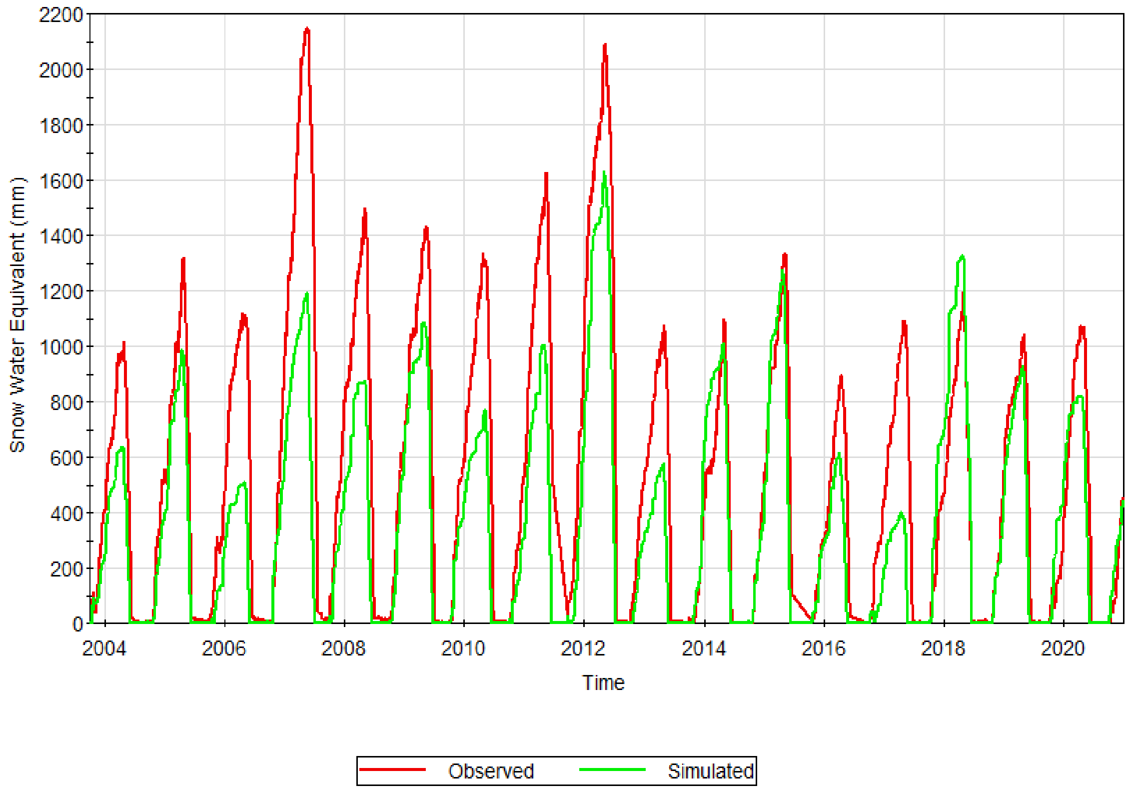


Figure 4-7: Tsai Creek Snowmelt Snow Water Equivalent Calibration

Source: from snowmelt calibration model for Tsai Creek. Z:\01_SITES\Telkwa Coal\1CT027.002 2017-18 permitting Support (Phase 2)\0200_SurfaceWater\Snowmelt Model\ TsaiCreek_Snow17.gsm

The validation with Tsai Creek suggests the snowmelt timing is well captured, with some understimations of maximum snowpack. This may be a result of inaccuracies in the precipitation record estimated for Tsai Creek. For the purpose of water management planning and design and water balance modeling, the SNOW-17 model and inputs were applied to the Project. Figure 4-8 illustrates the average snow water equivalent depths for the Project based on the adjusted precipitation and temperature records from 1942 to 2020.

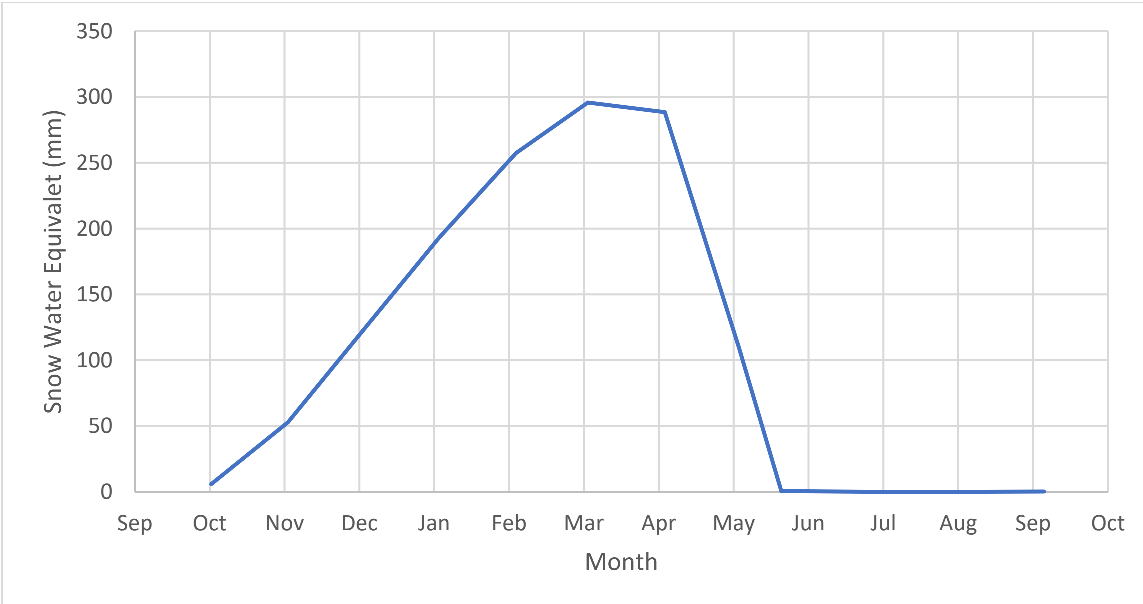


Figure 4-8: Project Average Snow Water Equivalent

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\500_Water_Balance\Model\SnowmeltModel\SWE_ModelledOutput_09172020.xlsx

In addition to snow-water-equivalent, the snowmelt model produces a daily excess water term, which represents the sum of rainfall and snowmelt and can be interpreted as the daily depth of water available to generate runoff. Table 4-12 presents the monthly average excess water results for the Project, along with the monthly average distribution.

Table 4-12: Project Excess Water Monthly Average Summary [mm]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Total Excess Water	1	2	9	122	219	46	47	44	52	56	9	2	608
Monthly Excess Water Distribution	0%	0%	1%	20%	36%	8%	8%	7%	8%	9%	1%	0%	100

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\500_Water_Balance\Inputs\Hydrology\Compiled_ModelClimate_11172020.xlsx

A frequency analysis was performed on the maximum 1-day and 3-day (72-hour) snow water equivalent results from the Project snowmelt model based on the adjusted record from 1942 to 2020. Results for return periods up to the 1000-year snowmelt event are presented in Table 4-13.

Table 4-13: Project Snowmelt Frequency Analysis

Return Period	24-hour Snowmelt [mm SWE]	72-hour Snowmelt [mm SWE]
2	23	59
5	27	68
10	29	74
25	31	80
50	32	81
100	33	85
200	35	89
500	36	93
1000	38	97

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\ \Telkwa Coal\1CT027.003_2020 EA Water Management\500_Water_Balance\Model\SnowmeltModel\SWE_ModelledOutput_09172020.xlsx

4.1.4 Solar Radiation

Given the short period of record at the Tenas Deposit Station and large differences to Smithers Airport Station, the FAO model (Allen et al. 1998) was adopted to calculate historical baseline averages of solar radiation using the corrected temperature timeseries developed for the Project (Table 4-14). The appropriateness of the FAO model to approximate incoming solar radiation at the Tenas Deposit Station was illustrated from October 2017 to September 2018 in Figure 4-9.

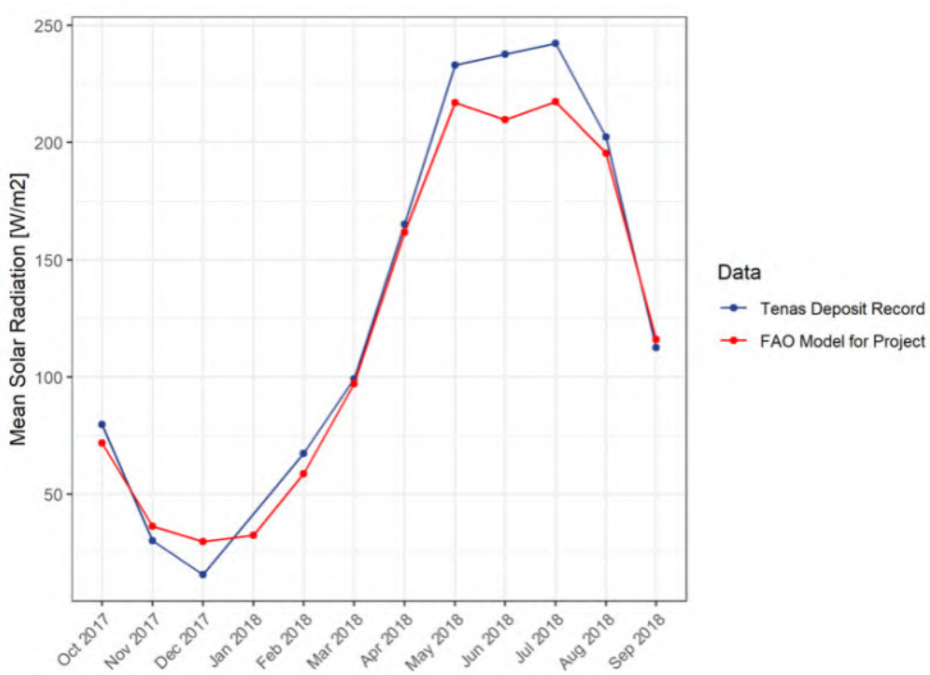


Figure 4-9: Solar Radiation – Modelled versus Measured (October 2017 to September 2018)

Source: from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Evaporation_rev02.Rmd

Table 4-14: Average Monthly Solar Radiation [W/m^2] at Project

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average	38	64	114	173	220	224	224	201	134	73	40	34	38

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Evaporation_1CT027.003_rev01.Rmd

4.1.5 Relative Humidity

Given the short period of record at the Tenas Deposit Station and the similarities observed between Smithers Airport Station records presented in Section 2.3.6, Smithers Airport station relative humidity was applied to the Project. Table 4-15 presents the monthly average relative humidity for the Project.

Table 4-15: Average Monthly Relative Humidity [%] at Project

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average (%)	83.6	79.3	71.2	63.3	61.3	65.7	68.8	72.1	79.5	82.1	85.9	85.4	74.8

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Evaporation_1CT027.003_rev01.Rmd

4.1.6 Evaporation

Large and shallow water bodies can experience direct water losses from evaporation. Lake surface evaporation for the Project was estimated using the Morton CRWE shallow lake evaporation method (Morton 1983). Table 2-17 summarizes the input parameters required for this method including the Project-specific solar radiation generated using the FAO model.

Based on the adjusted temperature record, modelled solar radiation and relative humidity and wind speeds from the Smithers Airport station, the estimated mean annual evaporation for the Project is 529 mm. Table 4-16 and Figure 4-10 demonstrate the mean open water evaporation rates for the Project. The potential evaporation estimates generated using the Morton CRWE results for the derived Project timeseries were closest to the Topley Landing Normals.

Table 4-16: Project Monthly Total Lake Evaporation [mm]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Evaporation	0	0	0	60	97	108	116	99	50	0	0	0	529

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Evaporation_rev02.Rmd

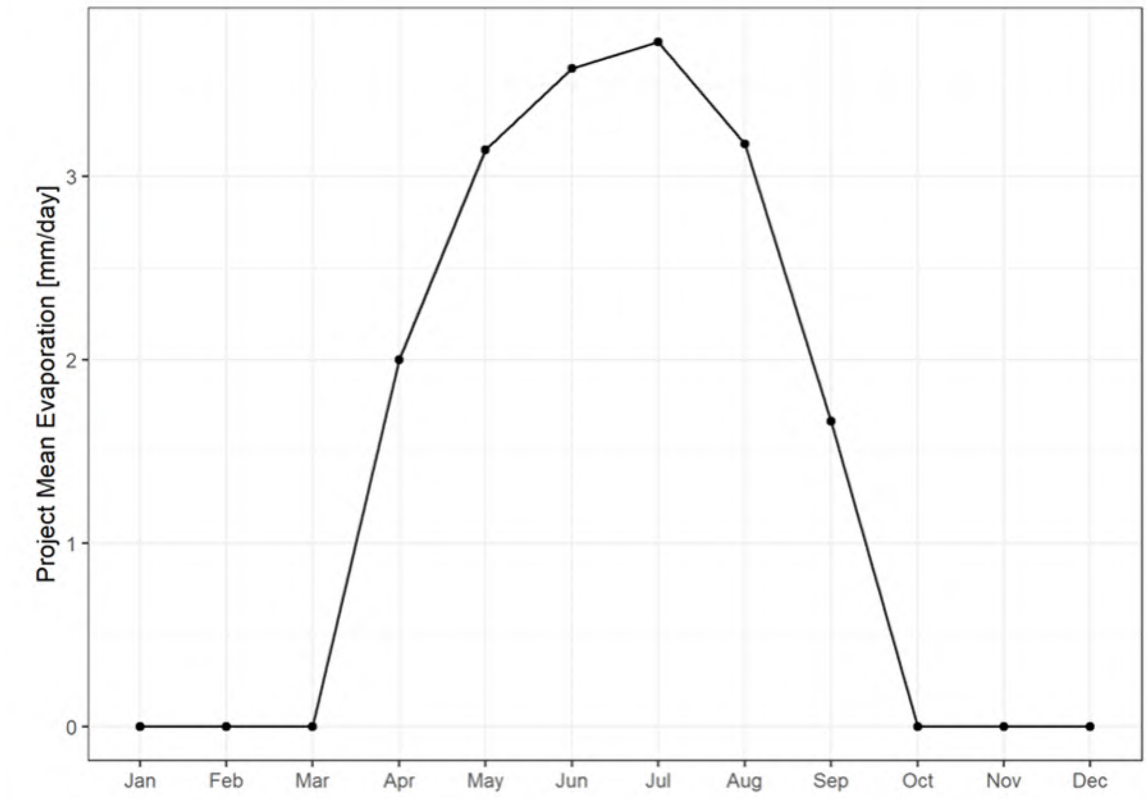


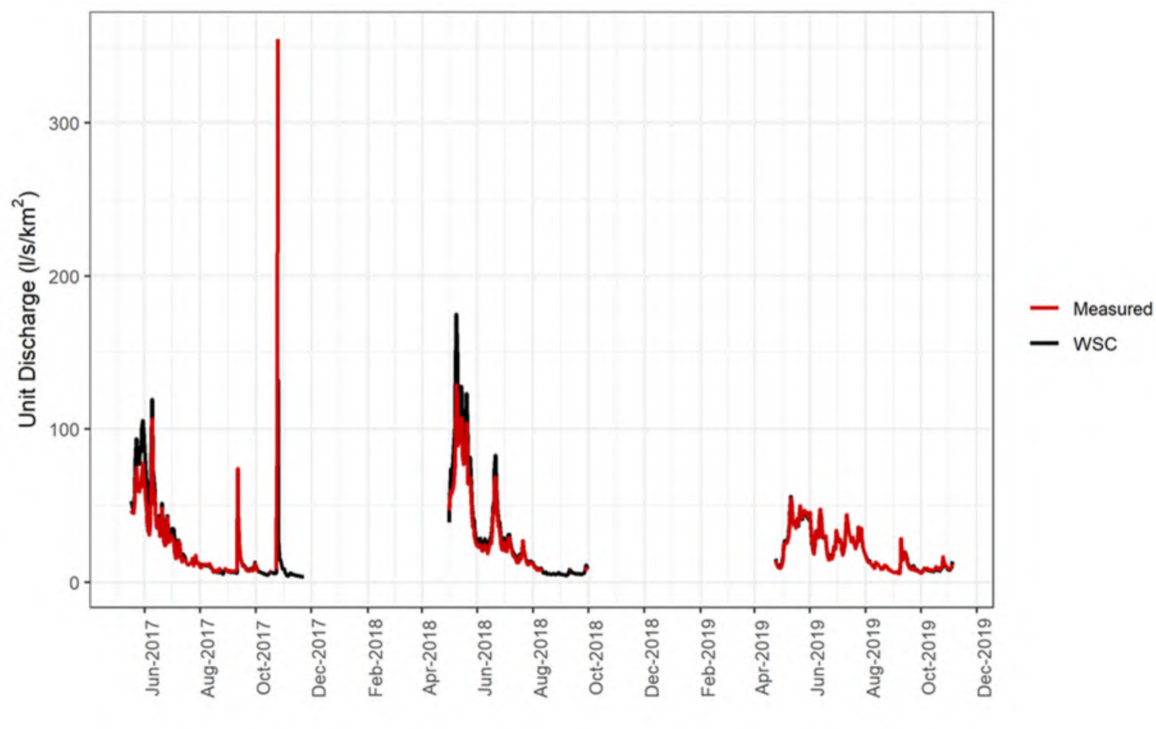
Figure 4-10: Mean Daily Open Water Evaporation Rates

Source: from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Evaporation_rev02.Rmd

4.2 Derived Hydrological Parameters

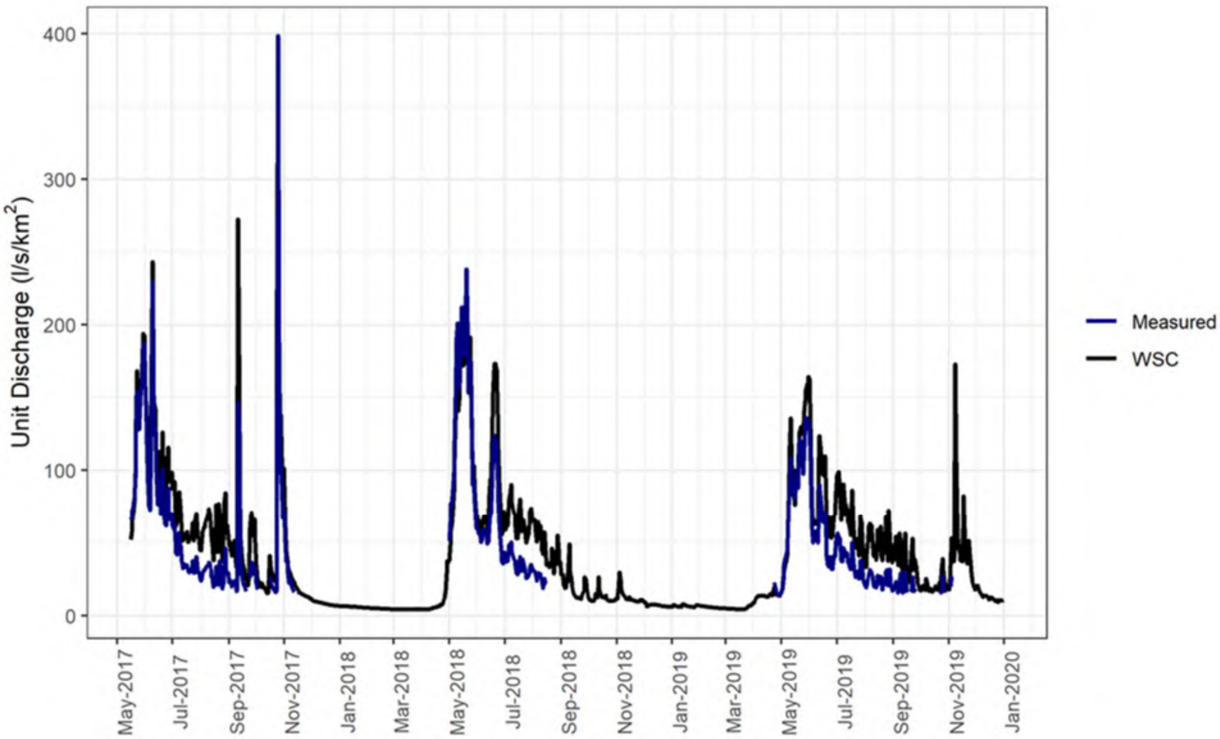
4.2.1 Time Series Comparison

Comparisons of the unit discharge at each Project hydrometric station with regional station data records led to pairing of the Project record with the most appropriate regional analogue (Table 4-18). Regression approaches were used for the periods of overlap between each of the Project hydrometric stations and their respective regional analogue. Time series of Project Area and regional station unit discharge records for Goathorn-Hydro and Goathorn Creek (08EE008), Telkwa-Hydro and Telkwa River (08EE020) Tenas-Hydro B and Goathorn Creek (08EE008), and Four-Hydro and Goathorn Creek (08EE008) are shown in Figure 4-11, Figure 4-12, Figure 4-13, and Figure 4-14, respectively. Additional comparisons for Four Creek based on 1999 baseline data are also described.



Source: Compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\Telkwa_flows.R

Figure 4-11: Project Hydrometric Station Goathorn-Hydro (red-Measured) and Water Survey of Canada Goathorn Creek Near Telkwa (08EE008) (black-WSC).



Source: Compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\Telkwa_flows.R

Figure 4-12: Project Hydrometric Station Telkwa-Hydro (blue-Measured) and Water Survey of Canada Telkwa River Below Tsai Creek (08EE020) (black-WSC).

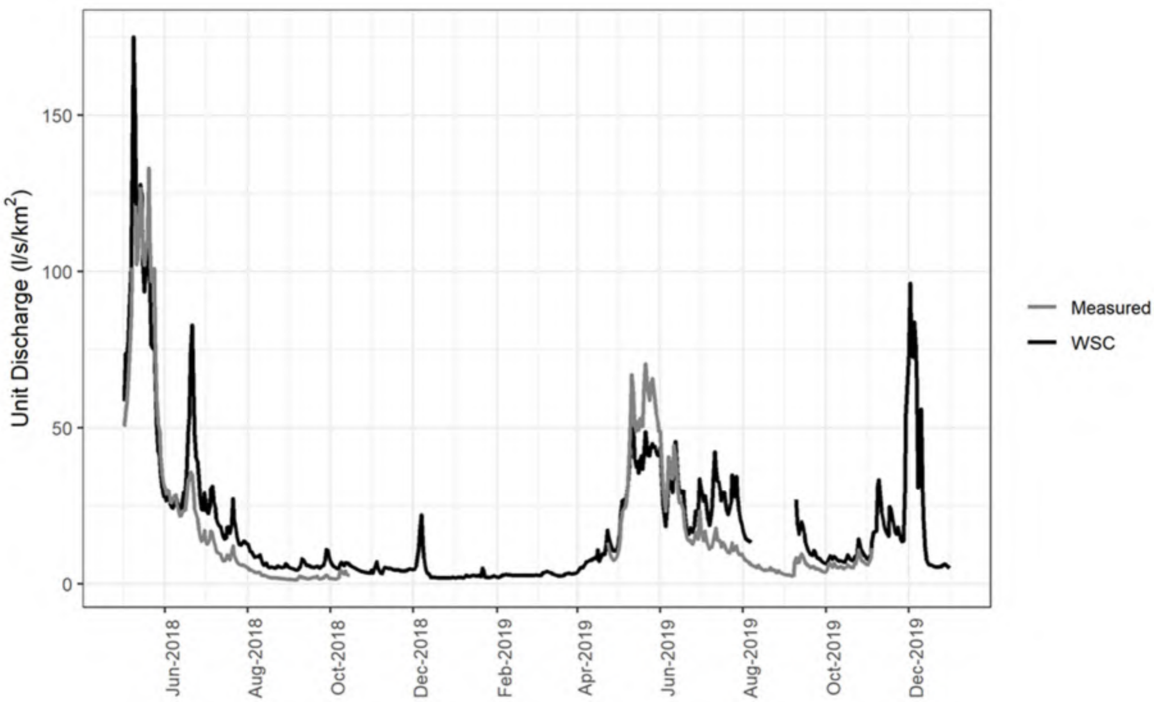


Figure 4-13: Project Hydrometric Station Tenas-Hydro B (grey-Measured) and Water Survey of Canada Goathorn Creek Near Telkwa (08EE008) (black-WSC).

Source: Compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\Telkwa_flows.R

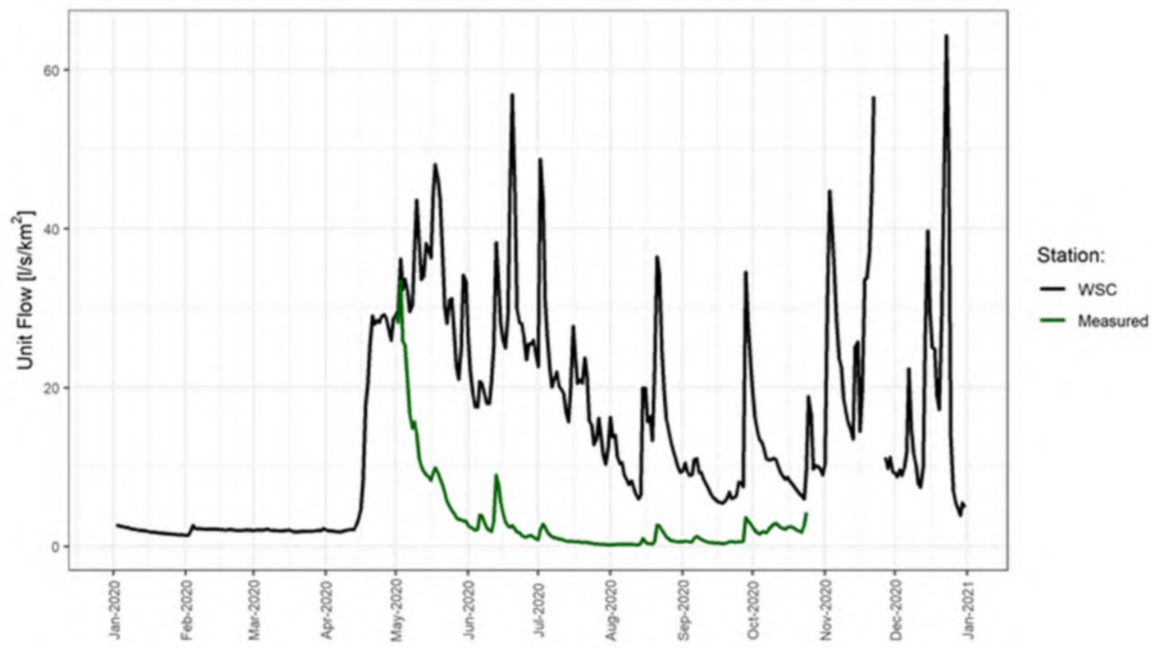


Figure 4-14: Project Hydrometric Station Four-Hydro (green-Measured) and Water Survey of Canada Goathorn Creek Near Telkwa (08EE008) (black-WSC).

Source: Compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\Telkwa_flows.R

Recent hydrometric data at Four-Hydro is limited to 8 measurements in 2021 with an additional low flow measurement taken under ice in February. The continuous flow record is based on a regression developed by ERM for the 6 measurements taken in open water during 2020. The continuous record spans the end of April 2020 to mid-October 2020. The two time series of unit flows show noticeable differences in terms of both magnitude as well as timing. Visual analysis of Figure 4-14 suggests that WSC Goathorn (08EE008) may not be a suitable foundation for a regression with Four-Hydro.

A previous investigation into the hydrology of Four Creek was completed in 1997 (October to November) to 1998 (June to November) to support the Telkwa Coal Project 1999 Baseline Surface Flow and Water Quality Final Data Report (AGRA, 1999; Attachment A). The precise location of the AGRA hydrometric stations are not known, which limits the transferability of analyses using historical data. Based on the station descriptions in AGRA 1999, approximate locations were estimated and catchment areas were calculated.

Unit flows and monthly runoff rates were calculated based on assumed catchment areas and compared between Tenas, Four and Goathorn creeks, presented in Table 4-17 and Figure 4-15 and described in Attachment A and in tabular form in Attachment C. Runoff rates by month show a lower yield in Four Creek than in Tenas Creek, and higher rates in Goathorn Creek than in Tenas Creek during summer months of August and September. Unit flows in October 1997 show a storm response peak flow in all three streams, while 1998 records show a consistently lower yield in Four Creek than in Goathorn Creek.

Table 4-17: Comparison of Monthly Runoff Rates based on Hydrometric Data from AGRA 1999 at Goathorn, Tenas and Four Creeks (Attachment A, C)

Stream	Year	Runoff (mm/month)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tenas Creek	1997	ND	ND	ND	ND	ND	ND	ND	22	12	47	ND	ND
	1998	ND	ND	ND	ND	40	ND	ND	5	8	11	ND	ND
Four Creek	1997	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	4	ND
	1998	ND	ND	ND	ND	ND	ND	3	1	1	2	ND	ND
Goathorn Creek	1997	4	5	5	49	166	142	88	54	32	46	16	6
	1998	3	3	4	28	145	68	50	25	16	27	12	6

Notes:

1. Monthly runoff is calculated for months containing greater than 25 days of runoff data
2. ND: No Data or less than 25 days with data in a month

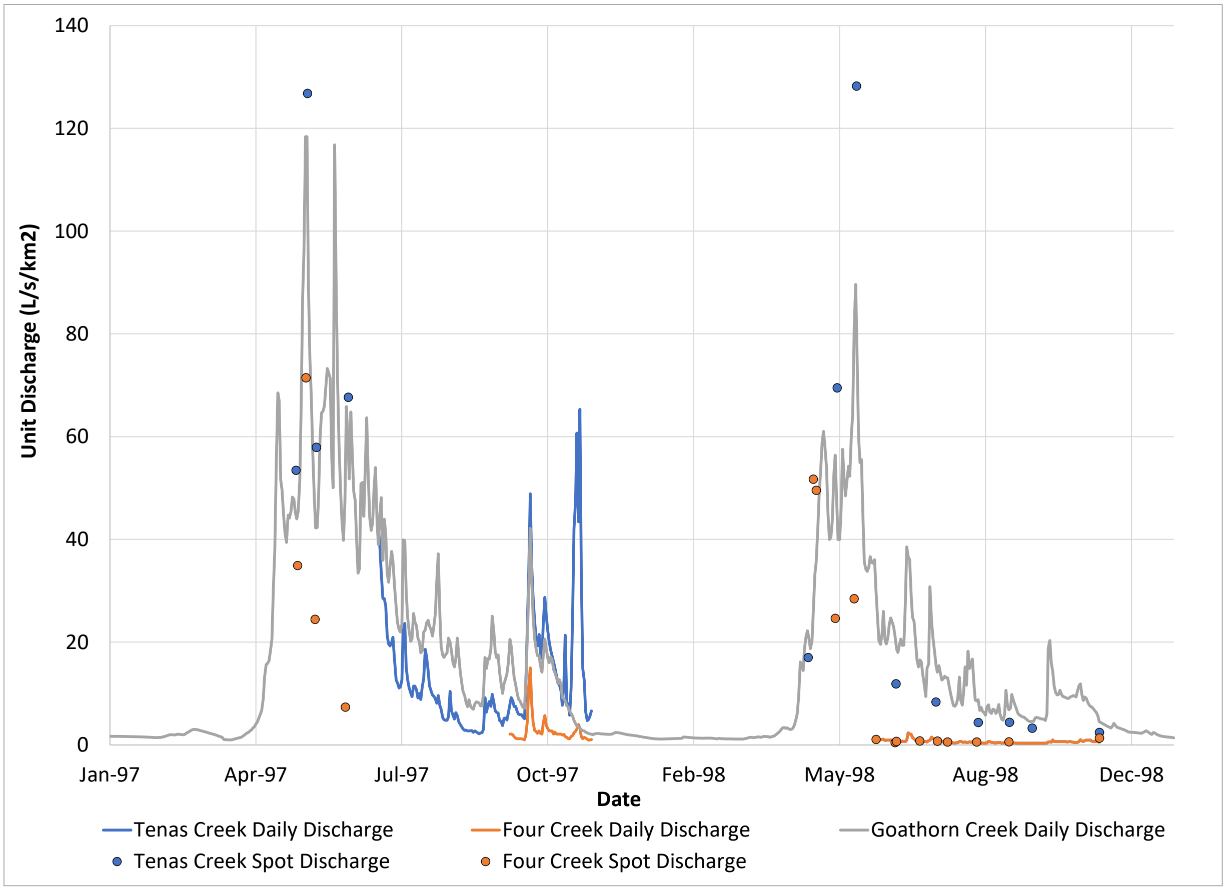


Figure 4-15: Comparison of Unit Flows based on Hydrometric Data from AGRA 1999 at Goathorn, Tenas and Four Creeks (Attachment A, C)

AGRA 1999 describes runoff ratios, based on annual runoff yield and annual precipitation data from Smithers Airport. The runoff ratios for WSC's Goathorn Creek station were calculated as 0.65 and 0.83 in 1997 and 1998, respectively, and 0.28 in both years for Four Creek. Note that results from Section 4.1.2 show that precipitation data from Smithers Airport is expected to be distinct from precipitation that falls near the Telkwa Project Area or within each stream's catchment, limiting the applicability of these ratios. This discrepancy is also noted in AGRA 1999. AGRA 1999 stated that the difference in runoff ratios between Goathorn and Four Creek could be attributed to potential orographic gradients in precipitation and the difference in the altitude range between Goathorn Creek (1745 m, from 550 to 2295 masl) versus Four Creek (670 m from 700 to 1370 masl). The Four Creek basin generally faces the northeast, where as the Goathorn Creek basin faces northeast and northwest, which is expected to cause differences in snowpack accumulation and ablation (AGRA 1999). AGRA also concluded that groundwater baseflows would be more pronounced in Goathorn Creek as it extends lower in the basin than Four Creek, which may result in an increased occurrence of springs surfacing from fractures.

The general timing of the discharge record for Goathorn Creek and Four Creek compared favorably in the 1999 study, which justified extension of the Four Creek data with Goathorn Creek at the time of the study. A similar record extension using regressions with Goathorn Creek were attempted for the purpose of this study and are described in Section 4.2.2.

4.2.2 Regression Equation Development

The regression approach ultimately selected to develop regressions between measured, Project hydrometric records and regional analogues was chosen based on: (1) The simplicity of the regression, (2) the Nash-Sutcliffe Efficiency (NSE) between the estimated flows and the measured flows for the period of overlap and (3) the ability of the regression to approximate both high and low flows based on flow duration curves. The regressions were then used to generate synthetic flow records for each Project hydrometric stations using the long-term, regional records from Water Survey of Canada as a foundation. The time series generated from the developed regression equations for each hydrometric station were compared to the measured unit discharges at each station using tables.

Table 4-18 summarizes the pairings between Project hydrometric stations and the most suitable regional analogue, catchment areas for each station and the NSE from the regression. The Four-Hydro station record was compared against Goathorn Creek (08EE008) by ERM and by SRK, however insufficient data were available to develop a strong regression and record extension. Two equations were developed using linear regression and provisional WSC Goathorn flow data that has not been approved by WSC. The 2020 WSC Goathorn flows show a jump in February that is likely erroneous and will require correction by WSC. Given the provisional WSC data and the short period of record at Four-Hydro, it was unsurprising that neither equation adequately captured the correct magnitude for freshet as well as lower flow conditions. Additional regression options were explored but were not successful.

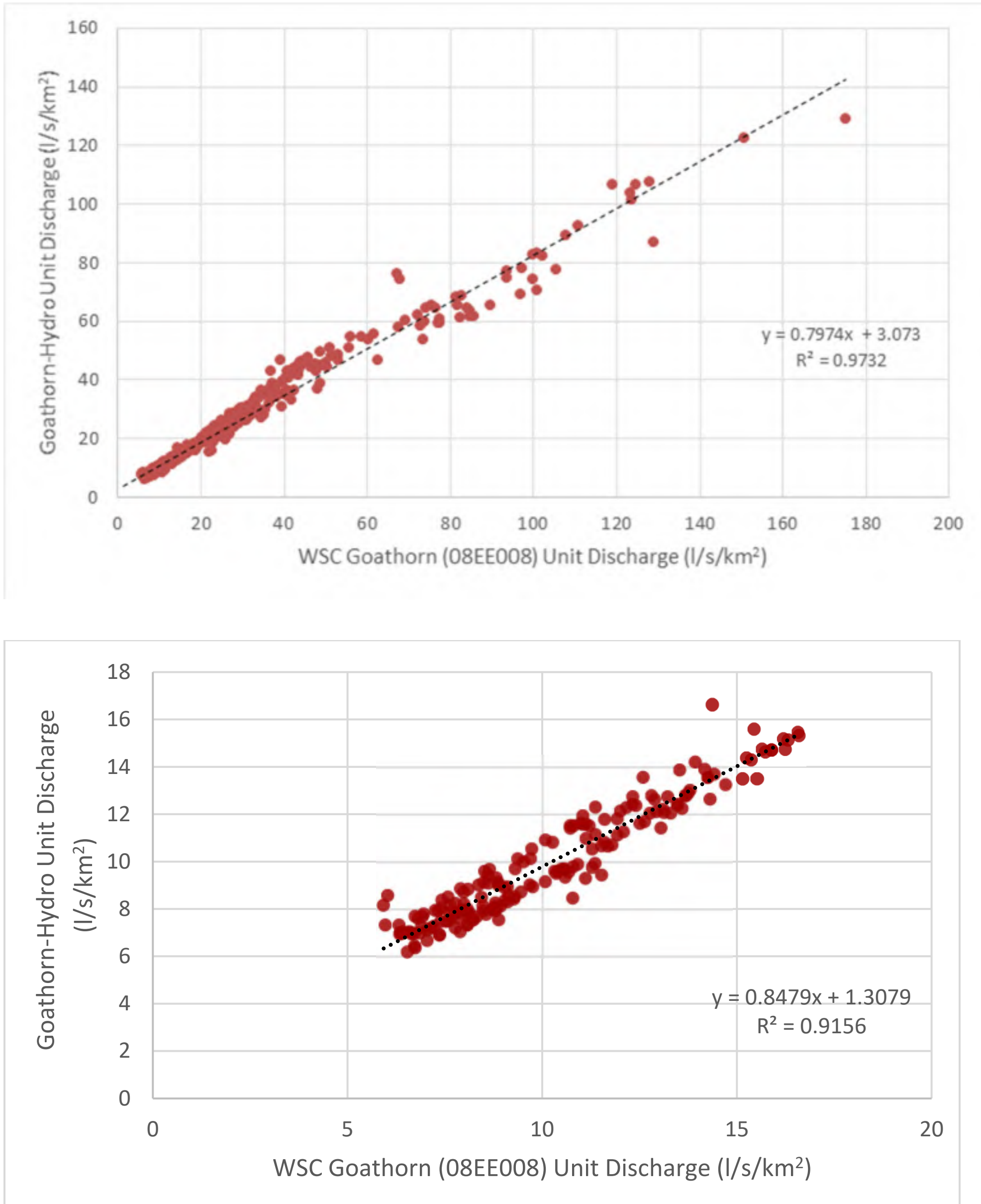
Table 4-18: Project and WSC Regional Regression Type and Fit Parameter.

Project Station ID	Project Station Catchment Area (km^2)	Regional Station ID	Regional Catchment Area (km^2)	Regression Type	Regression NSE
Goathorn-Hydro	123.5	Goathorn (08EE008)	125	Linear, Chronological Pairing	0.96
Tenas-Hydro B	46.8	Goathorn (08EE008)	125	Linear, Chronological Pairing	0.92
Telkwa-Hydro	997.2	TelkwaBTC (08EE020)	367	Ranked Regression, Time-independent	0.96
Four-Hydro	11.0	Goathorn (08EE008)	125	Linear, Chronological Pairing	0.28

Source: Compiled in text.

Goathorn-Hydro

The linear regression for Goathorn-Hydro was developed for moderate to high flows while a separate linear regression was developed to generate low flows. The low flow regression was developed from low flows in November. The linear regression developed excluded a high flow event recorded at Goathorn-Hydro on 25 October 2017 (Figure 4-16). This event was removed from the dataset as its occurrence was not supported by any similarly large discharge event recorded at the Water Survey of Canada Goathorn station. The recorded daily average unit flow at Goathorn-Hydro was 354 L/s/km^2 while the WSC Goathorn station recorded 132 L/s/km^2.



Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\ 01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\Goathorn_regression_rev00_20200421_njs.xlsx

Figure 4-16: Linear regressions developed for WSC Goathorn Creek Near Telkwa (08EE008) and Goathorn-Hydro stations for moderate to high flows (upper panel) and low flows (lower panel).

Table 4-19 shows the unit discharge measured at Goathorn Hydro compared to the unit

Year	Month	Goathorn-Hydro Unit Discharge (L/s/km^2)	Annual Average (L/s/km^2)	Regression Unit Discharge (L/s/km^2)	Annual Average (L/s/km^2)
2017	May	59.9	24	65.7	25
	Jun	41.9		42.6	
	Jul	16.5		16.8	
	Aug	9.3		9.0	
	Sep	12.8		11.9	
	Oct	15.2		13.3	
2018	May	71.5	35	75.3	36
	Jun	30.4		30.8	
	Jul	17.7		17.6	
	Aug	8.9		9.3	
	Sep	8.1		9.0	
2019	Apr	11.0	20	11.5	17
	May	37.8		33.4	
	Jun	27.4		24.4	
	Jul	27.7		24.7	
	Aug	10.6		4.1	
	Sep	10.5		9.0	
	Oct	9.2		8.6	
	Nov	10.0		9.7	

discharge calculated from the regression equations for the same time period each year. The measured unit discharge and the regressed values are very similar with slight overestimation in 2017 and 2018 and some underestimation in 2019.

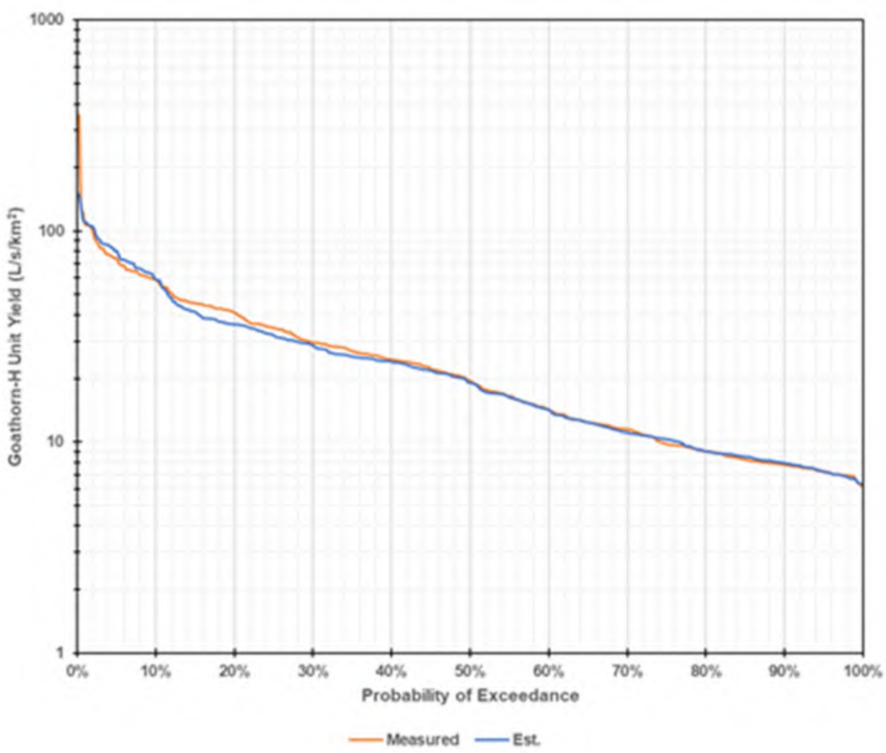
Exceedance probabilities of the measured and regressed unit discharge are presented in Table 4-19.

Figure 4-17, which shows that estimate flows are very similar in magnitude for low and high flows.

Table 4-19: Measured and Regressed Unit Discharge Values at Goathorn-Hydro

Year	Month	Goathorn-Hydro Unit Discharge ($L/s/km^2$)	Annual Average ($L/s/km^2$)	Regression Unit Discharge ($L/s/km^2$)	Annual Average ($L/s/km^2$)
2017	May	59.9	24	65.7	25
	Jun	41.9		42.6	
	Jul	16.5		16.8	
	Aug	9.3		9.0	
	Sep	12.8		11.9	
	Oct	15.2		13.3	
2018	May	71.5	35	75.3	36
	Jun	30.4		30.8	
	Jul	17.7		17.6	
	Aug	8.9		9.3	
	Sep	8.1		9.0	
2019	Apr	11.0	20	11.5	17
	May	37.8		33.4	
	Jun	27.4		24.4	
	Jul	27.7		24.7	
	Aug	10.6		4.1	
	Sep	10.5		9.0	
	Oct	9.2		8.6	
	Nov	10.0		9.7	

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\Goathorn_regression_rev00_20200421_njs.xlsx



Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\
Goathorn_regression_rev00_20200421_njs.xlsx

Figure 4-17: Probability Exceedance of Goathorn-Hydro Unit Discharge

Tenas-Hydro B

The Tenas-Hydro B station was paired with Goathorn Creek Near Telkwa (08EE008) for developing a regression to develop a synthetic time series. The linear regression was separated into two periods, based on the month, as shown in Figure 4-18.

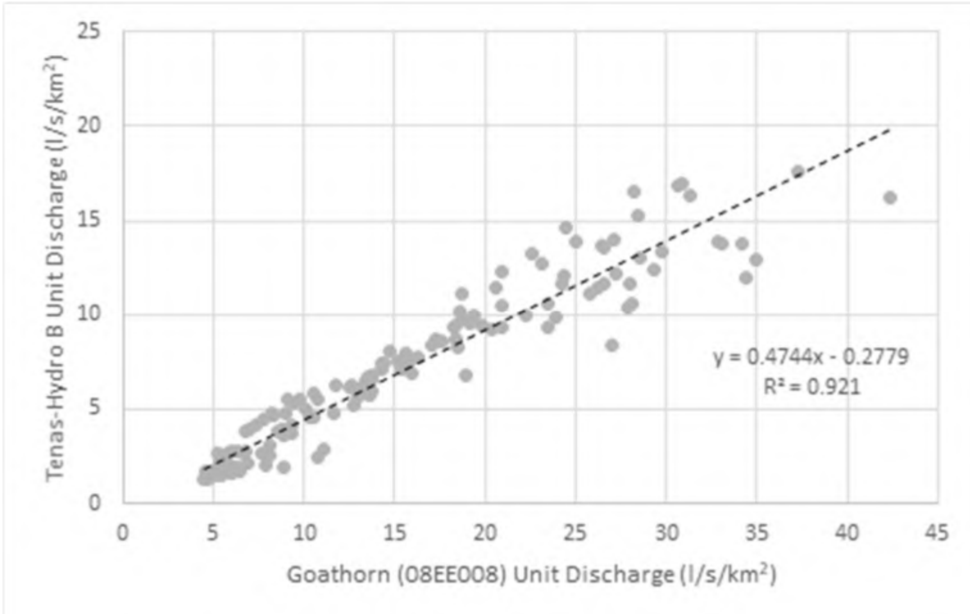
Table 4-20 shows the unit discharge measured at Tenas Hydro compared to the unit discharge calculated from the regression equations for the same time period each year. Both years present very similar annual average flows.

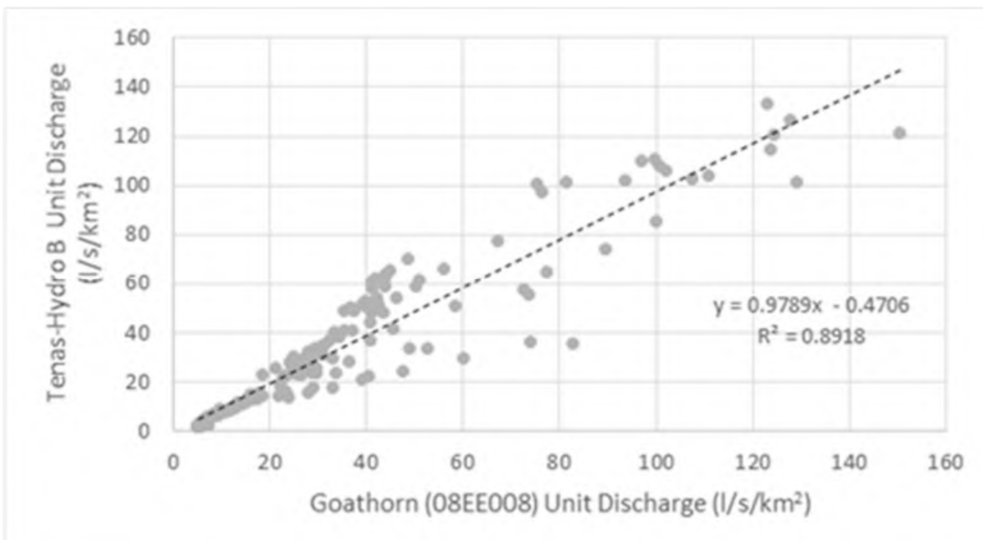
Exceedance probabilities of the measured and regressed unit discharge are presented in Figure 4-19 which shows that estimate flows are very similar in magnitude for low and high flows, with extreme low flows being slightly overestimated in the synthetic dataset.

Table 4-20: Measured and Regressed Unit Discharge Values at Tenas-Hydro B.

Year	Month	Tenas-Hydro B Unit Discharge (L/s/km²)	Annual Average (L/s/km²)	Regression Unit Discharge (L/s/km²)	Annual Average (L/s/km²)
2018	May	85.7	21	85.0	23
	Jun	25.3		33.6	
	Jul	9.7		8.8	
	Aug	2.8		3.1	
	Sep	2.0		2.7	
	Oct	2.7		4.7	
2019	Apr	9.4	16	8.3	15
	May	47.8		36.5	
	Jun	26.1		26.2	
	Jul	12.7		12.8	
	Aug	5.3		6.7	
	Sep	5.4		5.6	
	Oct	6.2		7.9	

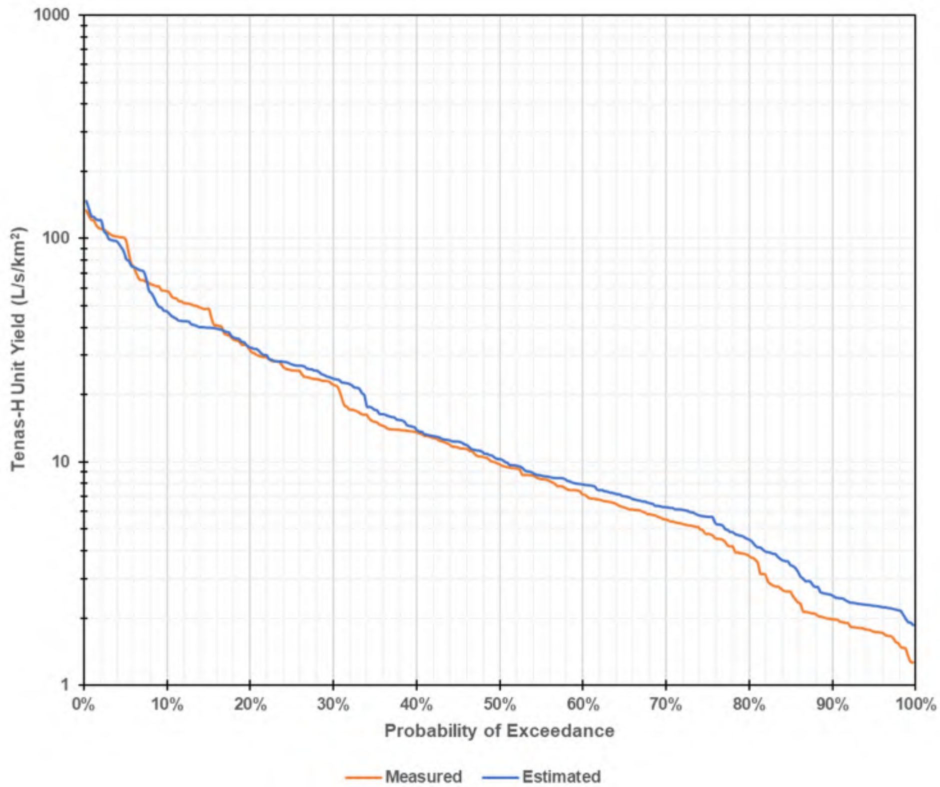
Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\Tenas_regression_rev00_20200421_njs.xlsx





Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\Tenas_regression_rev00_20200421_njs.xlsx

Figure 4-18: Linear regression between WSC Goathorn Creek Near Telkwa (08EE008) station and Tenas-Hydro B for the months of April, May, June, October and November (top) and July to September (bottom).



Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\Tenas_regression_rev00_20200421_njs.xlsx

Figure 4-19. Probability Exceedance of Tenas-Hydro Unit Discharge.

Telkwa-Hydro

The Telkwa-Hydro hydrometric data was regressed against Water Survey of Canada Telkwa River Below Tsai Creek (08EE020) using ranked regressions, which uses paired discharge records independent of chronological order. Monthly ranked regression results are presented in Figure 4-20, and regression equations with goodness of fit indicators are presented in Table 4-21.

Table 4-22 presents the unit discharge measured at Telkwa Hydro compared to the unit discharge calculated from the monthly regressions with Telkwa River Below Tsai Creek for the same time period each year. The regressed values underestimated flow in 2017 but provided similar results for 2018 and 2019.

Exceedance probabilities of the measured and regressed unit discharge are presented in Figure 4-20 which shows that estimated flows are very similar in magnitude for average and high flows, but less accurate for low flows (higher exceedance probability results), where the estimated results are lower than the measured values.

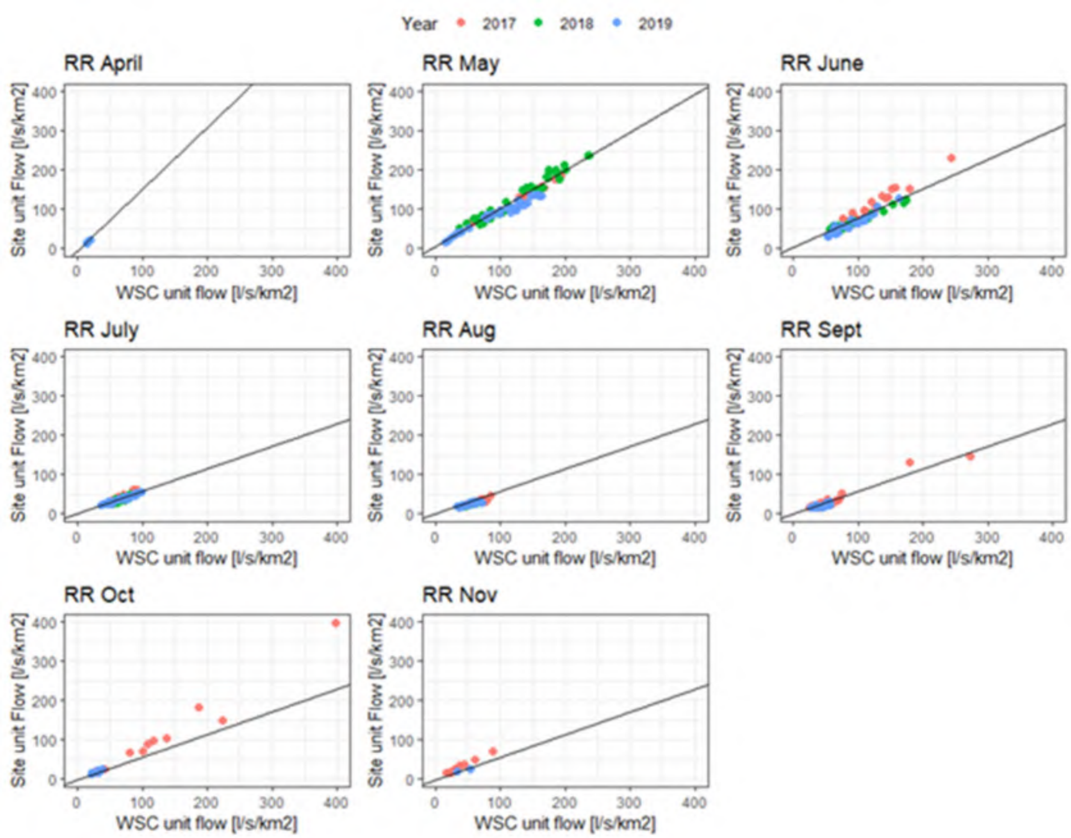


Figure 4-20: Monthly ranked regression between WSC Telkwa River Below Tsai Creek (08EE020) and Telkwa-Hydro stations.

Source: Compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\ Flows_update_rev12_monthlyregr.Rmd

Table 4-21: Monthly Ranked Regression Equations and R-squared Value.

Month	April	May	June	July	Aug	Sept	Oct	Nov
Equation	1.58x-7.29	0.97x+4.69	0.75x+2.12	0.57x -0.73	0.43x+2.49	0.55x-1.95	0.96x-8.93	0.79x+0.93
R^2	0.84	0.88	0.81	0.75	0.76	0.83	0.95	0.85

Source: Compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\ Flows_update_rev12_monthlyregr.Rmd

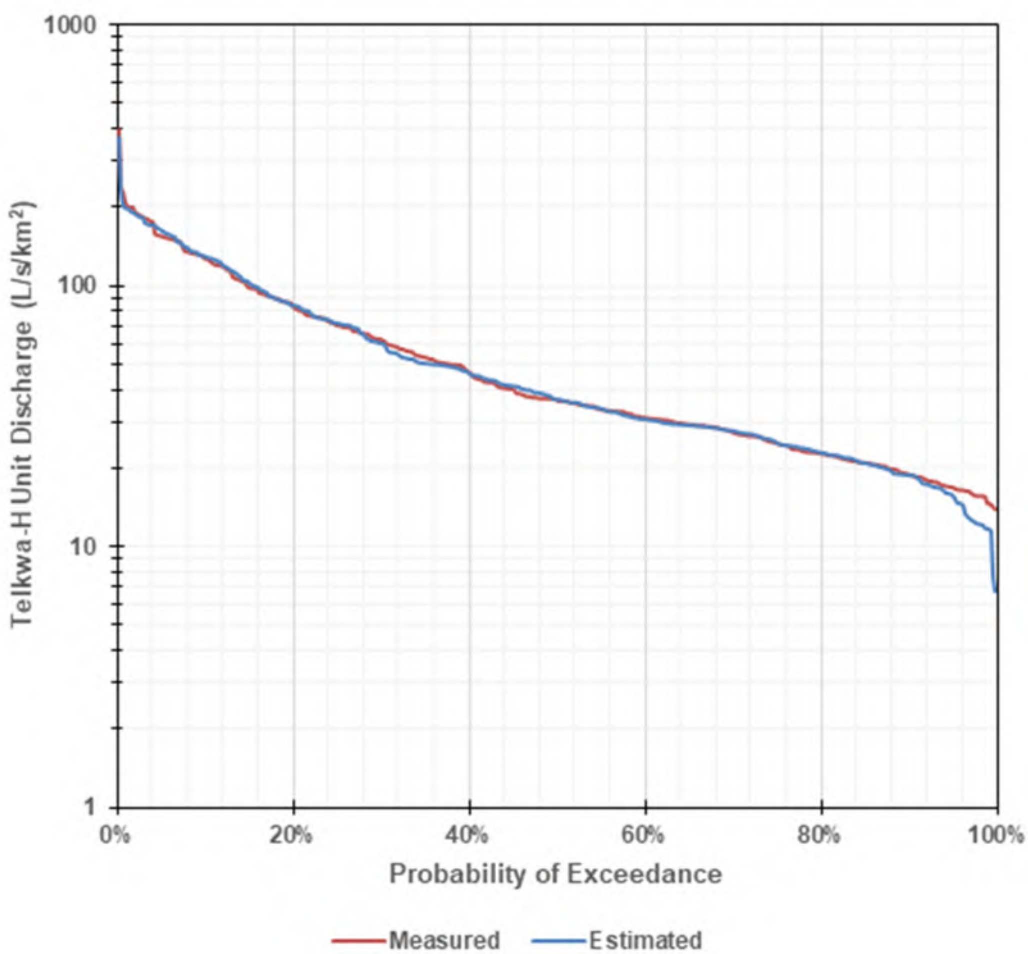


Figure 4-21: Probability Exceedance of Unit Discharge (L/s/km2) at Telkwa-Hydro.

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\Telkwa_regression_rev00_20200423_njs.xlsx

Table 4-22. Measured and Regressed Unit Discharge Values at Telkwa-Hydro.

Year	Month	Telkwa-Hydro Unit Discharge (L/s/km^2)	Annual Average (L/s/km^2)	Regression Unit Discharge (L/s/km^2)	Annual Average (L/s/km^2)
2017	May	125.2	61	88.9	48
	Jun	97.1		86	
	Jul	38.9		35.2	
	Aug	29.3		28.1	
	Sep	34.7		29.5	
	Oct	75.6		50.3	
	Nov	28.3		16.7	
2018	May	140.1	58.5	135.3	55
	Jun	68.4		69.9	
	Jul	35.9		37.2	
	Aug	25		23	
	Sep	23.1		9.3	
2019	Apr	16.6	36	12.3	38
	May	87.8		98.1	
	Jun	58		63.4	
	Jul	37.6		37.2	
	Aug	24		23.6	
	Sep	20		18.2	
	Oct	19.3		11	
	Nov	23.5		35.9	

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\Telkwa_regression_rev00_20200423_njs.xlsx

Four-Hydro

The Four-Hydro hydrometric data was regressed against Water Survey of Canada Goathorn Creek Near Telkwa (08EE008) using linear regressions for the open water period as well as for the low flow season. The primary regression that was explored had a NSE of 0.27 and provided a very poor representation of freshet flows in terms of both timing and magnitude. The short data record at Four-Hydro was not sufficient to develop a meaningful regression with a longer-term flow record. Two seasonal regressions were attempted using measured unit flow data from Four-Hydro and WSC Goathorn and are displayed in Figure 4-22 and Figure 4-23. The results of each regression are shown in Figure 4-24 and Figure 4-25.

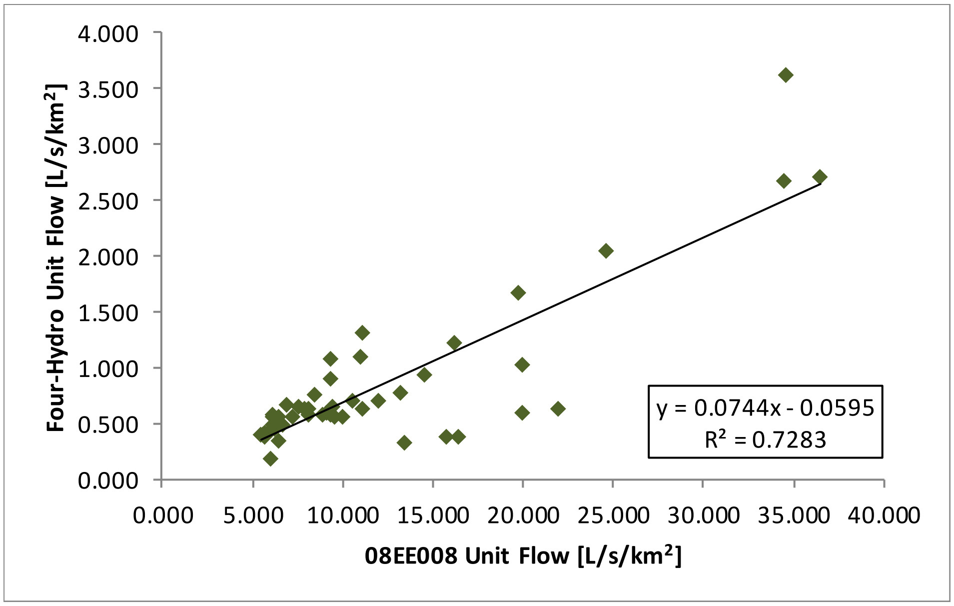


Figure 4-22: Regression (A) Based on Measured Data from WSC Goathorn (08EE008) and Four-Hydro Over the Open Water Period. Regression Developed by ERM

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\Four_regression_rev00_20210407_njs.xlsx

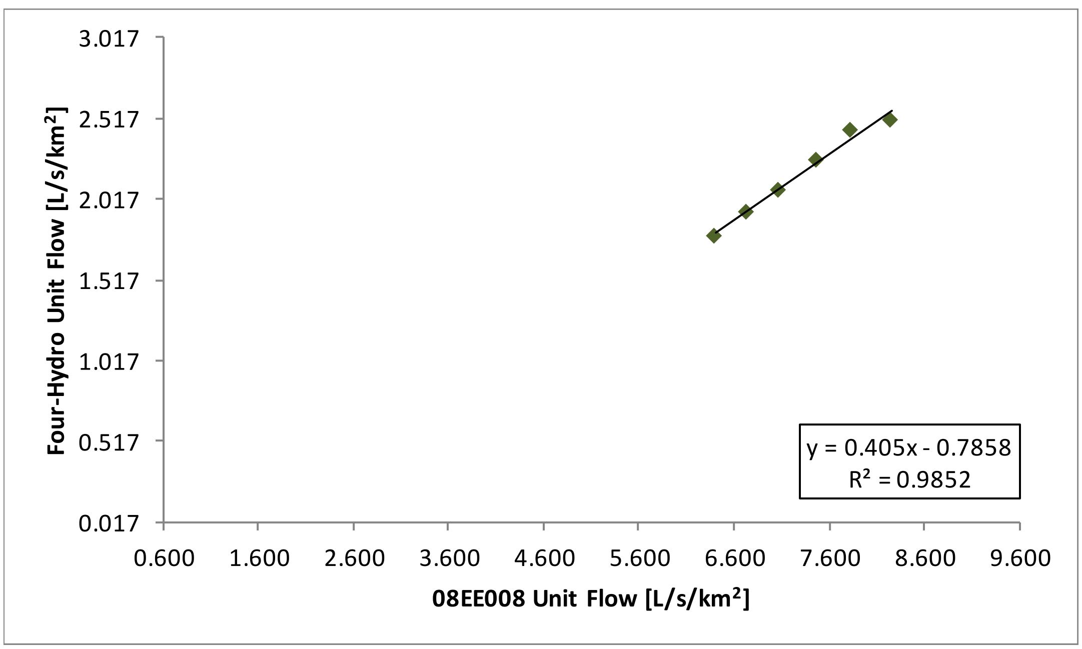


Figure 4-23: Regression (B) Based on Low Flow Measurements Captured at the End of the Open Water Period. Regression Developed by ERM.

Source: Compiled in text. \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\Four_regression_rev00_20210407_njs.xlsx

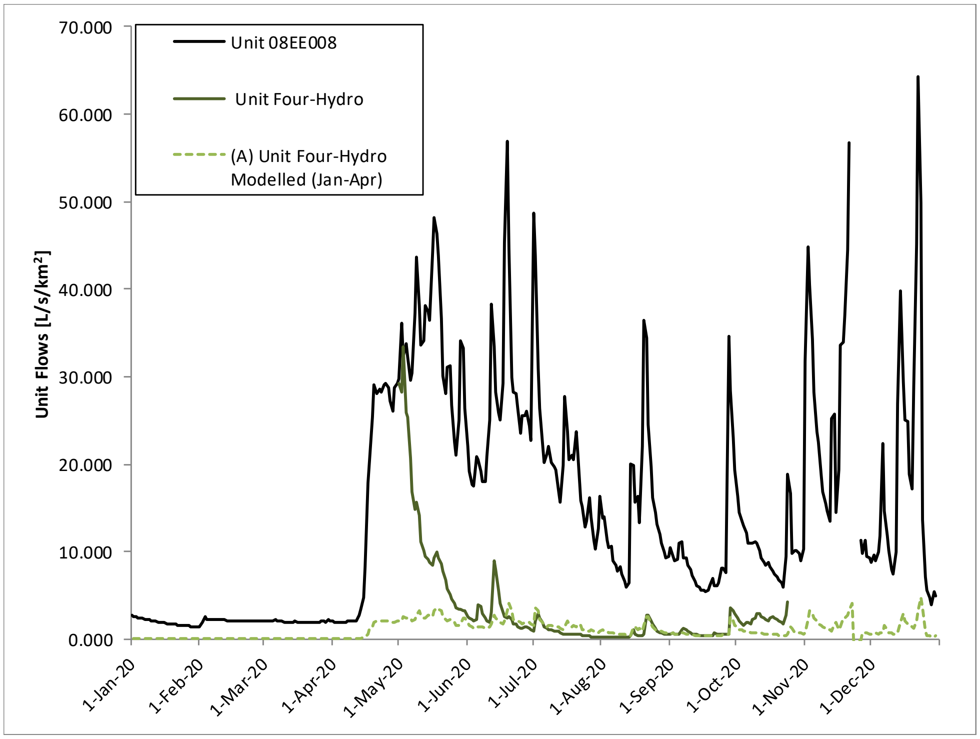


Figure 4-24: Unit Flow Hydrograph Resulting From Application of Regression (A).

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\Four_regression_rev00_20210407_njs.xlsx

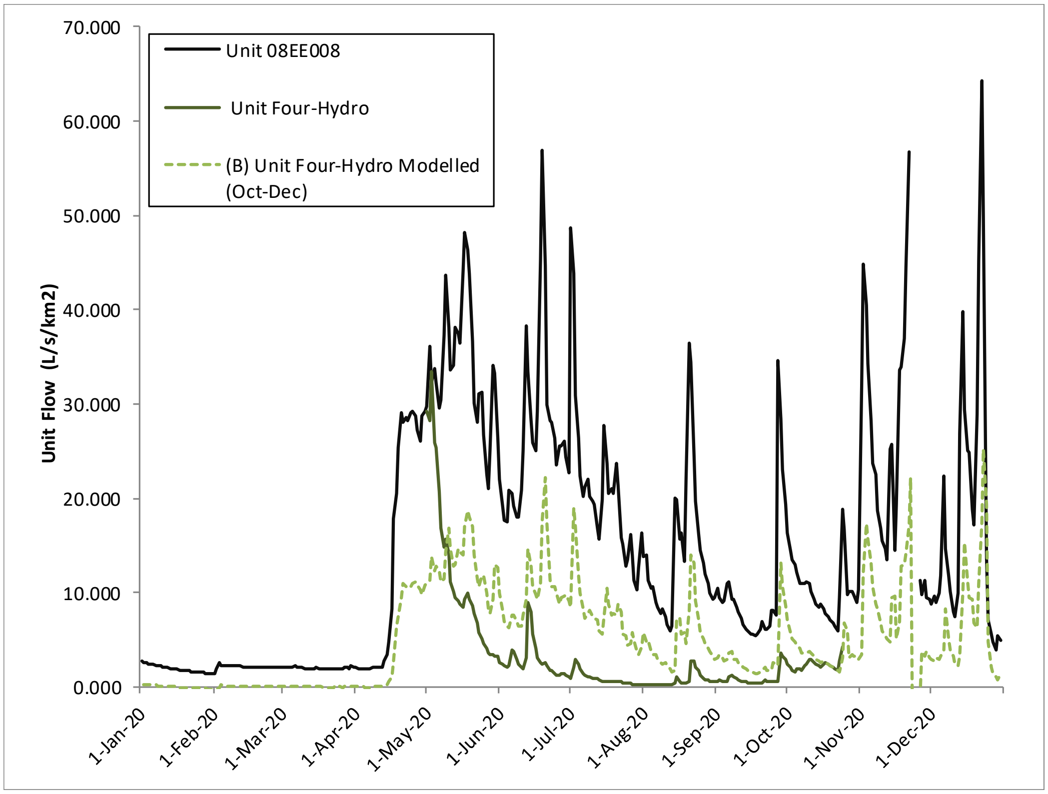


Figure 4-25: Unit Flow Hydrograph Resulting From Application of Regression (B).

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\Four_regression_rev00_20210407_njs.xlsx

Neither regression sufficiently reproduced magnitudes, timing and patterns of the hydrology at Four-Hydro. Regression A was implemented for January to April while regression B was used for the remaining months (October to December) to fill any gaps in the measured record. A comparison of the measured and gap-filled Four-Hydro records is shown in Table 4-23.

Table 4-23: Measured and Regressed Unit Discharge Values at Four-Hydro.

Year	Month	Four Hydro Unit Discharge [L/s/km^2]	Average [L/s/km^2]	Regression A Unit Discharge [L/s/km^2]	Average [L/s/km^2]	Regression B Unit Discharge [L/s/km^2]	Average [L/s/km^2]
2020	Jan	--	3.3	0.09	1.0	0.001	5.2
	Feb	--		0.1		0.06	
	Mar	--		0.09		0.02	
	Apr	--		0.9		4.5	
	May	3.0		2.5		13.0	
	Jun	11.9		2.0		10.1	
	Jul	2.8		1.5		7.7	
	Aug	0.9		1.0		5.0	
	Sep	0.7		0.7		3.2	
	Oct	2.3		0.7		3.6	
	Nov	--		1.5		8.0	
	Dec	--		1.3		6.5	

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_regressions\Four_regression_rev00_20210407_njs.xlsx

Previous investigations into Four Creek hydrology (AGRA 1999) developed a similar regression and R-squared value as the 2020 flow comparison (regression (A)). Another approach undertaken previously was to compare unit runoff yield but this approach relies on the two locations having similar responses, which was not observed in 2020 (Figure 4-14, Figure 4-24, Figure 4-25). Therefore, calibration of Four-Hydro was conducted using the available 2020 record, which includes partial extension with Goathorn Creek (08EE008) and no long-term regression was developed.

4.2.3 Extended (Synthetic) Time Series for Project Hydrometric Stations

The regressions developed for Goathorn-Hydro, Telkwa-Hydro and Tenas-Hydro were used to generate a long-term, extended or synthetic time series based on the Water Survey of Canada regional records. Due to the poor performance of the Four-Hydro regression using more recent data from ERM, an extended time series was not developed. Additional data collected in 1997-1998 was of insufficient duration to use in developing a synthetic time series. The synthetic unit discharge time series are shown in Figure 4-26 for Goathorn-Hydro, Figure 4-27 for Telkwa-Hydro and Figure 4-28 for Tenas-Hydro B.

Table 4-24, Table 4-25, and Table 4-26 present the monthly average streamflow, unit flow, and runoff yield for each hydrometric station based on the extended time series results, and Table 4-35 presents the monthly 7Q10.

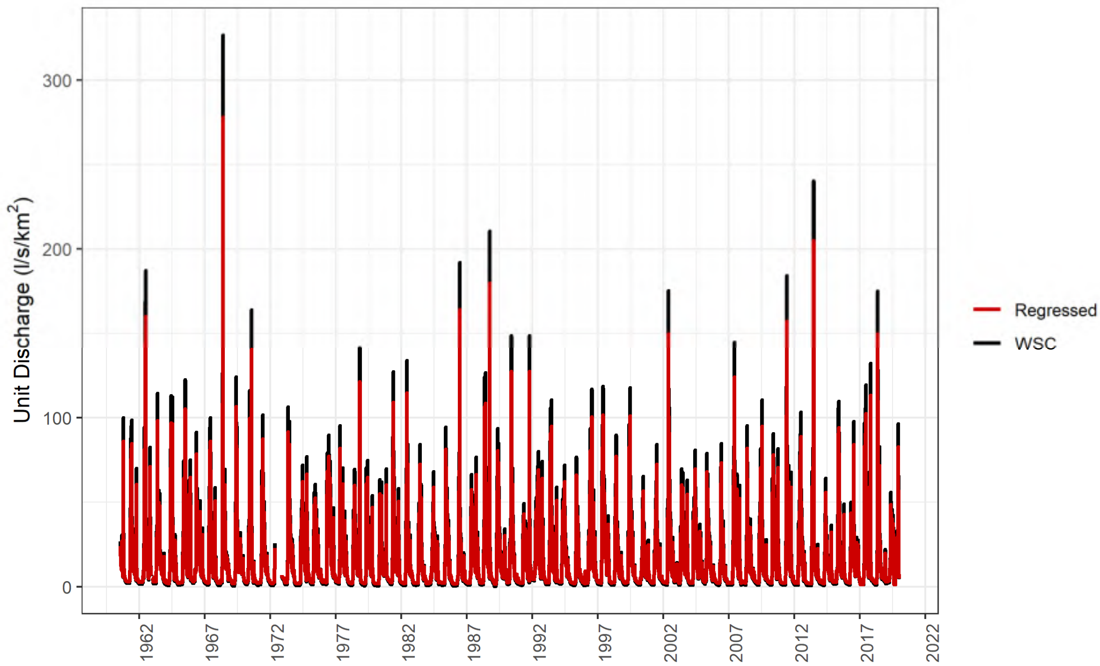
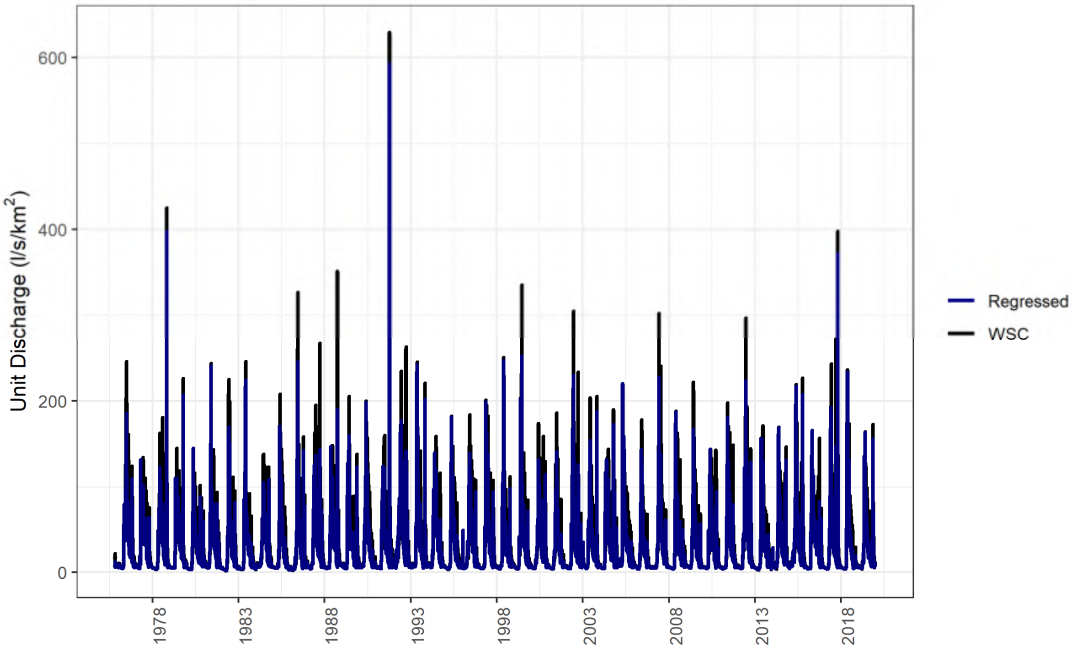


Figure 4-26: Synthetic time series for Goathorn Hydro (red – regressed) and Water Survey of Canada Goathorn Creek Near Telkwa stations

Source: Compiled in R \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\RegionalFlows\Telkwa_flows_1CT027003_Plots_njs.R



Source: Compiled in R \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\RegionalFlows\Telkwa_flows_1CT027003_Plots_njs.R

Figure 4-27: Synthetic time series for Telkwa-Hydro (blue-regressed) and Water Survey of Canada Telkwa Below Tsai Creek stations

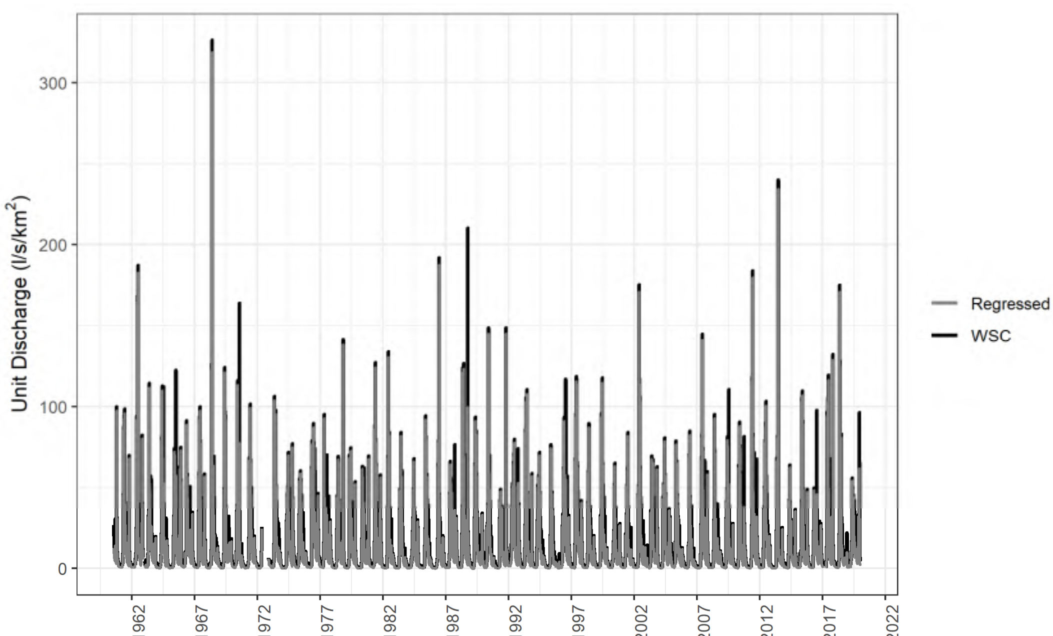


Figure 4-28: Synthetic time series for Tenas-Hydro B (grey-regressed) and Water Survey of Canada Goathorn Creek Near Telkwa stations

Source: Compiled in R \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\RegionalFlows\Telkwa_flows_1CT027003_Plots_njs.R

Table 4-24: Average Monthly and Mean Annual Discharge (m^3/s)

Station Name	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Ann.
Goathorn-Hydro (Synthetic)	0.4	0.3	0.3	1.1	4.5	4.6	2.9	1.6	1.2	1.3	0.9	0.5	1.7
Telkwa-Hydro (Synthetic)	6.4	5.3	5.4	16.2	74.1	81.9	45.7	26.5	20.3	24.5	13.2	7.5	27.3
Tenas-Hydro B (Synthetic)	0.03	0.02	0.02	0.4	1.9	1.9	0.6	0.3	0.2	0.5	0.3	0.1	0.5

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_summaries\
Telkwa_1CT027.003_FlowSummaries_Collated_njs.xlsx

Table 4-25: Average Monthly and Annual Unit Discharge ($L/s/km^2$)

Station Name	Area (km^2)	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Ann.
Goathorn-Hydro (Synthetic)	123.5	2.87	2.6	2.67	9.12	36.2	37.1	23.2	12.9	10.0	10.7	7.43	4.1	13.2
Telkwa-Hydro (Synthetic)	966.9	6.7	5.5	5.56	16.8	76.6	84.7	47.3	27.4	20.9	25.3	13.6	7.7	28.2
Tenas-Hydro B (Synthetic)	46.75	0.6	0.4	0.5	8.6	39.9	40.8	12.0	6.3	4.6	10.4	6.6	1.3	11.0

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_summaries\
Telkwa_1CT027.003_FlowSummaries_Collated_njs.xlsx

Table 4-26: Average Monthly and Annual Runoff Yield (mm)

Station Name	Area (km^2)	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Ann.
Goathorn-Hydro (Synthetic)	123.5	7.7	6.3	7.2	23.9	97.0	95.7	63.0	34.3	25.7	28.5	19.3	10.9	413
Telkwa-Hydro (Synthetic)	966.9	17.9	13.4	14.9	43.5	205.2	219.5	126.7	73.4	54.2	67.8	35.3	20.6	892
Tenas-Hydro B (Synthetic)	46.75	1.6	1.0	1.3	22.2	105.4	104.1	32.1	16.3	11.6	27.3	16.9	3.4	338

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Streamflow_summaries\
Telkwa_1CT027.003_FlowSummaries_Collated_njs.xlsx

4.2.4 Baseflow separation

The rate at which groundwater discharges into surface streams was characterized using a recursive digital filter to separate baseflow from surface runoff. A single filter parameter, typically ranging from 0.9 to 0.99 based on visual observations was incorporated (Nathan and McMahon1990) to separate total streamflow into a baseflow component and surface runoff component for each of the local and regional hydrometric stations. In this method, the filter is passed over the data 1 to 3 times, where the more passes processed results in a more consistent seasonal baseflow value. Flow records from 2000 to 2019 were used in the separation model, and an upper range of filter parameters were incorporated to simulate a uniform baseflow regime with reduced peaks. A series of parameter combinations were tested, and select results are presented in Attachment B, showing baseflow and total flow from 2010 to 2015. A filter parameter of 0.99 was selected with three passes (n=3).

Monthly average baseflows were calculated over the 19-year modelled period for Tenas Hydro, Telkwa Hydro, Goathorn Hydro and Bulkley River at Quick (WSC) based on the selected filter parameter inputs. Unit baseflows were calculated by dividing by respective catchment areas and are presented in Table 4-27.

The Four-Hydro dataset provided insufficient low flow measurements and monitoring period to perform a separate baseflow separation. Instead, the measured baseflows were used to constrain the model as well as runoff yield comparisons similar to what was computed in AGRA (1999, Attachment A). There are three low flow measurements that span November 2020 to February 2021 and range from unit runoff values of 5.1 L/s/km^2 to 0.72 L/s/km^2 as well as a discharge measurement in July of 0.33 L/s/km^2. In addition, low flow values for unit runoff were recored from June to November 1998 and spanned 0.45 L/s/km^2 to 1.34 L/s/km^2 (Attachment C). These measurements form the basis of assumptions made to constrain baseflows at Four-Hydro. Low flow measurements collected in February 2021 spanned several locations along Four Creek and showed that baseflows have natural heterogeneity.

Table 4-27: Unit Baseflows (L/s/km^2) for Each Major Stream within Project Area

Month	Bulkley	Telkwa	Goathorn	Tenas
1	3.24	4.65	2.03	0.24
2	3.02	4.43	1.96	0.20
3	2.95	4.38	1.93	0.18
4	3.06	4.52	1.98	0.23
5	3.94	5.85	2.60	0.89
6	6.22	9.41	4.05	2.11
7	7.94	11.57	4.91	2.40
8	7.95	10.01	4.49	1.83
9	6.78	7.49	3.76	1.51
10	5.78	6.24	3.17	1.31
11	4.62	5.38	2.51	0.73
12	3.57	4.97	2.09	0.31

Source: Z:\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\BaseflowSeparation\UpdatedBaseflows_07212020_sab.xlsx

4.2.5 Rainfall-Runoff Model Configuration

Surface runoff is defined as the total amount of surface water discharged from a watershed and is frequently presented as the depth of water distributed evenly throughout the watershed area. The Project is located within the Goathorn Creek, Tenas Creek and Four Creek watersheds.

A daily rainfall-runoff model was generated to support streamflow estimations in the water and load balance model and to provide Project-specific runoff rates. The runoff model for the Project Area was developed using a snowmelt model (see Section 4.2.4), a minimum baseflow function, a lag time, recession coefficient and monthly runoff coefficients for each of the main catchments. Monthly runoff coefficients were calibrated automatically within GoldSim by optimizing the Nash Sutcliffe Efficiency, based on the difference between observed and modelled daily flow.

The model required long-term precipitation and temperature inputs for the same period as the synthetic streamflow datasets. The long-term Project temperature and precipitation records were adjusted using PRISM datasets to estimate climate parameters for each of the hydrometric stations. An average monthly precipitation for each hydrometric station watershed was derived from the gridded PRISM monthly precipitation model. These monthly precipitation values were compared against the monthly precipitation estimates for the Project, and a ratio was calculated for each month and each station (Table 4-28).

Table 4-28: Monthly Precipitation Correction Factors applied to Project Precipitation based on PRISM

Month	Tenas Hydro	Four-Hydro	Goathorn Hydro	Telkwa Hydro	Bulkley Hydro
Jan	1.84	1.30	1.88	2.06	1.74
Feb	1.68	1.19	1.71	1.89	1.81
Mar	2.00	1.42	2.03	2.29	2.07
Apr	1.81	1.39	1.87	2.05	1.83
May	1.28	1.04	1.26	1.31	1.14
Jun	1.18	1.15	1.23	1.19	1.09
Jul	1.11	1.13	1.16	1.10	1.03
Aug	1.28	1.03	1.28	1.31	1.17
Sep	1.52	1.09	1.53	1.60	1.33
Oct	1.53	1.09	1.56	1.79	1.70
Nov	1.92	1.37	1.94	2.20	1.95
Dec	1.92	1.36	1.96	2.22	1.93

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\WQS Climate_Correction_Coefs_ 20210107.xlsx

A similar process was employed for temperature. A monthly average temperature for each hydrometric station watershed was derived from the gridded PRISM monthly temperature model. These monthly temperature values were compared against the monthly temperature estimates for the Project, and a correction addend was calculated for each month and each station (Table 4-29).

Table 4-29: Monthly Average Temperature Correction Addends (in degrees Celsius) applied to Project Average Temperature based on PRISM

Month	Tenas Hydro	Four-Hydro	Goathorn Hydro	Telkwa Hydro	Bulkley Hydro
Jan	-0.45	-0.24	-0.52	-0.45	-0.27
Feb	-0.88	-0.37	-0.98	-1.03	-0.73
Mar	-1.27	-0.43	-1.54	-1.66	-0.93
Apr	-1.64	-0.68	-1.96	-2.13	-1.19
May	-1.74	-0.78	-2.03	-2.29	-1.26
Jun	-1.81	-0.74	-2.06	-2.46	-1.38
Jul	-1.77	-0.80	-2.00	-2.33	-1.24
Aug	-1.48	-0.51	-1.71	-2.00	-0.92
Sep	-1.28	-0.43	-1.51	-1.73	-0.70
Oct	-1.17	-0.55	-1.46	-1.50	-0.58
Nov	-0.93	-0.30	-1.08	-1.16	-0.43
Dec	-0.32	-0.04	-0.36	-0.37	-0.15

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\WQS Climate_Correction_Coefs_ 20210107.xlsx

Using the daily temperature and precipitation time series adjusted for each streamflow station, the remaining runoff model inputs were calibrated in order to mimic the long-term synthetic streamflow records. Calibrated inputs included monthly runoff coefficients, baseflow, lag time and recession value.

Figure 4-29 illustrates the observed and modelled flows at the Goathorn-Hydro station from October 2001 to October 2018. Results produced an average Nash Sutcliffe Efficiency of approximately 0.68 which is deemed acceptable for a flow calibration model (Axel Ritter, 2013). The modelled flow closely resembles the synthetic record derived from the Water Survey of Canada station flows, however, peaks in modelled flows occasionally exceed the peaks observed in the synthetic and Water Survey of Canada observed flow record.

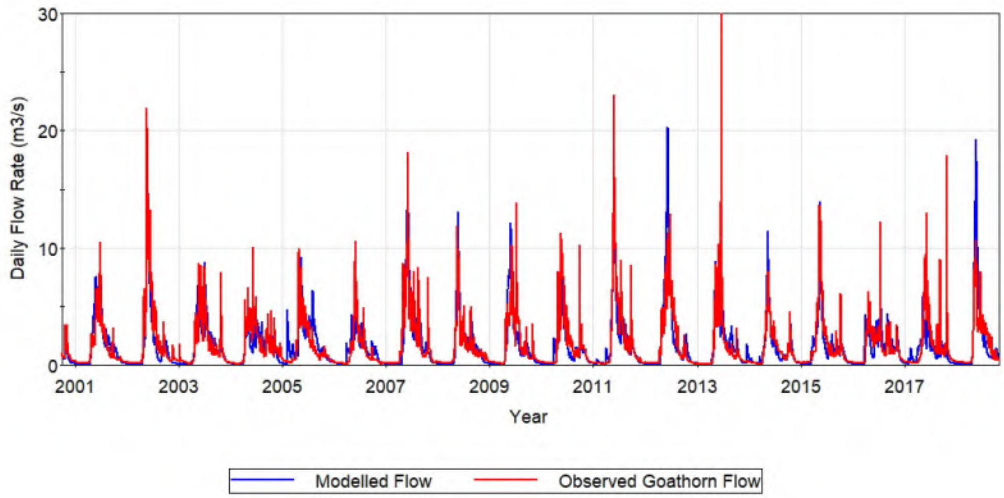


Figure 4-29: Rainfall-Runoff Model Calibration for Goathorn Creek

Source: Z:\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\500_Water_Balance\Model\RunoffCalibration\Telkwa_FlowCalibrationModel_Goathorn_v4_20200429.gsm

This process was repeated for Tenas Creek. Monthly runoff coefficients were calibrated automatically within GoldSim by optimizing the Nash Sutcliffe Efficiency, based on the difference between observed and modelled daily flow. Figure 4-30 illustrates the synthetic and modelled flows at the Tenas-Hydro B station from 2000 to 2019. Results produced an average Nash Sutcliffe Efficiency (NSE) of approximately 0.74. At this location, observed data is superimposed atop modelled flow for 2017 (Tenas-Hydro) and 2018 to 2019 (Tenas-Hydro B). The modelled flow record shows an underestimation of synthetic and measured flow at the Tenas-Hydro B location along Tenas Creek. Derivation of runoff coefficients was tested over multiple periods to ensure that the rainfall-runoff model flow results were as representative as possible. The rainfall-runoff model currently underestimates flows and should be revisited once more flow data is available from the Tenas-Hydro station.

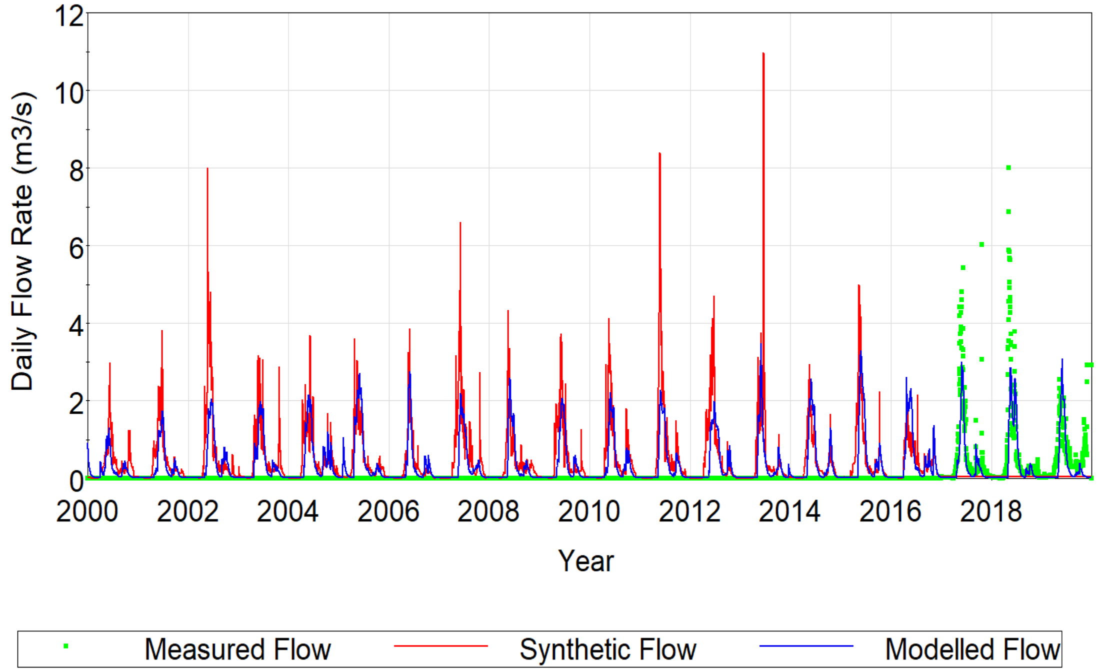


Figure 4-30: Rainfall-Runoff Model Calibration for Tenas-Hydro B

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\500_Water_Balance\Model\RunoffCalibration\Telkwa_FlowCalibrationModel_Tenas_v3_20200428.gsm

The Bulkley River rainfall-runoff model for 2000 to 2018 resulted in a NSE value of 0.72 (Figure 4-31). The flows produced by the Bulkley River rainfall-runoff model show good correspondence with the observed flows at the Water Survey of Canada hydrometric station. For most of the observed flow record spanning 2000 to 2018, the modelled flows match or exceed peak flows. In some years, the model underestimates peak flows although the hydrograph shape remains similar despite the difference in magnitudes.

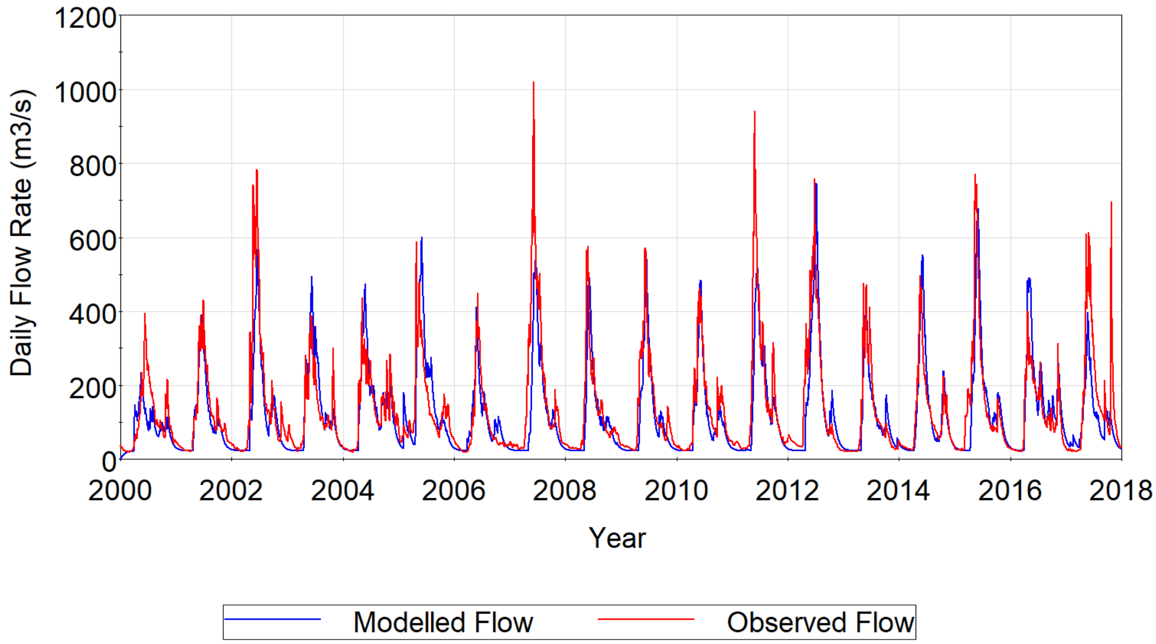


Figure 4-31: Rainfall-Runoff Model Calibration for Bulkley River

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\500_Water_Balance\Model\RunoffCalibration\Telkwa_FlowCalibrationModel_Bulkley_v2_2000-2018_20200421.gsm

The Telkwa-Hydro rainfall-runoff model is shown in Figure 4-32 for 2005 to October 2019 with a NSE of 0.82. The modelled flows correspond well with the synthetic flow record generated for the Telkwa-Hydro station. The synthetic and modelled flows are typically similar in both magnitude and shape although the modelled flow can recede more quickly post-freshet than the synthetic record leading to lower flows in early summer.

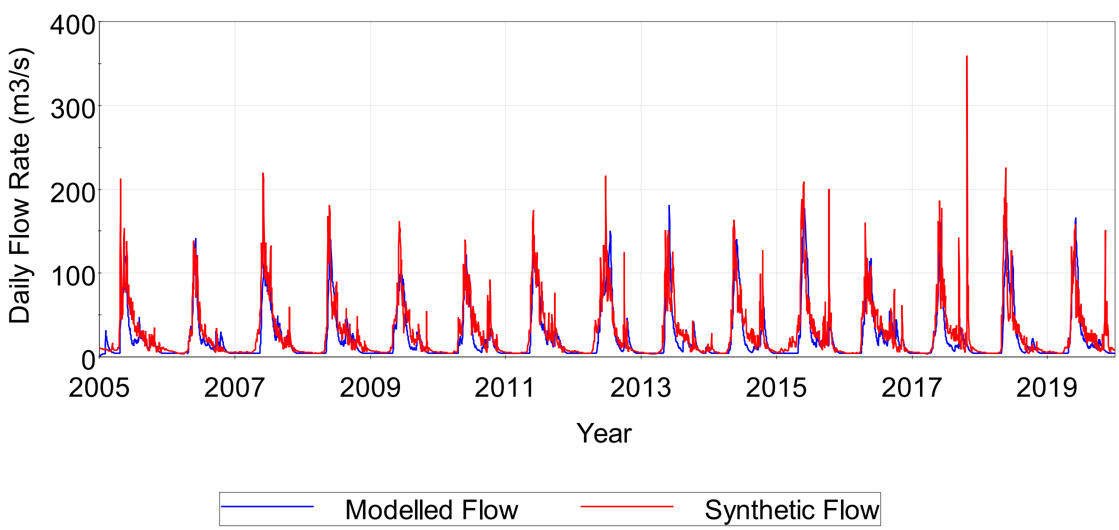


Figure 4-32: Rainfall-Runoff Model Calibration for Telkwa River

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\500_Water_Balance\Model\Telkwa_FlowCalibrationModel_Telkwa-Hydro_v3_20200430.gsm

Calibration of Four-Hydro was conducted using the available 2020 record, which includes partial extension with Goathorn Creek (08EE008), as described in Section 4.2.3. The continuous flow record in Four Creek from 1997 and 1998 did not include spring freshet (October and November 1997 and July through October 1998). For this reason, the data was not used in the model calibration. With only one year of flow record available, the monthly runoff coefficients are specific to the 2020 timing of freshet, which occurred at the end of April and receded throughout May. Figure 4-33 presents the modelled and measured Four-Hydro flows, as well as the synthetic flow based on Goathorn Creek (08EE008). Adjusted temperature for Four Creek suggests an earlier onset of freshet, as shown by the blue line in Figure 4-33, which is not captured in the available Four-Hydro record, which begins April 30th 2020. The remainder of the year experienced low flow, with minor peaks in response to rainfall events. Beyond October 23rd 2020, the model responds to two above-freezing temperature events coinciding with rainfall, which appears to have been observed at Goathorn Creek based on the synthetic record in red.

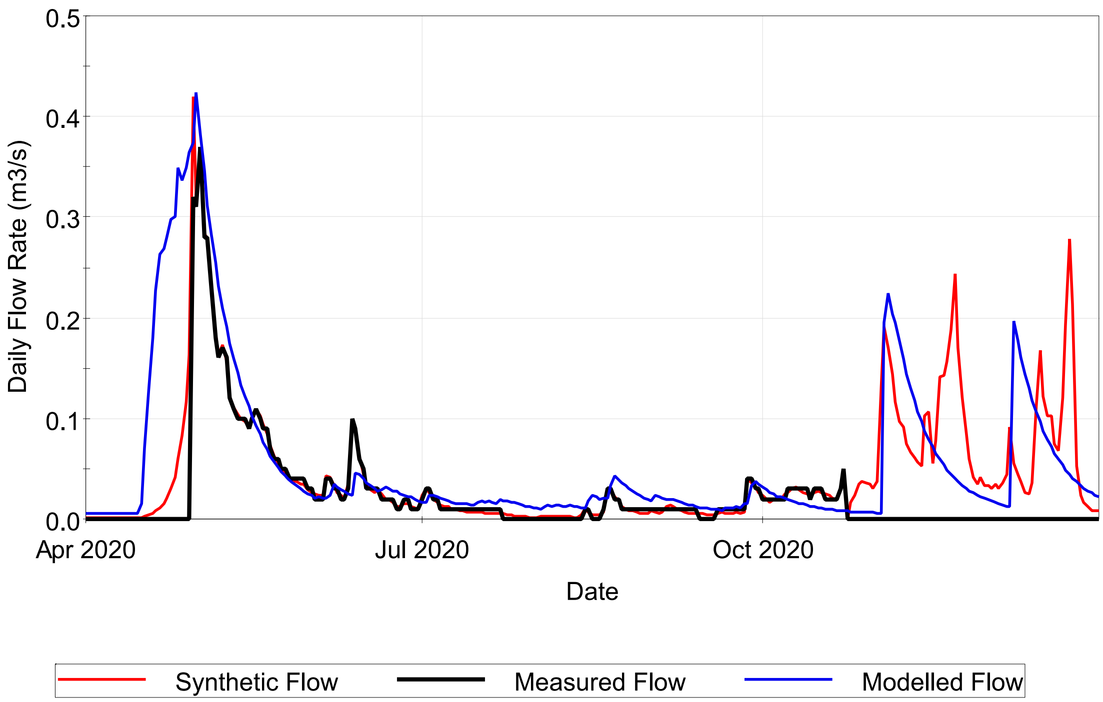


Figure 4-33: Rainfall-Runoff Model Calibration for Four Creek

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\500_Water_Balance\Model\ Telkwa_FlowCalibrationModel_Four_v1_20210218.gsm

Table 4-30 presents the calibrated parameters for each catchment with the average of Tenas and Goathorn results for runoff coefficients, recession value and baseflow parameters applied to the Project Area. Four Creek parameters were developed based on the 2020 monitoring dataset only and should be reviewed when additional data become available.

Table 4-30: Rainfall-Runoff Model Inputs

Location		Goathorn	Telkwa	Tenas	Bulkley	Four	Project
Minimum Unit Baseflow [L/s/km^2]		1.8	4.1	0.43	3.0	0.3	1.1
Lag Time [days]		1	1	1	1	1	1
Recession		0.9	0.92	0.91	0.96	0.90	0.905
Runoff Coefficient	January	1	1	1	1	1	1
	February	1	1	1	1	1	1
	March	1	1	1	1	1	1
	April	0.42	1	0.45	0.76	0.5	0.43
	May	0.27	0.83	0.32	0.50	0.01	0.30
	June	0.20	0.38	0.17	0.36	0.1	0.18
	July	0.46	0.59	0.09	0.88	0.05	0.28
	August	0.33	0.74	0.03	0.22	0.05	0.18
	September	0.29	0.54	0.19	0.48	0.08	0.24
	October	0.29	0.69	0.28	0.47	0.03	0.28
	November	0.56	0.5	0.88	0.81	0.9	0.72
	December	1	1	1	1	0.4	1

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\500_Water_Balance\Model\RunoffCalibration\Project_RunoffModel.gsm

The synthetic long-term Project precipitation and temperature records were incorporated to the snowmelt and runoff model to generate Project-specific runoff rates using the calibrated values from Tenas and Goathorn Creek. Figure 4-34 presents the monthly average runoff distribution based on the 70-year synthetic record (1949-2019), which produced a mean annual runoff (MAR) of 219 mm. Based on the mean annual precipitation calculated for the Project, the annual runoff coefficient is equal to 0.36.

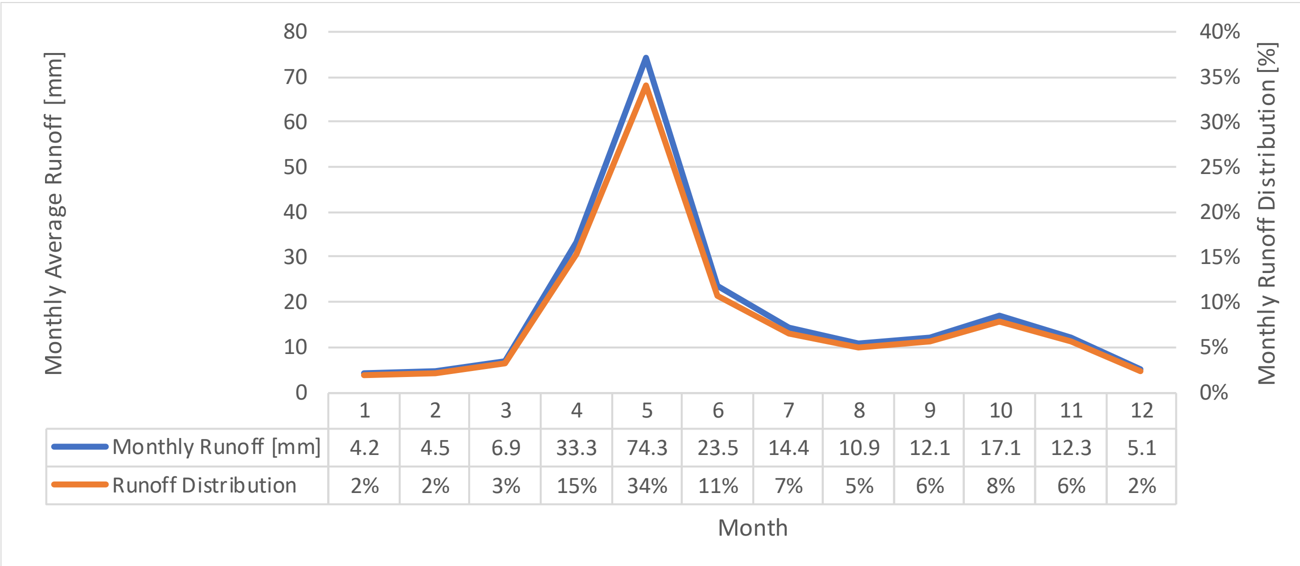


Figure 4-34: Project Area Monthly Average Runoff Depth [mm] and Distribution

Source: : \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\500_Water_Balance\Model\RunoffCalibration\ProjectRunoff_Results_10272020.xlsx

A frequency analysis was performed using the time series of annual runoff rates generated from the model, producing annual runoff rates associated with a range of exceedance probabilities. Multiple distributions were tested against the historical data, including the Normal, Log Normal, Gumbel, Log Pearson III, and GEV distributions, and the normal distribution was selected as the best statistical fit to observed data. Results of annual runoff for a range of return periods are presented in Table 4-30.

Table 4-31: Return Periods Calculated for Mean Annual Runoff

Hydrological Condition	Return Period [years]	Annual Runoff [mm]
Wet	1000	319
	500	312
	200	302
	100	294
	50	285
	25	275
	20	272
	10	260
	5	246
Mean Annual Runoff (MAR)		219
Dry	5	191
	10	177
	20	165
	25	162
	50	152
	100	143
	200	135
	500	125
	1000	118

Source: Z:\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\500_Water_Balance\Model\RunoffCalibration\ProjectRunoff_Results_10272020.xlsx

4.2.6 Baseflow Review

The calibrated rainfall-runoff model incorporates a constant baseflow value for each stream. Results of the calibration were compared against the monthly baseflow estimates calculated from the baseflow separation technique described in Section 4.3.4 and are presented in Figure 4-35. Note that due to the limited dataset for Four Creek, baseflow separation and comparisons for this stream were not available.

Points on the plot represent the constant and calibrated unit baseflow estimates for each stream, while lines show the monthly results from the baseflow separation model.

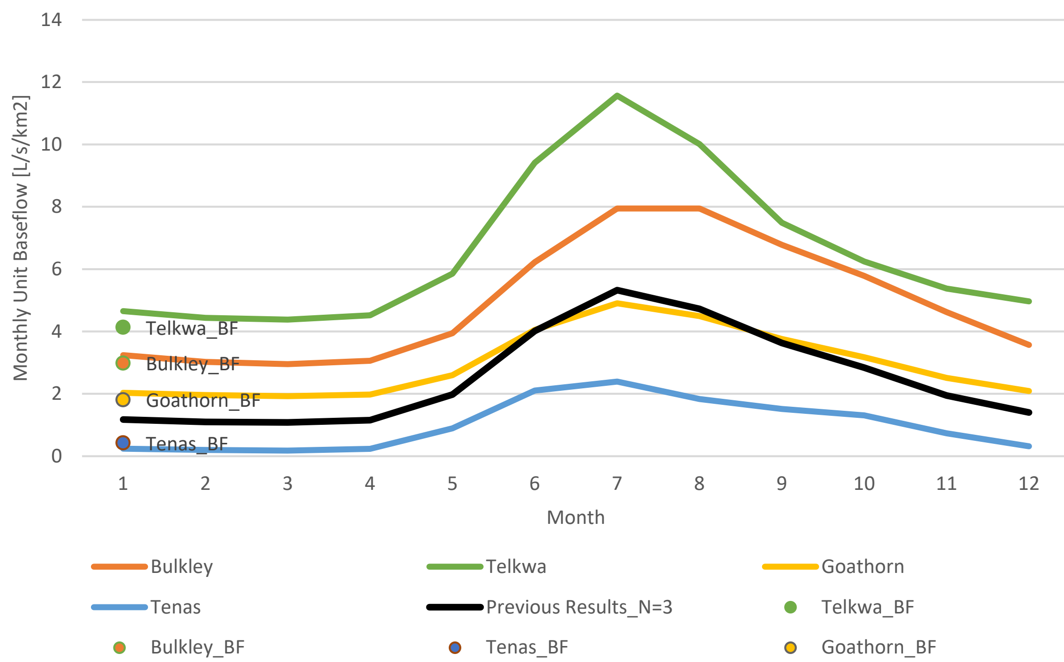


Figure 4-35: Comparison of Calibrated Unit Baseflows and Monthly Baseflow Separation Results

Source: Z:\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\BaseflowSeparation\UpdatedBaseflows_07212020_sab.xlsx

The constant calibrated baseflow estimates are representative of the winter and low flow monthly baseflow results from the baseflow separation. Based on the rainfall-runoff model used, the only time of year where the constant baseflow input is used is during winter months without rainfall or snowmelt. This is reasonable since the monthly runoff coefficients are calibrated to match flows in the open water season, and therefore account for baseflow contributions in their development.

The calibrated constant baseflow selected for Four-Hydro was compared against the available low-flow manual measurements collected in 2020, 2021 and presented in AGRA 1999, in the development of station rating cures. Measurements are presented in Table 4-32 and show that the selected model baseflow for Four Creek based on 2020 data is representative of the measured flows in July 2020 and may overestimate typical winter flow conditions.

Table 4-32: Four Creek Baseflow and Available Measurements Comparison

Measurement Details	Manual Measurement	Manual Measurement	Manual Measurement	Manual Measurement	Manual Measurement	SRK Rainfall-Runoff Model
Date	June 23 1998	July 28 2020	18 November 2020	15 December 2020	24 February 2021	n.a.
Unit Flow [L/s/km^2]	0.45	0.36	5.1	5.4	0.72	**0.3**

Source: Z:\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\FourCreek_Review\ Four-Hydro Rating Curve and Hydrograph 2020_njs_r1.xlsx

The calibrated constant unit baseflows were used in groundwater modeling calibration to develop base case estimates of baseflow.

4.2.7 Peak Flows

A peak flow analysis was performed for Tenas Creek, Goathorn Creek, and Telkwa River based on the synthetic records detailed in section 4.2.3. The Bulkley River peak flow analysis was based on the extended records from WSC Bulkley River at Quick 08EE004 hydrometric station. Table 4-33 presents the unit peak-flows for each identified stream.

Tenas Creek statistics were applied to Four Creek for the purpose of the EA.

Table 4-33: Unit Peak Flows from Extended Records [L/s/km^2]

Return Period [years]	Goathorn-Hydro (Synthetic)	Telkwa-Hydro (Synthetic)	Tenas-Hydro B (Synthetic)	WSC Bulkley River at Quick 08EE004
1000	388	620	1,067	165
500	356	516	884	160
200	313	404	691	153
100	280	336	574	147
50	248	278	478	140
25	215	230	398	133
20	205	216	376	130
10	172	178	313	122
5	140	144	260	111
2	98	105	198	91

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Flows_update_rev11.Rmd

4.2.8 Low Flows

A low flow analysis was performed for Tenas Creek, Goathorn Creek and Telkwa River based on the synthetic records detailed in section 4.3.3. The Bulkley River low flow analysis was based on the extended records from WSC Bulkley River at Quick 08EE004 station. Table 4-34 presents the day low-flows for each identified stream.

Low flow statistics calculated at Tenas Creek were applied to Four Creek for the purpose of the EA.

Table 4-34: 7-Day Low Flows from Extended Records [L/s]

Return Period [years]	Goathorn-Hydro (Synthetic)	Tenas-Hydro B (Synthetic)	Telkwa-Hydro (Synthetic)	WSC Bulkley River at Quick 08EE004
2	269	10.0	4,220	22,743
5	234	5.1	3,655	17,373
10	218	3.7	3,381	15,090
20	206	3.0	3,166	13,413
25	202	2.8	3,105	12,955
50	193	2.5	2,934	11,711
100	186	2.3	2,785	10,671
200	179	2.1	2,653	9,778
500	172	2.1	2,499	8,761
1000	167	2.0	2,393	8,087

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Flows_update_rev11.Rmd

Seven-day low flows for a 10 year return period (7Q10) were also computed for Tenas Creek, Goathorn Creek and Telkwa River during each month of the synthetic records. Table 4-35 and Table 4-36 present the 7Q10 results for these series as low flows and unit low flows respectively.

Table 4-35: 7-day Low Flows for 10-year Return Period for Synthetic Records (m^3/s)

Station Name	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Ann.
Goathorn-Hydro (Synthetic)	0.24	0.24	0.23	0.26	0.99	1.9	1.2	0.70	0.51	0.49	0.32	0.27	0.22
Telkwa-Hydro (Synthetic)	4.2	3.7	3.4	3.7	15	40	25	15	6.7	6.8	5.6	3.4	3.4
Tenas-Hydro B (Synthetic)	0.01	0.004	0.005	0.016	0.34	0.64	0.20	0.11	0.07	0.12	0.036	0.10	0.004

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\ Flows_update_rev11.Rmd

Table 4-36: 7-day Unit Low Flows for 10-year Return Period Flows for Synthetic Records (L/s/km²)

Station Name	Area (km²)	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Ann.
Goathorn-Hydro (Synthetic)	123.5	1.94	1.94	1.86	2.11	8.02	15.4	9.72	5.67	4.13	4.00	2.59	2.19	1.78
Telkwa-Hydro (Synthetic)	966.9	4.34	3.83	3.52	3.83	15.5	41.4	25.9	15.5	6.93	7.03	5.79	3.52	3.52
Tenas-Hydro B (Synthetic)	46.75	0.150	0.0856	0.107	0.342	7.27	13.7	4.28	2.35	1.50	2.57	0.770	2.14	0.0856

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\ Flows_update_rev11.Rmd

5 Climate Change

The section below discusses climate change trends and effects that may impact the Project. This analysis was completed for temperature and precipitation, and incorporated into the evaporation and streamflow models discussed in Section 4.

5.1 Climate Change Methodology

Climate change assessment for the Project was completed using the fifth version of the Coupled Model Intercomparison Project (CMIP5). The purpose of CMIP5 is to provide a database of global coupled ocean-atmosphere general circulation model simulations using standardized boundary conditions and provide simulations for the Intergovernmental Panel on Climate Change (IPCC) fifth Assessment Report (AR5).

Climate change scenarios were evaluated considering three different Representative Concentration Pathways (RCP 2.6, 4.5 and 8.5). The RCPs are defined based on how much greenhouse gases are expected to be emitted in the years to come where the possible range of radiative forcing values for RCP 2.6, RCP 4.5 and RCP 8.5 by year 2100 is 2.6, 4.5 and 8.5 W/m² respectively. These three scenarios are among the RCPs adopted by the IPCC for the AR5 and assume that global anthropogenic forces are not constant in time (IPCC 2014).

Environment Canada (ECCC) provides access to monthly gridded global climate data (precipitation and air temperature) from 29 CMIP5 models for the period of 1900 – 2100, with historical results from 1900 to 2005 and forecast results from 2006 to 2100. The median response of the ensembled models, for each RCP, is also provided and was used for this analysis. Note that the CMIP5 ensemble results do not differentiate between emission scenarios (RCPs) prior to 2006. Data for the Tenas Project location were obtained and processed by SRK to evaluate predicted trends up to year 2100, deemed the maximum reasonable prediction range (IPCC 2014).

The Pacific Climate Impacts Consortium (PCIC 2014) attach no probability or likelihood of occurrence to the different RCPs and leave it up to each designer/stakeholder to judge. Table 5-1 summarizes the rationale adopted for the Project for selecting RCP4.5 as the most representative for climate change based on guidance provided by Baisley (2016).

Table 5-1: Adopted RCP Qualitative Probabilities

Scenario	Likelihood	Reasoning
RCP2.6	Very Unlikely	Emission values are relative to pre-industrial levels requiring stringent global climate change policies to limit emissions.
RCP4.5	Very Likely	Current proposed climate change policies are achieved.
RCP8.5	Very Unlikely	Continue current trend of increasing emissions without applying any climate change policies.

The following sections present the climate change analysis for mean annual and monthly air temperature as well as mean annual and monthly precipitation. Changes to lake evaporation were also assessed based on the temperature climate change forecasts.

5.2 Climate Change Effects to Temperature

5.2.1 Annual Temperature Trends

Projected climate change effects were evaluated on an annual basis, relative to a defined baseline period for three consecutive 30-year forecast periods, defined as follows:

- Baseline period from 1981 to 2010 (CMIP5), centred on 1995
- First forecast period from 2011 to 2040 (CMIP5), centred on 2025
- Second forecast period from 2041 to 2070 (CMIP5), centred on 2055
- Third forecast period from 2071 to 2100 (CMIP5), centred on 2085

Figure 5-1 presents the mean annual air temperature (MAAT) from the Project record during the baseline period, as well as the historical CMIP5 ensemble results over the same period and the forecasted MAAT for the three different RCP scenarios.

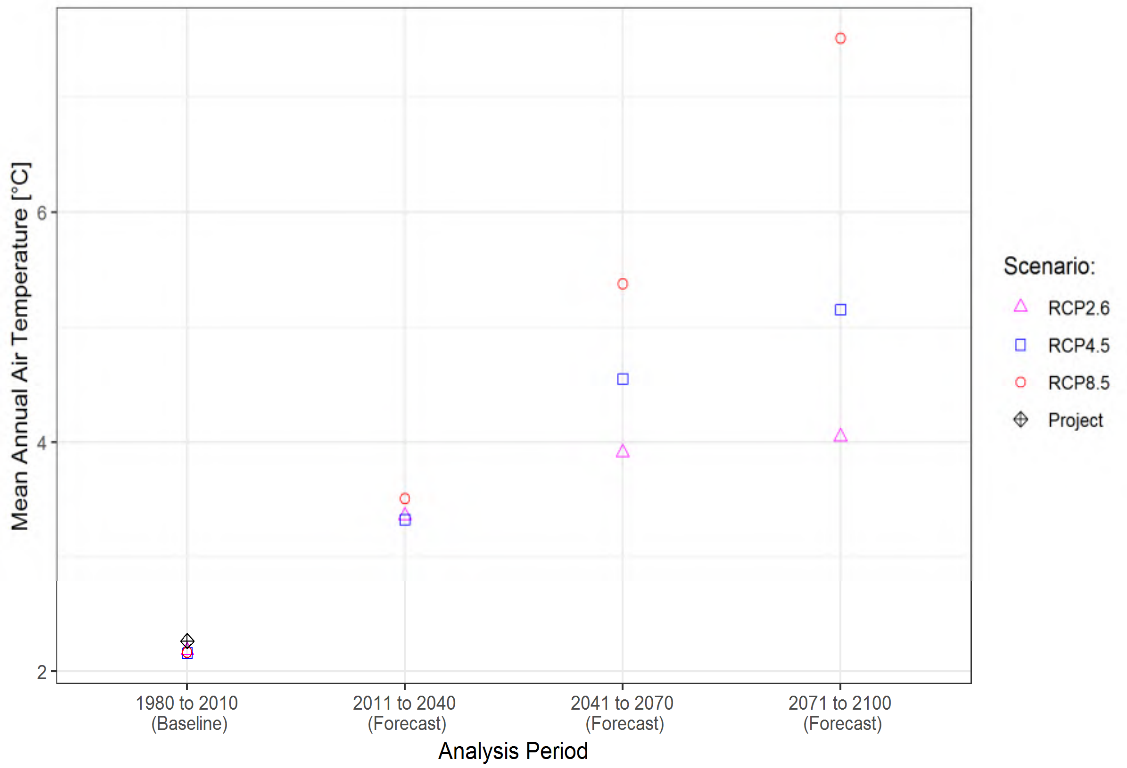


Figure 5-1: Forecast of Climate Change Effect on Mean Annual Air Temperature

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Climate_Change_rev03.Rmd

Table 5-2 presents the rates of change relative to the baseline results for the three RCPs up to year 2100 using CIMP5 ensemble data.

Table 5-2: MAAT Increase from Baseline

Timeframe	RCP 2.6	RCP 4.5	RCP 8.5
2011-2040	1.2°C	1.2°C	1.3°C
2041-2070	1.7°C	2.4°C	3.2°C
2071-2100	1.9°C	3.0°C	5.3°C

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Climate_Change_rev03.Rmd

Based on the ensembled median data, the mean annual temperature for the Project is expected to increase by 2°C to 5°C by year 2100.

5.2.2 Monthly Temperature Rates of Change

Monthly impacts to temperature as a result of climate change were evaluated using the same methodology as described above. RCP 4.5 projections are shown below.

Table 5-3 presents the monthly change in temperature relative to monthly baseline data for the RCP 4.5 up to year 2100 using CIMP5 ensemble data.

Table 5-3: Monthly Average Temperature Increase from Baseline for RCP 4.5 (in °C)

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
2011-2040	1.25	1.23	1.16	1.13	1.35	1.44	1.35	1.21	1.00	0.97	1.02	0.86	**1.2**
2041-2070	2.89	2.16	2.42	2.30	2.60	2.51	2.45	2.39	2.11	2.07	2.26	2.48	**2.4**
2071-2100	3.45	2.79	3.01	3.04	3.14	3.13	3.24	2.99	2.72	2.56	2.85	2.97	**3.0**

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Climate_Change_rev03.Rmd

Results show a consistent increase in temperature for all months and can be applied to the monthly average temperature data for the Project.

5.3 Climate Change Effects to Precipitation

5.3.1 Annual Precipitation Trends

As with temperature, projected climate change effects were evaluated relative to a defined baseline period for three consecutive 30-year forecast periods, defined as follows:

- Baseline period from 1981 to 2010 (CMIP5), centred on 1995
- First forecast period from 2011 to 2040 (CMIP5), centred on 2025
- Second forecast period from 2041 to 2070 (CMIP5), centred on 2055
- Third forecast period from 2071 to 2100 (CMIP5), centred on 2085

Figure 5-2 illustrates the mean annual precipitation (MAP) from the Project record during the baseline period, as well as the historical CMIP5 ensemble results over the same period, and the forecasted forecast MAP for the three different RCP scenarios.

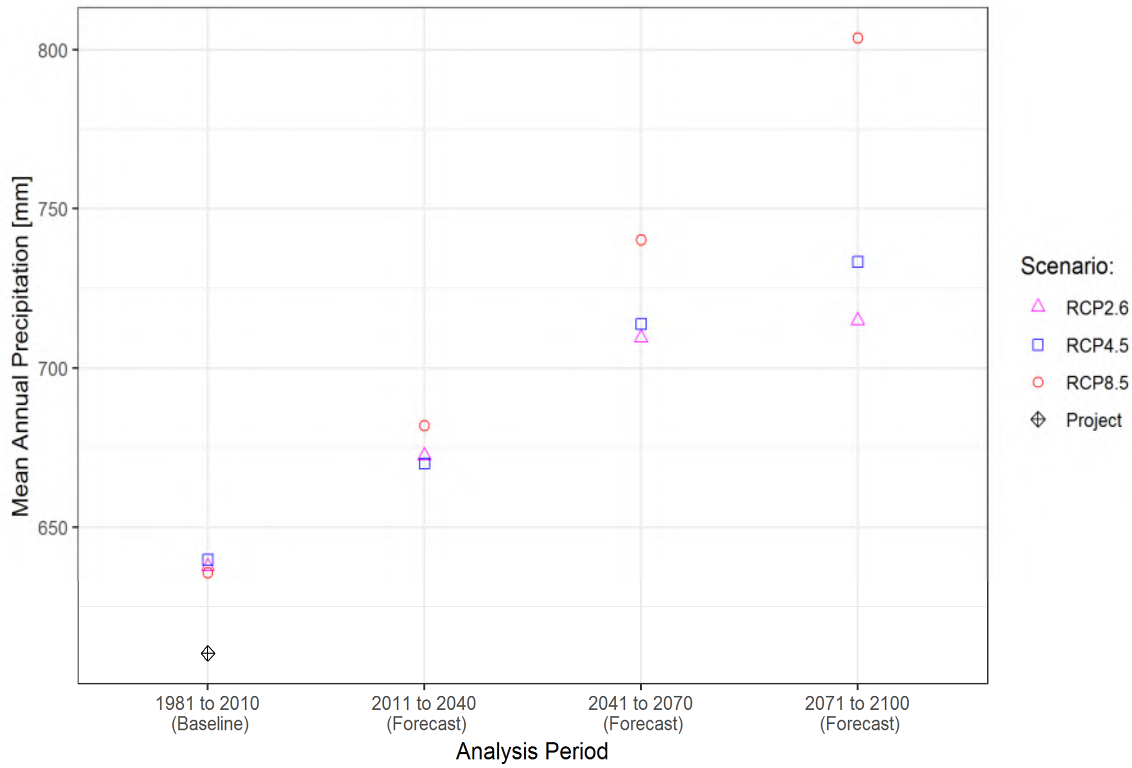


Figure 5-2: Forecast of Climate Change Effect on Mean Annual Precipitation

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Table 5-4 presents the percent increase of mean annual precipitation for the three RCPs up to 2100.

Table 5-4: Mean Annual Precipitation Percent Increase from Historical Baseline Average

Timeframe	RCP 2.6	RCP 4.5	RCP 8.5
2011-2040	+5%	+5%	+7%
2041-2070	+11%	+12%	+16%
2071-2100	+12%	+15%	+26%

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Climate_Change_rev03.Rmd

Based on the ensembled median data, the mean annual precipitation for the Project is expected to increase by 75 mm to 175 mm by year 2085.

5.3.2 Monthly Precipitation Rates of Change

Monthly impacts to precipitation as a result of climate change were evaluated using the same methodology as described above. RCP 4.5 projections are shown below.

Table 5-5 presents the monthly rate of change to precipitation relative to monthly baseline data for the RCP 4.5 up to year 2100 using CIMP5 ensemble data.

Table 5-5: Monthly Average Precipitation Variation from Baseline for RCP 4.5 (in %)

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
2011-2040	5%	7%	6%	0%	14%	2%	1%	-1%	5%	7%	4%	3%	**+5%**
2041-2070	12%	8%	14%	14%	34%	33%	-5%	0%	10%	12%	11%	12%	**+12%**
2071-2100	12%	11%	16%	9%	48%	23%	-23%	2%	14%	18%	16%	18%	**+15%**

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Climate_Change_rev03.Rmd

Results indicate a net increase in precipitation for all months except July and August, which are expected to decrease to 2070, after which August will begin to increase and July will continue to decrease through 2100. Rates of change can be applied to the monthly average precipitation rates for the Project.

5.3.3 Extreme Precipitation with Climate Change

Extreme precipitation under climate change conditions was estimated using the IDF_CC Tool (Version 3) (ICLR 2018), similarly to the baseline depth-duration-frequency curve, for return periods 2 to 100 years (Table 4-9).

Depth-duration-frequency curves for the Project with climate change were developed using bias corrected RCP4.5 GCMs for the time-period 2006 to 2100 as summarized in Table 5-6.

Table 5-6: Project Depth-Duration-Frequency Curves with Climate Change (Precipitation Depth – mm)

Duration (min)	Return Period							
	2	**5**	**10**	**25**	**50**	**100**	**200**	**1000**
5	4.7	7.3	8.9	10.5	11.8	12.7	15.7	19.7
10	6.7	10.4	12.8	15.3	17.3	18.8	23.4	29.2
15	8.1	12.3	14.9	17.4	19.5	20.9	25.8	32.2
30	11.3	16.5	19.5	22.4	24.7	26.1	32.0	40.0
60	15.4	22.7	26.9	30.9	33.9	35.7	43.6	54.6
120	20.1	29.0	33.9	38.2	41.6	43.3	52.3	65.8
360	32.8	45.9	52.2	56.7	59.8	61.6	72.3	91.5
720	40.4	57.7	67.0	75.0	81.2	84.3	101.4	127.5
1,440	49.2	70.6	84.2	98.4	110.6	119.7	150.7	187.0

Source: Z:\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\300_Hydrology_Update\Telkwa_CNFlowCalibration_gmj_sab_rev06.xlsm

Note(s):

1. RCP4.5 was chosen as the most likely scenario for the Project.

5.4 Climate Change Effects to Lake Evaporation

Changes to lake evaporation were assessed by updating the Morton CRWE methodology described in Section 4.3.6 with the temperature changes obtained for RCP 4.5 and presented in Table 5-5. The maximum temperature, minimum temperature and dew temperature Project time series were updated using the same net increase rates. Note that the model did not apply a climate change adjustment to solar radiation. Table 5-7 presents the monthly rates of change relative to the baseline lake evaporation for RCP 4.5 up to year 2100.

Table 5-7: Monthly Lake Evaporation Variation from Baseline for RCP 4.5 (in %)

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
2011-2040	1%	1%	3%	3%	3%	4%	3%	3%	3%	1%	1%	1%	**+2%**
2041-2070	2%	2%	6%	6%	6%	6%	6%	6%	6%	2%	2%	2%	**+4%**
2071-2100	2%	3%	7%	8%	8%	8%	8%	8%	8%	2%	2%	2%	**+5%**

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Climate_Change_rev03.Rmd

Results indicate a net increase in lake evaporation for all months of the year and can be applied to the Project monthly evaporation rates.

5.5 Climate Change Effects to Streamflow

The calibrated rainfall-runoff model was updated to include the projected rates of change to temperature and precipitation. Calibrated monthly runoff coefficients and baseflow values were incorporated for each major stream. Monthly flows from historic climate were compared against monthly flows projected in 2100 based on the monthly climate change variability.

The runoff model was simulated for 100 realizations under historic conditions and projected climate change conditions (year 2100). The 50th percentile (median), 10th percentile (low flow) and 90th percentile (high flow) statistics were extracted from the realization record, and are compared in each creek for historic conditions versus 2100 climate change conditions.

Historic monthly streamflow for each percentile and both historic and climate change conditions are presented in Figure 5-3 for Goathorn Creek, Figure 5-4 for Tenas Creek, Figure 5-5 for Telkwa River, Figure 5-6 for Bulkley River and Figure 5-7 for Four Creek, where dashed lines represent climate change conditions and solid lines represent historic conditions, for a range of percentiles shown in different colours.

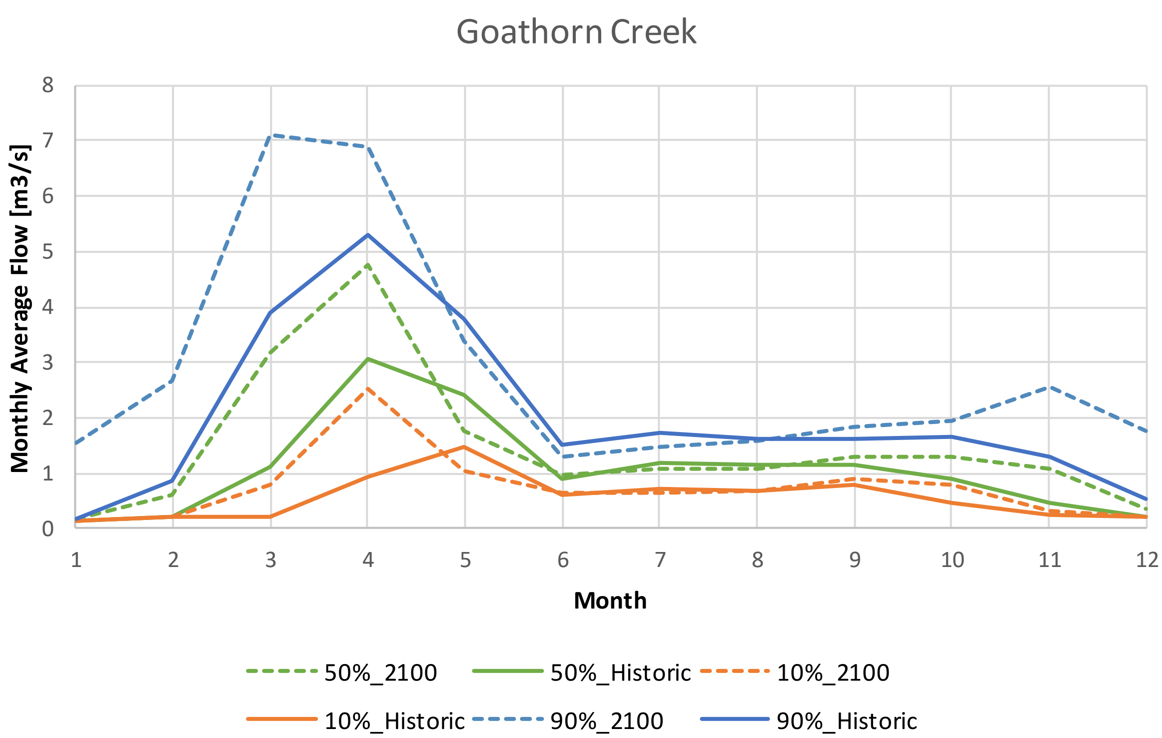

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Figure 5-3: Goathorn Creek Monthly Streamflow Summary for Historical Conditions and Climate Change Conditions in 2100 with RCP 4.5

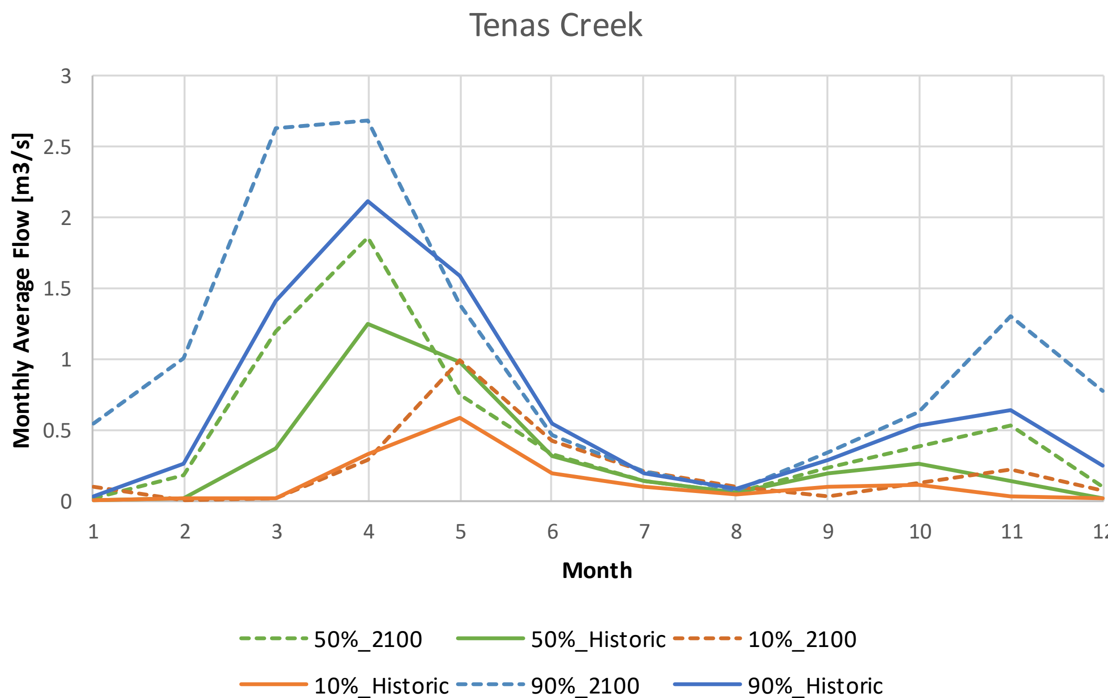

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Figure 5-4: Tenas Creek Monthly Streamflow Summary for Historical Conditions and Climate Change Conditions in 2100 with RCP 4.5

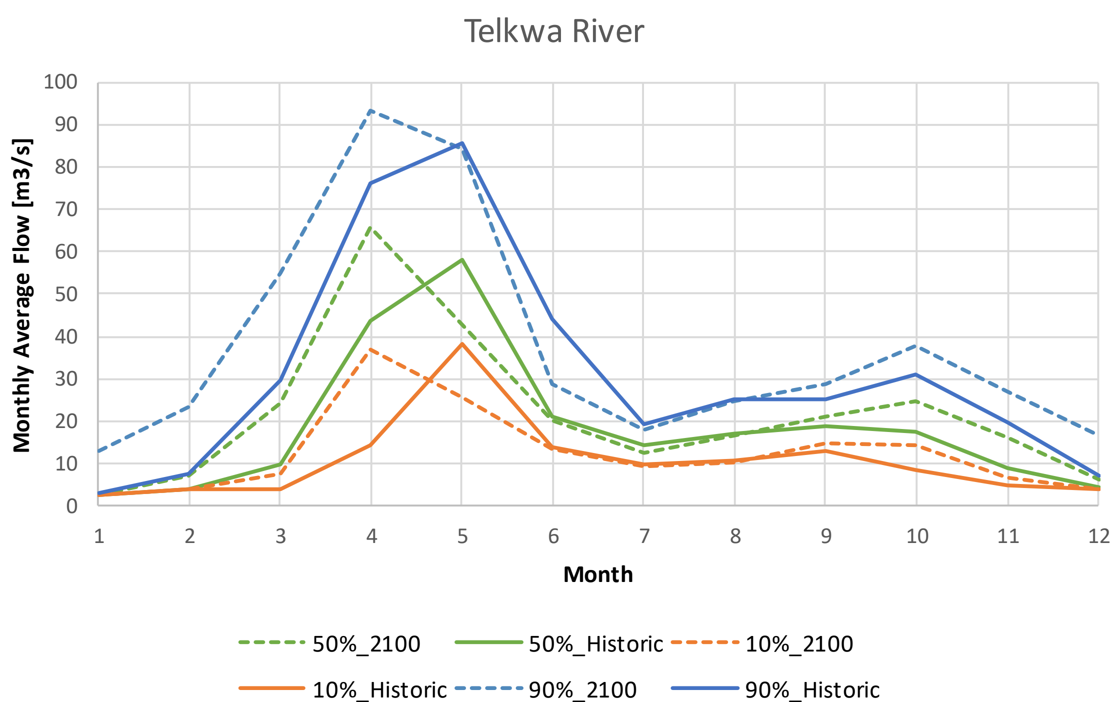

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Figure 5-5: Telkwa River Monthly Streamflow Summary for Historical Conditions and Climate Change Conditions in 2100 with RCP 4.5

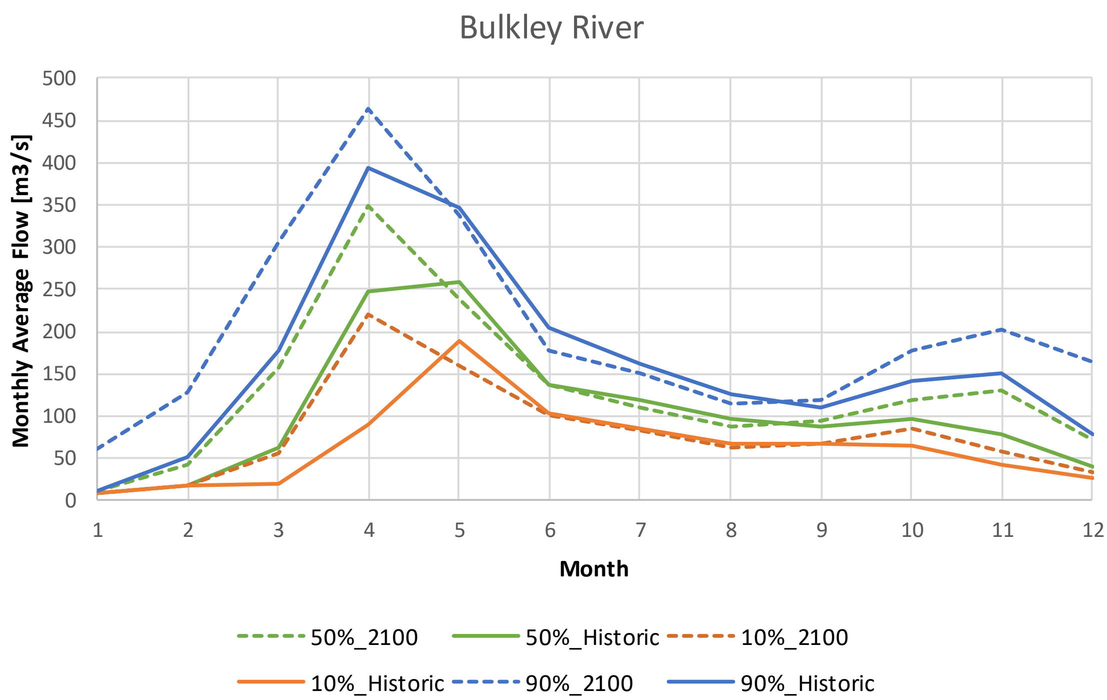

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Figure 5-6: Bulkley River Monthly Streamflow Summary for Historical Conditions and Climate Change Conditions in 2100 with RCP 4.5

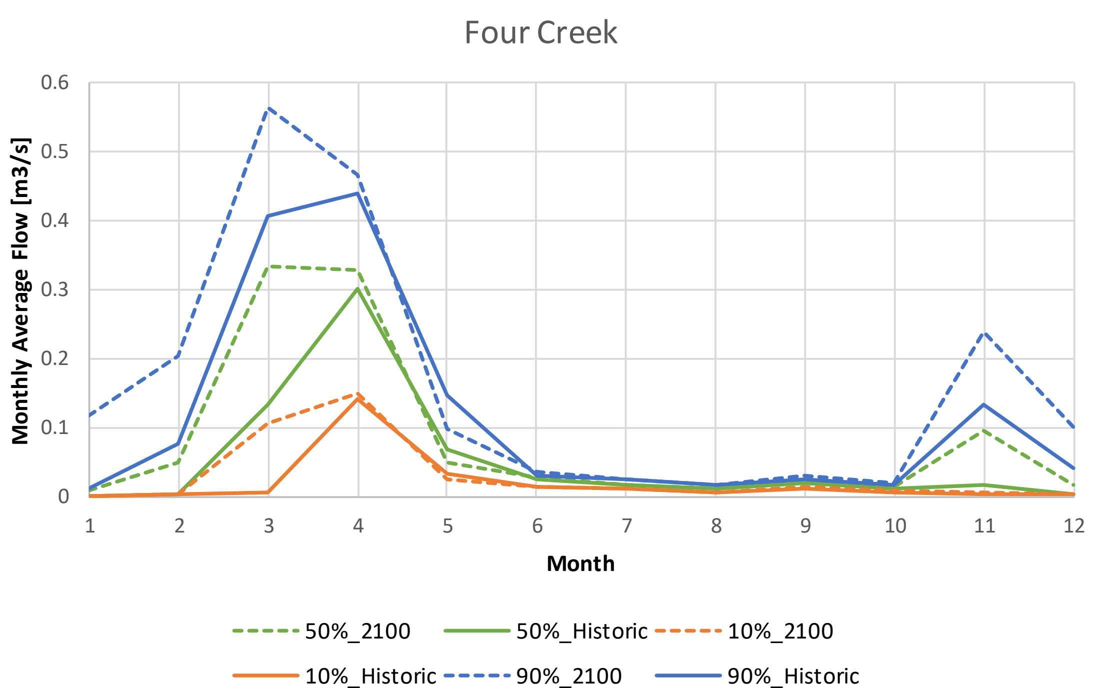

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Figure 5-7: Four Creek Monthly Streamflow Summary for Historical Conditions and Climate Change Conditions in 2100 with RCP 4.5

The general tendency when comparing historic and climate change monthly streamflow is an overall increase in flow magnitude and a shift to an earlier spring freshet. These observations coincide with the climate change projections in Table 5-5, showing a 15% in annual precipitation by 2100 under RCP 4.5, and a 48% increase in precipitation in May.

Note that the runoff model relies on a constant unit baseflow value for each river, which was not adjusted for climate change in these predictions. Precipitation is anticipated to decrease during the drier summer months (namely July), which, in combination with the higher evaporation rates in Table 5-7, would be expected to decrease streamflow during the low-flow summer period.

In addition, the changes to seasonality and snowmelt timing would also affect the runoff coefficients. The calibrated runoff coefficients were based on the historical flow regime, which coincides with a spring freshet in May, or April in the case of the Four Creek model for 2020 data. The monthly runoff coefficients could also be affected by climate change and are an additional limitation of this evaluation approach.

5.5.1 Peak Flow Trends

A trend analysis was carried out by SRK to identify trends and significance of trends for the peak flows from historical records. Ordinary least squares method, and quantile regression method were employed for statistical evaluation of the data. The non-parametric Mann-Kendall (MK) (1945) and Theil-Sen (Thiel 1950, Sen 1968) methods, the Prewhitening MK (Zhang 2001) method, and the Prewhitening MK (Yue et al. 2002) method were used for trend analysis. Where a trend was observed (upward or downward), its significance was evaluated. Trends with a significance greater than 95% are accepted as significant.

Goathorn Creek Peak Flow Historical Trend Analysis

Figure 5-8 represents yearly peak flows at the Goathorn WSC station from the extended timeseries, and its linear approximation equation obtained with the ordinary least squares method. Table 5-8 summarizes the results of the Goathorn peak flow trend statistical significance Mann-Kendall tests. No significant trend is observed for all three tests.

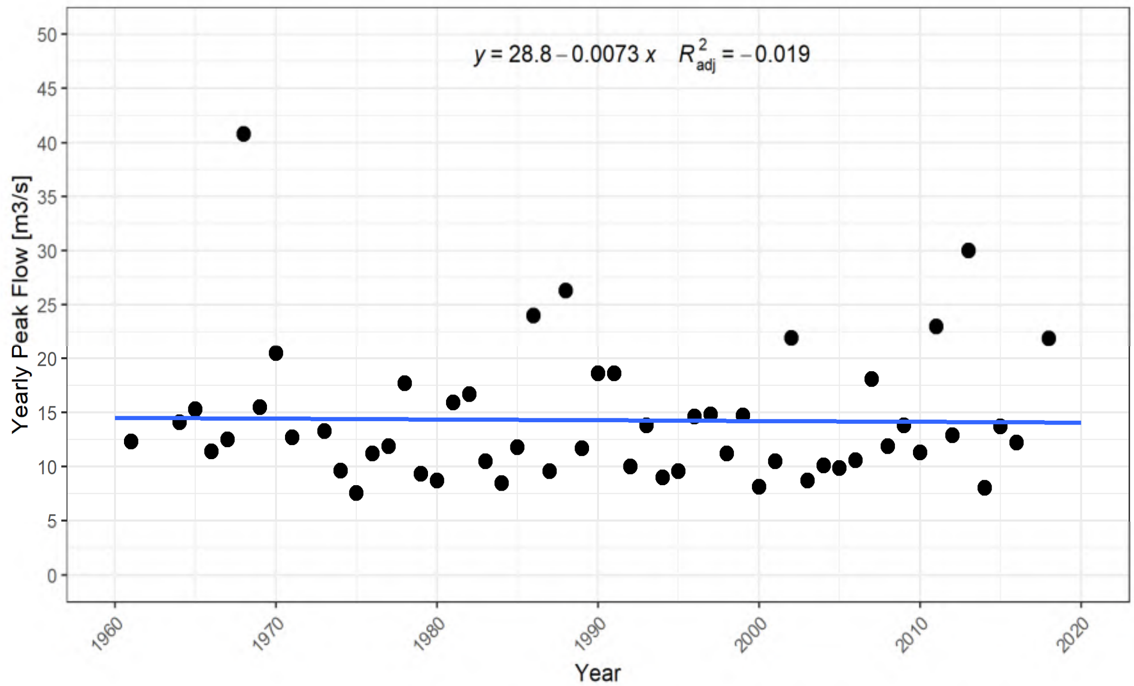

Figure 5-8: Goathorn Peak Flows Trend from 1960 to 2018

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Table 5-8: Mann-Kendall Significance test results for Goathorn Peak Flows

Method	Comment	Significance (%)
MK & Theil-Sen	No Significant Trend	53.3
Prewhit. MK, Zhang	No Significant Trend	53.3
Prewhit. MK, Yue & Pilon	No Significant Trend	59.9

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Flows_Climate_Change.html"

Telkwa River Peak Flow Historical Trend Analysis

Figure 5-8 represents yearly peak flows at the Telkwa WSC station from the extended timeseries, and its linear approximation equation obtained with the ordinary least squares method. Table 5-9 summarizes the results of the Telkwa peak flow trend statistical significance Mann-Kendall tests. No significant trend is observed for all three tests.

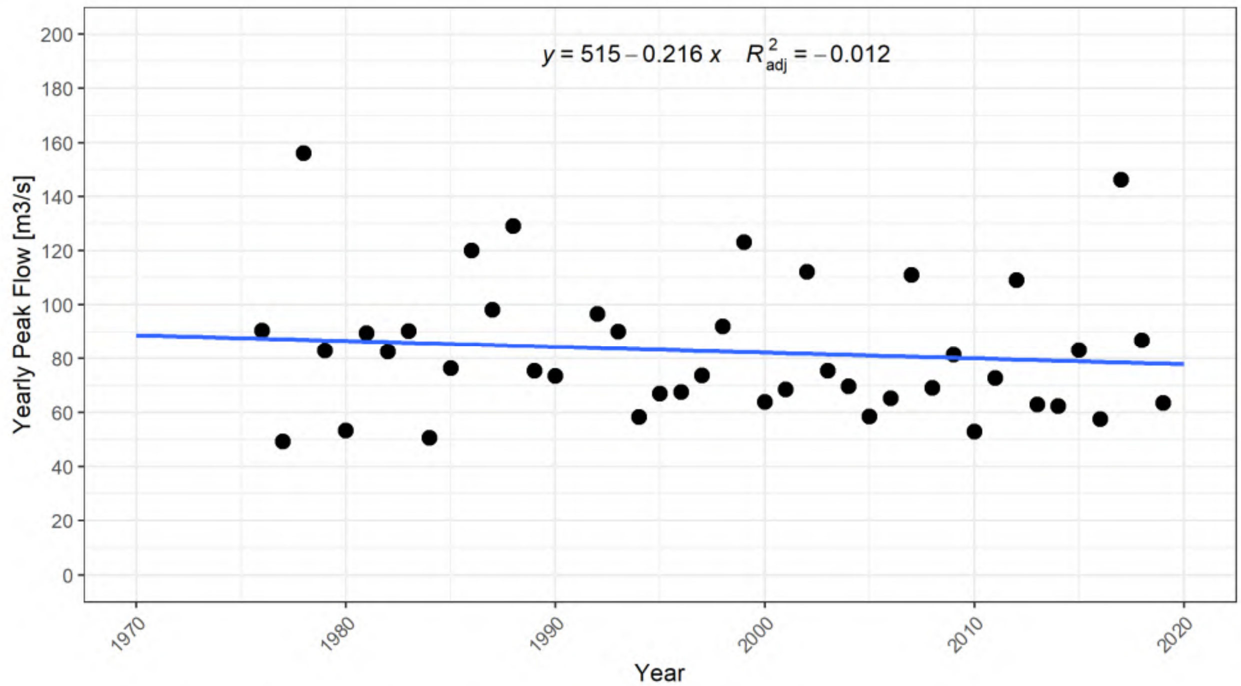


Figure 5-9: Telkwa Peak Flows Trend from 1976 to 2019

Source: from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Flows_Climate_Change.html"

Table 5-9: Mann-Kendall Significance test results for Telkwa Peak Flows

Method	Comment	Significance (%)
MK & Theil-Sen	No Significant Trend	88.4
Prewhit. MK, Zhang	No Significant Trend	88.4
Prewhit. MK, Yue & Pilon	No Significant Trend	83.7

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Flows_Climate_Change.html"

Bulkley River Creek Peak Flow Historical Trend Analysis

Figure 5-8 represents yearly peak flows at the Bulkley River at Quick WSC station from the extended timeseries, and its linear approximation equation obtained with the ordinary least squares method. Table 5-10 summarizes the results of the Bulkley River peak flow trend statistical significance Mann-Kendall tests. No significant trend is observed for all three tests.

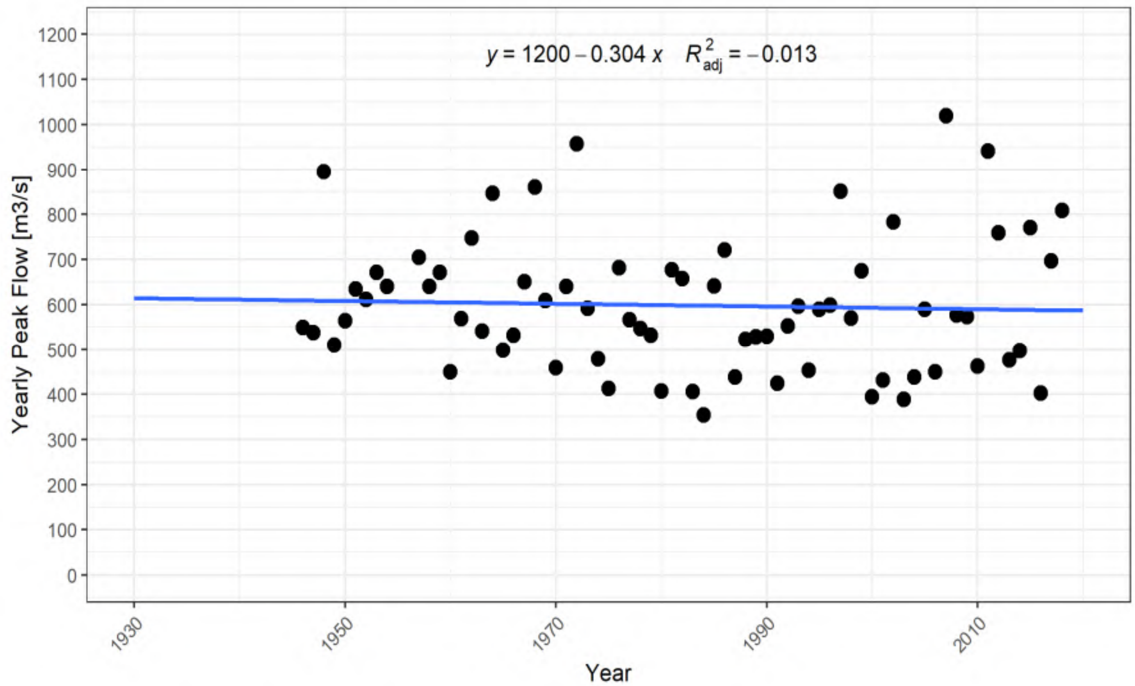


Figure 5-10: Bulkley River Peak Flows Trend from 1976 to 2019

Source: from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Flows_Climate_Change.html"

Table 5-10: Mann-Kendall Significance test results for Bulkley River Peak Flows

Method	Comment	Significance (%)
MK & Theil-Sen	No Significant Trend	77.5
Prewhit. MK, Zhang	No Significant Trend	77.5
Prewhit. MK, Yue & Pilon	No Significant Trend	78.6

Source: compiled in text from R code \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\200_Meteorology_Update\R work\Telkwa_EA_Flows_Climate_Change.html"

In all streams evaluated, no significant change in peak flow magnitude has been observed historically. This is not to say that a change in peak flows may not occur with projected climate change. Variations with respect to snowmelt timing and rainfall depth may result in higher peaks in the future, however the effects of a thinner snowpack should also be considered. Peak flow models for the purpose of engineering design should incorporate both snowmelt events and climate change depth-duration-frequency rainfall tables presented in Table 5-6.

6 Conclusions and Limitations

Regional analyses coupled with a compilation of Project-specific meteorological and hydrometric datasets were used to develop Project specific hydrometeorological baseline parameters, including long-term temperature and precipitation records. Climate change impacts for three RCP scenarios were considered for temperature, precipitation and evaporation and are presented in terms of monthly and annual rates of change. Results from this study will be used as inputs to Project designs and EA modeling, including the water and load balance model, groundwater model, and design of water management infrastructure.

Provisional Water Survey of Canada flow records were used for Goathorn Creek, Telkwa River and Bulkley River in the development of calibrated rainfall-runoff models. Provisional records may change when officially published.

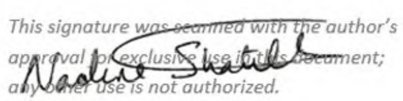
Available Four Hydro data for 2020 were analysed, along with data collected as part of baseline monitoring in 1997 and 1998. Due to the limited period of record, there is still significant uncertainty regarding Four Creek hydrology. Ongoing monitoring and validation of presented hydrologic indices is required.

The calibrated rainfall runoff model established to support the water and load balance model and runoff estimates for the hydrometric stations underestimates flows in Tenas Creek. This model should be revisited once more flow data is available at Tenas Hydro. However for the purpose of the EA, an underestimated runoff result is more conservative in terms of dilution capacity. Review of the Four-Hydro regressions with Goathorn Creek (08EE008) and calibration model should be performed after an additional year of monitoring data become available.

It is strongly suggested that this study be revisited and that the model be recalibrated when longer Project data records are available from the meteorological station as well as the hydrometric stations, and when all WSC flow data are published (*i.e.,* not provisional). The correlations between meteorological parameters measured at the Tenas Deposit Station and the regional stations should be improved by assessing a longer period of Project record from the Tenas Deposit Station. An initial analysis of the precipitation record showed that recent years (2017 to 2019) were drier than average, which may create bias in the extended Project precipitation record. Complete water years (from October to September of the following year) are critical in any assessment of the hydrological regime and longer flow data series will improve streamflow regressions and provde a robust calibration dataset.

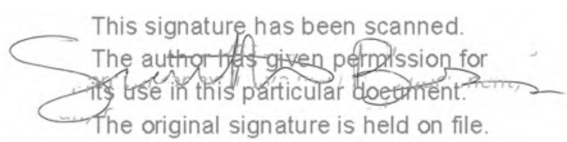
This report, Tenas Hydrometeorological Baseline Report, was prepared by

Camilo Gallard, EIT
Consultant



Nadine Shatilla, PhD,
Consultant

and reviewed by



Samantha Barnes, P.Eng
Senior Consultant

Michael Dabiri, P.Eng
Senior Consultant

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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Appendix A: AGRA 1999 Report

received April 5/2000

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

AGRA Earth & Environmental Limited
Box 3966
#3, 3167 Tatlow Road
Smithers, BC
Canada V0J 2N0
Tel (250) 847-8783
Fax (250) 847-9049

March 28, 2000
KS00076

Luscar Ltd.
1600 Oxford Tower
10235 – 101 Street
Edmonton, A.B. T2P 3V4

Attention: Mr. Allan Flemming

Dear Mr. Flemming:

RE: TELKWA COAL PROJECT 1999 BASELINE SURFACE FLOW AND WATER QUALITY FINAL DATA REPORT

AGRA Earth & Environmental Limited (AGRA) is pleased to submit two copies of the *Telkwa Coal Project 1999 Baseline Surface Flow and Water Quality Final Data Report*. The report presents the results of the 1999 field monitoring program conducted by AGRA for Luscar Ltd. on the proposed Telkwa Coal Project.

AGRA understands that the recent state of the coal industry has put the proposed Telkwa Coal Project on hold. AGRA looks forward to working with Luscar Ltd. on the proposed Telkwa Coal Project when the decision to proceed with the project is made. Should you have any questions or comments regarding this report, or require any support on this, or other projects, please do not hesitate to contact the undersigned at (250) 847-8783.

Respectfully submitted,

AGRA Earth & Environmental Limited

Scott Davidson, P.Geo., M.Sc.
Geomorphologist

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

AGRA Earth &
Environmental Limited
Box 3966
#3, 3167 Tatlow Road
Smithers, BC
Canada V0J 2N0
Tel (250) 847-8783
Fax (250) 847-9049

March 27, 2000
KS00076

Luscar Ltd.
1600 Oxford Tower
10235 - 101 Street
Edmonton, Alberta T2P 3V4

Attention: Mr. Allan Flemming, P.Eng. Fax: (780) 420-5875

Dear Mr. Flemming:

RE: TELKWA COAL PROJECT 1999 BASELINE DATA REPORT

1.0 INTRODUCTION

AGRA Earth & Environmental Limited is pleased to present the 1999 Baseline Surface Water Flow and Water Quality Monitoring Report for the Telkwa Coal Project (TCP). The TCP is a proposed open pit coal mine located near Telkwa, B.C. and owned by Luscar Inc. (Luscar). The location of the mine is illustrated on Figure 1. This report contains the data collected during the 1999 baseline monitoring program and updates the rating curves for sites where discharge measurements were conducted.

2.0 SCHEDULE OF 1999 SITE VISITS

The schedule of site visits for the 1999 field monitoring program is contained in the March 3, 1999 AGRA proposal to conduct the TCP baseline monitoring. A copy of the AGRA proposal is contained in Appendix A for reference. The dates of actual site visits and a listing of the work conducted during the site visits is contained in Table 1.

TABLE 1: 1999 MONITORING SITE VISITS

Week of:	Feb 1	Aug 1	Sept 19	Nov 14
Telkwa River	WQ		WQ	
Upper Tenas Creek	No site access		SM, WQ, Q	S
Lower Tenas Creek	WQ, Q	S	SM, WQ, Q	S
Bulkley River	WQ		WQ	
Hubert Creek	WQ, S	S	WQ, S	S
Four Creek	WQ	S	WQ, Q	S
Upper Goathorn Creek	WQ, Q		SM, WQ, Q	S
Lower Goathorn Creek	WQ		WQ	

Q = Discharge and stage measurements conducted
S = Stage measurements conducted
WQ = Water quality sampling conducted
SM = Site Maintenance Visit

The purpose of the August field trips was to collect peak flow information from the crest gauges at each site.

3.0 SURFACE WATER MONITORING RESULTS

This section contains a summary of the five sites where surface water monitoring was conducted during the 1999 field season. Summary field data for the site visits is contained in Appendix B.

3.1 LOWER TENAS CREEK SITE

The Lower Tenas Creek site was visited four times as part of the 1999 monitoring program. The station was operated as a manual sampling with no installation of the automated equipment used in previous years.

The two low flow discharge measurements conducted during February and September yielded discharges of 0.041 m^3/s and 0.163 m^3/s respectively. These discharge measurements have been added to the rating curve and a revised rating curve for this site is shown in Figure 2.

An initial crest gauge installed in late 1998 at the site was replaced during the 1999 sampling season. Level surveys conducted at the site during the 1999 field season did not show significant shift of the benchmarks or the staff gauge. There was evidence of sand deposition noted near the gauge during the November 1999 field visit.

3.2 UPPER TENAS CREEK SITE

The upper Tenas Creek was visited twice during the 1999 monitoring program. There was no site access during the February 1999 field trip. As the crest gauge for this site was not checked and reset during February, this site was not visited during the August field trip.

The crest gauge was checked during September and the maximum stage was observed to be 0.70 m. This value would translate to a discharge of 8.43 m^3/s and is expected to be due to the spring freshet which consistently produces greater discharges than the fall peak flows. The low flow measurement from September 20th was 0.134 m^3/s. An updated rating curve for this site is shown in Figure 3.

The September field visit to this site showed that the braces for the staff gauge had snapped but that the staff gauge did not appear to have shifted (based on a review of previous site photographs). Braces at the site were replaced and a third benchmark was added on the right bank side of the stream. Levelling checks showed that there was no significant shift of the benchmarks or the staff gauge during 1999. The breakage of the braces resulted in slight downstream leaning of the staff gauge mounting but this was corrected during the site maintenance visit.

3.3 UPPER GOATHORN CREEK SITE

The Upper Goathorn Creek site was visited four times during the 1999 monitoring program. The station was monitored as a manual station with a staff gauge and crest gauge.

The two low flow discharge measurements conducted during February and September yielded discharges of 0.097 m^3/s and 0.337 m^3/s respectively. These discharge measurements have been added to the rating curve and a revised rating curve for this site is shown in Figure 4.

Maintenance of the gauge equipment was conducted during the September visit. The bracing for the staff gauge was reinforced and the staff gauge was lowered by a distance of 0.19 m. A second staff gauge was added to the top of the first staff gauge to allow for visual measurement of peak flow levels during the freshet period. The level check of benchmarks showed that there were no changes in the elevations of the benchmarks. The staff gauge did not show any significant shift during the 1999 season.

3.4 FOUR CREEK SITES

Two sampling locations were operated on Four Creek during the 1999 field season. The low flow discharge measurements were made at the lowest culvert crossing of Four Creek on the 120 Road. Other stage measurements and water quality sampling were conducted at the original stream flow sampling site located approximately 1,800 m upstream of the culvert crossing on Four Creek.

Discharges for the low flow periods were determined by calculation of the discharge through the culvert based on the known inlet water levels and the culvert characteristics. The February low flow measurement revealed that there was only a small quantity of baseflow (< 1L/min) during the sampling trip. The culvert was almost completely iced up. The September low flow discharge for the culvert was calculated to be 0.077 m^3/s.

3.5 HUBERT CREEK SITE

The Hubert Creek site was visited four times during the 1999 monitoring program. Readings for the staff gauge are available from two of the site visits. Visits conducted during September and November did not yield useful data on flow levels due to numerous partial blockages of the culvert inlet by debris.

The crest gauge at the site indicated that there was a recorded stage greater than 1.23 m during the spring 1999 freshet period. This high stage is believed to be partially due to beaver debris blockage of the inlet of the Hubert Creek culvert.

4.0 WATER QUALITY MONITORING RESULTS

In 1999, baseline water chemistry was sampled during the two low flow periods at ten sites in the proposed Telkwa Coal Project area. The data for the February 1999 water quality monitoring was forwarded directly to Luscar as previously arranged. The laboratory results for the September water quality trip are included in Appendix C of this report. No analysis of the testing data, other than to identify specific stations where the BC Water Quality Criteria (Nagpal, 1995) were exceeded. A summary of metals and stations where exceedances occurred are summarized in Table 2. Due to operator error, no replicate sampling was conducted during the September water quality monitoring trip.

TABLE 2: B.C. WATER QUALITY CRITERIA EXCEEDANCE INFORMATION FOR THE SEPTEMBER 20, 1999 SAMPLING TRIP

METAL	B.C. WATER QUALITY CRITERIA	STATIONS WITH TOTAL METALS CONCENTRATIONS GREATER THAN THE B.C. CRITERIA	STATIONS WITH TOTAL METALS CONCENTRATIONS EQUAL TO THE B.C. CRITERIA
Cr	2.0 ug/L	Telkwa River (2.5)	Upper Goathorn Creek, Lower Goathorn Creek, Bulkley River, Hubert Creek, Lower Tenas, Four Creek
Cu	2.0 ug/L	Telkwa River (2.4)	
Fe	0.3 mg/L	Telkwa River (0.8), Hubert Creek (1.03), Bulkley River (0.33)	
Zn	3.0 ug/L	Telkwa River (3.5)	

5.0 CLOSURE

AGRA Earth Environmental Limited is pleased to present this 1999 data summary to Luscar Ltd. AGRA looks forward to continuing to work with Luscar on the Telkwa Coal project over the 2000 season. Should you have any questions concerning this project please do not hesitate to contact the undersigned at (250) 847-8783.

Respectfully Submitted,

PROFESSIONAL
PROVINCE OF
S.C. DAVIDSON
MAR 27 2000
BRITISH COLUMBIA
GEOSCIENTIST

Scott Davidson, M.Sc., P.Geo.
Project Manager

Reviewed by,

Gary R.E. Beckstead, M.Sc., P.Eng.
Senior Water Resource Engineer

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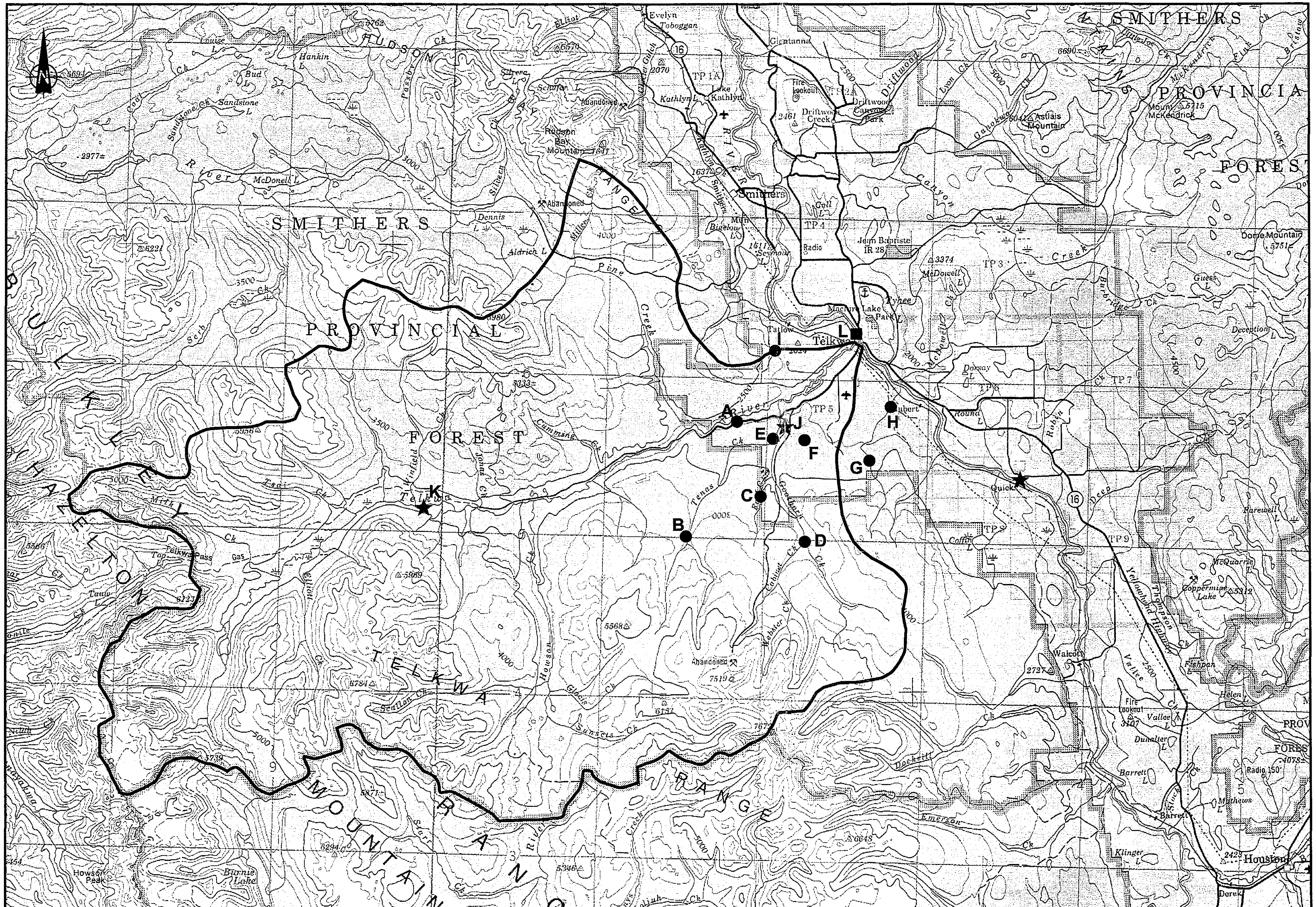
SCD\SCD



LEGEND

- Telkwa River Watershed
- ★ Existing WSC Station
- ■ Water Quality Station
- ● Hydrometric & Water Quality Site

A Lower Telkwa River
B Upper Tenas Creek
C Four Creek
D Upper Goathorn Creek
E Lower Tenas Creek
F Tailings Pond Drainage
G Helps Creek
H Hubert Creek
I North Site
J Lower Goathorn Creek
K Upper Telkwa River
L Bulkey River

0 5 10 15 20 25 Kilometres

Scale 1 : 250 000

AGRA Earth & Environmental
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CLIENT: LUSCAR LTD.		DATE: MAR. 2000	
PROJECT: TELKWA COAL PROJECT		JOB No.: KS00076	
APPROXIMATE LOCATIONS HYDROMETRIC AND WATER QUALITY SITES		COREL FILE: N/A	
		FIGURE 1	REV. -

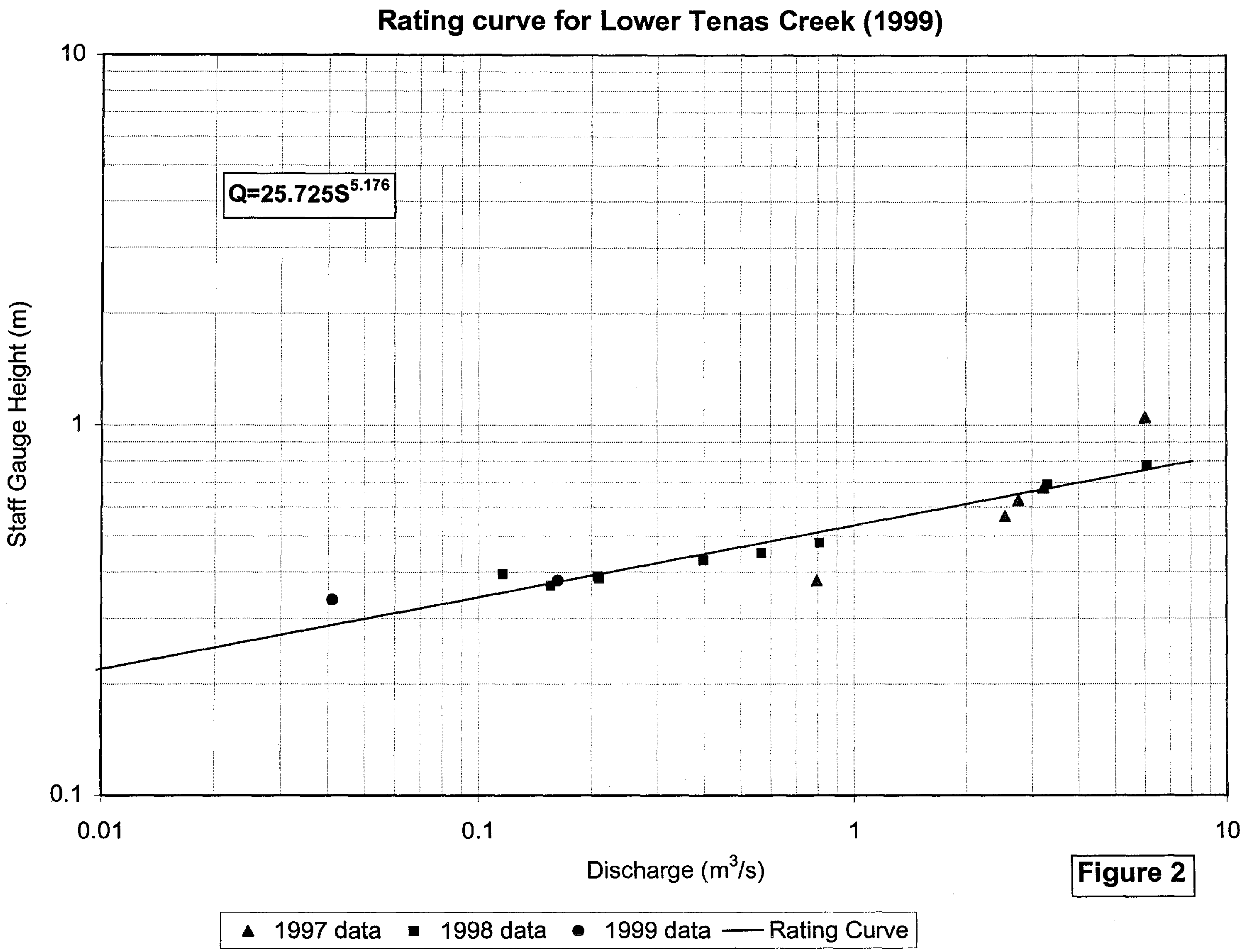

Figure 2

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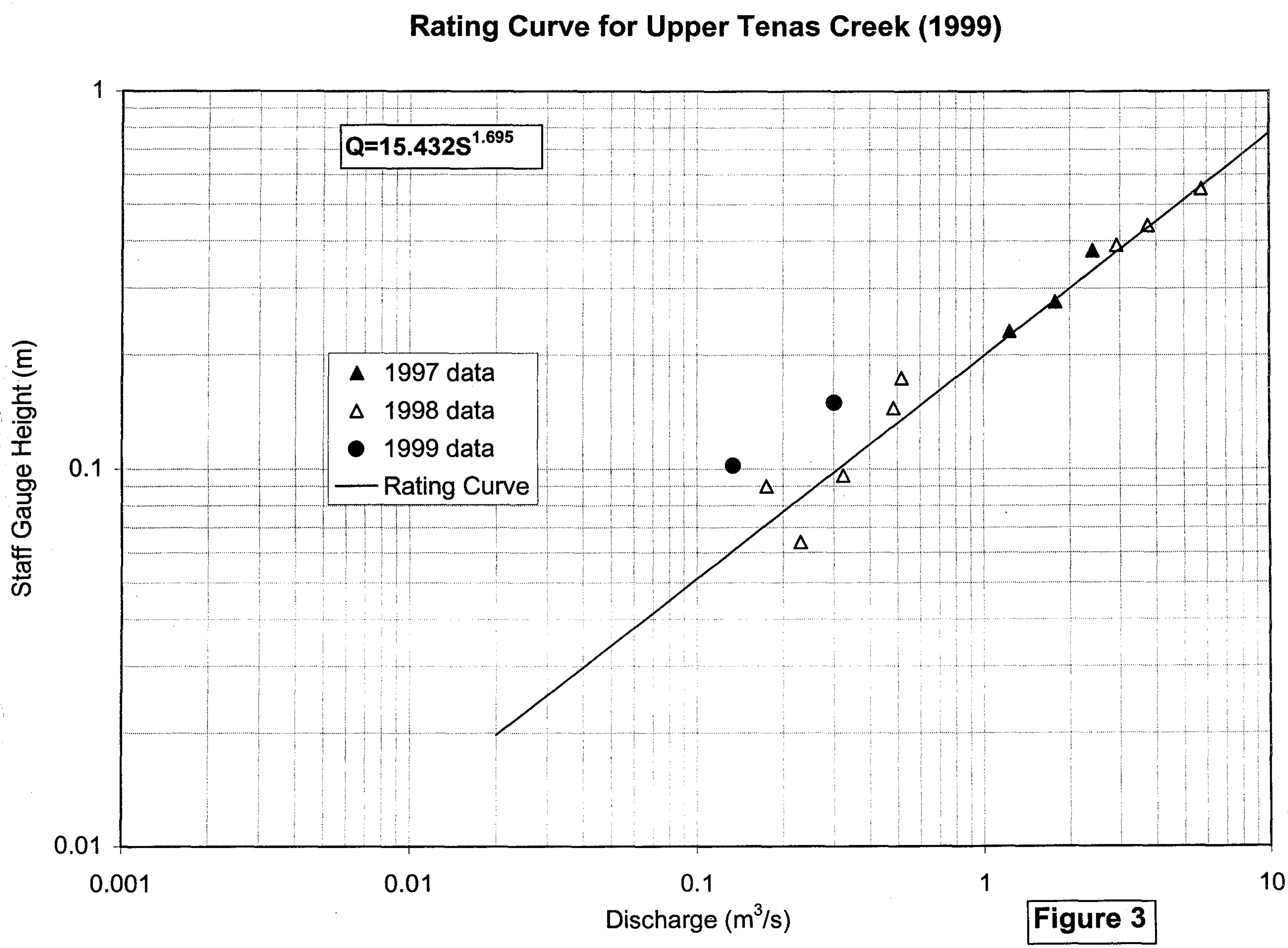

Figure 3

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rcurve-98.xls

15/02/2000

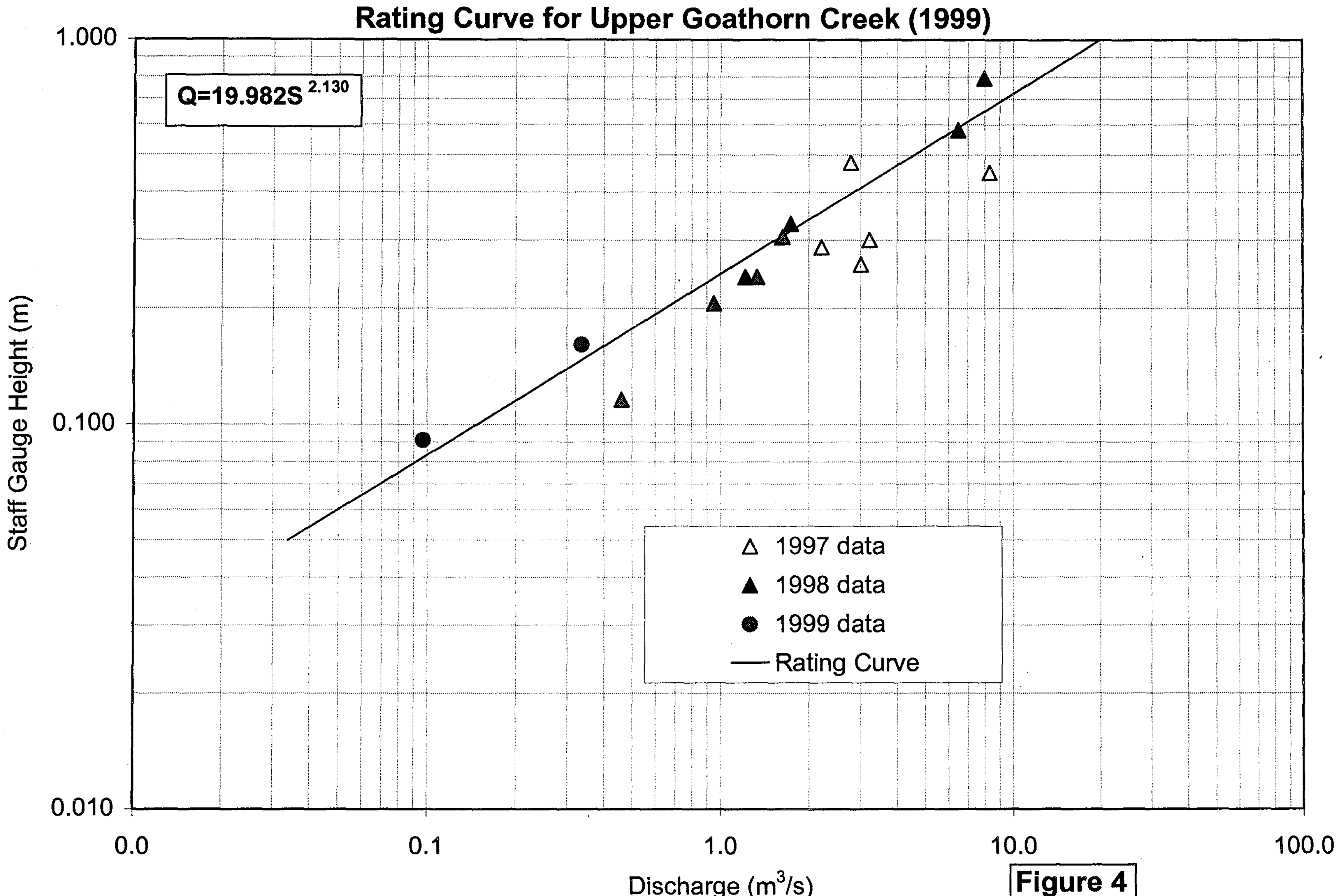

Figure 4

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APPENDIX A

AGRA PROPOSAL FOR 1999
TELKWA COAL MONITORING PROGRAM

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March 2, 1999
CW1537.1

Luscar Ltd.
1600 Oxford Tower
10235 - 101 Street
Edmonton, Alberta T2P 3V4

Attention: Mr. Allan Flemming, P.Eng. Fax: (403) 420-5875

Dear Mr. Flemming:

RE: TELKWA COAL PROJECT 1999 BASELINE DATA REPORT

1.0 INTRODUCTION

AGRA Earth & Environmental Limited is pleased to present this proposal to conduct the 1999 Baseline Surface Water Flow and Water Quality Monitoring Report for the Telkwa Coal Project (TCP). The TCP is a proposed open pit coal mine located near Telkwa, B.C. and owned by Luscar Inc. (Luscar). This report contains the data collected during the 1999 baseline monitoring program and updates the rating curves for sites where discharge measurements were conducted.

2.0 SCHEDULE

SURFACE WATER MONITORING

AEE is pleased to present this revised budget for the 1999 baseline water flow and water quality program for the proposed Telkwa Coal Project. It is the understanding of AEE that during 1999 Luscar should be submitting the Final Project Report to the B.C. Environmental Assessment Office. Following certification of the project, it is the understanding of AEE that the entire surface water and water quality program may need to be revised to meet the construction plan for the mine.

2.0 WORK PROGRAM AND BUDGET

The work program proposed for 1999 is as follows:

<u>Surface Water Flow</u>

- Concentration of the base program on the winter and summer low flow periods.
- Monitoring of low flows on Four Creek, Hubert Creek, Tenas Creek, Upper Goathorn Creek and Lower Goathorn Creek. No monitoring will be conducted on Helps Creek, Telkwa River, and the Bulkley River. Low flow monitoring will result in two site visits. To reduce cost to Luscar, AEE has scheduled the summer low flow period measurement trip to

coincide with site visit #3 described below.

- Monitoring of peak flows at the streams using crest gauges already installed at all of the existing sites. To conduct this portion of the required work, AEE will conduct a total of four sites visits planned as follows:

1. Pre-freshet to set up crest and staff gauges and survey to local bench marks (April),
2. Post freshet to record peak flow during period and survey to local bench marks (June),
3. Pre fall high flow period to re-survey benchmarks and survey to local bench marks (late August to early September),
4. Post fall high flow to record peak flow and survey to local bench marks (November).

Water Quality

- Sampling of baseline parameters for the two low flow periods only.

Data Analysis

AEE proposes to conduct data analysis and reporting for the 1999 sampling program following each monitoring trip. A data analysis period has been allowed following each of the five surface flow site visits (one low flow and four peak flow visits) described above. The information reports from each trip will assist Luscar in public meetings by providing the most up to date information on the project.

Project Management

Project management involves dealing with items such as cost control, client liaison, and interfacing with other consultants working for Luscar on the proposed Telkwa Coal Mine. For the 1999 sampling program, AEE proposes to conduct project management on a cost plus basis. The totals for this item in the attached Table 1 represent estimates of the total budget required for project management. AEE will make every effort to ensure that it conducts stringent cost control on the project management for Luscar. Project management for the 1999 program will be conducted by Mr. Scott Davidson, M.Sc., P.Geo. of the Smithers office. Mr. Gary Beckstead, M.Sc., P.Eng. and Mr. Dennis Trotter will provide technical input and review to the project as required.

3.0 CLOSURE

We thank you for the opportunity to provide engineering and environmental services to this project and look forward to continuing to work with Luscar on the proposed Telkwa Coal Mine during 1999. If you have any questions or require further information concerning this project, please call Scott Davidson at (250) 847-8783 or Gary Beckstead at (403)235-8118.

Yours sincerely,

AGRA Earth & Environmental Limited

Reviewed by

Scott Davidson, M.Sc., P.Geo.
Project Manager

Gary R.E. Beckstead, M.Sc., P.Eng.
Senior Water Resource Engineer

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cc. Gary R.E. Beckstead, AEE - Calgary

APPENDIX B

SUMMARY OF 1999 FIELD DATA

Telkwa Coal Project Field Note Summary for 1999 Sampling Season

Hubert Creek

Date	Aug 3/99	12:47	Sept 21/99	Nov 18/99
SG	0.1		0.945	
Crest	>1.23			
		Diff to SG		
HI	1.65			
Top SG	2.463		Culvert Blocked by Beaver Debris	Culvert Blocked by Beaver Debris
Top Crest	2.464			
Telephone Pole	1.221	-1.242		
Top Box	0.5	-1.963		

Four Creek

				Site					
Date	Aug 3/99	13:25		Sep-20	11:40		Nov 18/99	12:15	
SG	0.18			0.182			0.185		
Crest	0.4			0.55			0.2		
		Diff to SG							Diff to SG
HI	1.63						1.5621	1.5367	
Top SG	0.754						0.687	0.692	
Top Crest	0.506					Set up 1		0.444	Set up 2
BM1	0.005	-0.749				-0.72	-0.033	0.038	-0.654
BM2	0.215	-0.539				-0.54	0.147	0.151	-0.541
			Culvert depth		0.08	Culvert depth		0.1	
			Sept 21/99	10:15		Nov 18/99	11:45		

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Lower Tenas Creek								
	Aug 3/99	14:30	Sept 20/99	15:15		Nov 18/99	13:15	
SG	0.43		0.38			0.37		
Crest						0.25		
		Diff to SG		Diff to SG				Diff to SG
HI	1.6					1.6129		
Top SG	3.778		3.765			3.78	3.815	
Top Crest			3.275		Set up 1		3.325	Set up 2
BM1	1.18	-2.598	1.162	-2.603	-2.613	1.167	1.203	-2.612
BM2	1.227	-2.551	1.215	-2.55	-2.559	1.221	1.255	-2.56
Comments						Sand deposition near gauge		

Upper Goathorn Cr.							
	Sept 20/99	Sept 21/99	14:35		Nov 18/99	10:15	
SG	-0.03	0.12			0.075		
Crest					frozen shut		
			Diff to SG				Diff to SG
HI					1.6891	1.65735	
SG (to 1 m mark)		0.843			0.916	0.881	
Top Crest		1.546		Set up 1		1.585	Set up 2
BM1		0.185	-0.658	-0.659	0.257	0.221	-0.66
BM2		1.399	0.556	0.553	1.469	1.433	0.552
Comments:		SG lowered 0.191 m CG lowered 0.11 m			4" snow on ground SG surveyed to 2 m mark		

Upper Tenas Cr.		Sept 20/99				Nov 18/99	11:30	
SG		0.15				0.08		
Crest		0.18	0.7 read previous day			0.25		
				Diff to SG				Diff to SG
HI		1.71				1.651		
Top SG		1.035	1.035			0.972	1.022	
Top Crest	Set up 1	0.821		Set up 2	Set up 1		0.823	Set up 2
BM1	-0.969	0.066	0.066	-0.969	-0.967	0.005	0.071	-0.951
BM2	-0.97	0.065	0.065	-0.97	-0.967	0.005	0.07	-0.952
BM3	-0.755	0.28	0.28	-0.755	-0.737	0.235	0.285	-0.737

Site Maintenance Trip
Values for SG and Crest arer post-fix
BM3 added ~ 12m downstream of BM1 and BM2

Discharge MeasurementDeterminations

Site: Lower Tenas 21-Sep-99 15:15
Staff Gauge: 0.38

LOC	REVS	SEC	VEL	DEPTH	Q
3.300	0	0		0.000	0.000
3.600	0	0		0.060	0.000
3.900	2	36.1		0.140	0.000
4.200	3	41.9	0.048	0.200	0.003
4.500	7	44.5	0.106	0.220	0.007
4.800	9	41.7	0.145	0.260	0.011
5.100	13	38.9	0.224	0.280	0.019
5.400	12	42	0.192	0.320	0.018
5.700	17	41.2	0.277	0.330	0.027
6.000	21	43.1	0.327	0.340	0.033
6.300	21	44.5	0.317	0.260	0.025
6.600	18	41.9	0.288	0.220	0.019
6.900	20	41.4	0.324	0.18	0.018
7.200	17	42.4	0.269	0.140	0.011
7.500	16	42.2	0.255	0.12	0.009
7.8	14	40.1	0.234	0.1	0.007
8.1	0	0		0.04	0
8.4	0	0		0.04	0
8.7	0	0		0.08	0
9	0	0		0.08	0
9.3	0	0		0.03	0
9.6	0	0		0	0
				Sum Q:	0.163

Site: Upper Goathorn Cree 20-Sep-99 13:05
Staff Gaug -0.03

LOC	REVS	SEC	VEL	DEPTH	Q
8.700	0	0		0.000	0.000
9.000	0	0		0.030	0.000
9.300	0	0		0.070	0.000
9.600	0	0		0.100	0.000
9.900	12	40	0.201	0.190	0.011
10.200	27	42	0.432	0.220	0.028
10.500	23	45	0.343	0.280	0.029
10.800	35	45	0.522	0.380	0.060
11.100	32	40	0.537	0.320	0.052
11.400	19	42	0.304	0.420	0.038
11.700	29	40	0.487	0.370	0.054
12.000	33	40	0.554	0.390	0.065
12.300	21	41	0.344	0.39	0.040
12.600	38	40	0.638	0.330	0.063
12.900	35	40	0.588	0.35	0.062
13.2	52	41	0.852	0.31	0.079
13.5	48	40	0.806	0.29	0.070
13.8	40	40	0.672	0.24	0.048
14.1	26	42	0.416	0.26	0.032
14.4	23	40	0.386	0.3	0.035
14.7	49	40	0.823	0.24	0.059
15	12	40	0.201	0.26	0.016
15.3	0	0		0	0.000
15.6	0	0		0.07	0.000
15.9	11	40	0.185	0.09	0.005
16	0	0		0	0.000
				Sum Q:	0.337

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Site: Upper Tenas 20-Sep-99 11:30
Staff Gauge: 0.102

LOC	REVS	SEC	VEL	DEPTH	Q	
0.400	0	0		0.000	0.000	WW R/B
0.800	0	0		0.000	0.000	behind big rock
1.200	26	42	0.416	0.080	0.013	
1.600	21	42	0.336	0.100	0.013	
2.000	21	41	0.344	0.100	0.014	
2.400	22	42	0.352	0.120	0.017	
2.800	0	0		0.050	0.000	behind big rock
3.200	23	45	0.343	0.090	0.012	
3.600	0	0		0.140	0.000	back eddy behind roc
4.000	14	43	0.219	0.120	0.010	
4.400	41	40	0.688	0.120	0.033	
4.800	27	45	0.403	0.130	0.021	
5.200	28	44	0.427	0.15	0.026	
5.600	15	41	0.246	0.180	0.018	
6.000	16	40	0.269	0.18	0.019	
6.4	30	45	0.448	0.18	0.032	
6.8	22.5	43	0.351	0.14	0.020	
7.2	0	0		0.1	0.000	
7.6	0	0		0.02	0.000	
8	0	0		0		
8.1	0	0		0		L/B
				Sum Q:	0.134	

Upper Tenas 21-Sep-99 11:30
0.15

LOC	REVS	SEC	VEL	DEPTH	Q	
3.500	0	0		0.000	0.000	WW L/B
3.900	0	0		0.070	0.000	Too Shallow to Measure
4.300	17	41		0.080	0.000	
4.700	24	43.9	0.367	0.130	0.019	
5.100	30	43	0.468	0.170	0.032	
5.500	24	40.2	0.401	0.190	0.030	
5.900	34	45.1	0.506	0.220	0.045	
6.300	30	43.4	0.464	0.170	0.032	
6.700	35	38.8	0.606	0.180	0.044	
7.100	35	36.6	0.642	0.180	0.046	
7.500	30	37.1	0.543	0.200	0.043	
7.900	12	41.5	0.194	0.140	0.011	
8.300	15	38.8	0.260	0.14	0.015	
8.700	0	0		0.070	0.000	Too Shallow to Measure
9.100	45	40.6	0.744	0.13	0.039	
9.5	31	41.7	0.499	0.14	0.028	
9.9	20	42.5		0.12	0.000	
10.3	0	0		0.08	0.000	
10.7	0	0		0	0.000	WW R/B
				Sum Q:	0.302	

APPENDIX C

SEPTEMBER WATER QUALITY MONITORING TRIP RESULTS

Chemex Labs Ltd.
Analytical Chemists * Geochemists * Registered Assayers
212 Brooksbank Ave., North Vancouver
British Columbia, Canada V7J 2C1
PHONE: 604-984-0221 FAX: 604-984-0218

To: AGRA EARTH & ENVIRONMENTAL LIMITED ~*

BOX 3966, #3 - 3167 TATLOW ROAD
SMITHERS, BC
V0J 2N0

Project : KS00076
Comments: ATTN: SCOTT DAVIDSON

Page Number : 1
Total Pages : 1
Certificate Date: 05-OCT-1999
Invoice No. : I9929585
P.O. Number :
Account : OXF

* PLEASE NOTE

CERTIFICATE OF ANALYSIS A9929585

PARAMETER DESCRIPTIONS	SAMPLE LOWER TENAS	SAMPLE TRIP BLANK	SAMPLE UPPER TENAS	SAMPLE FOUR CREEK	SAMPLE UPPER GOATHORN	SAMPLE LOWER GOATHORN	SAMPLE TELKWA RIVER	SAMPLE HUBERT CREEK	SAMPLE BULKLEY RIVER	
Sample preparation code	221	221	221	221	221	221	221	221	221	
Sample preparation code	---	---	---	---	---	---	---	---	---	
pH	8.0	7.9	7.7	8.0	7.9	7.8	7.8	7.3	7.7	
Conductivity (umhos/cm)	147	2	138	230	124	132	63	215	62	
Total Susp Solids (mg/L)	< 5	< 5	< 5	< 5	< 5	< 5	14	< 5	6	
SO4 mg/L - Ion Chrom.	2.9	< 0.1	2.5	1.5	27.4	26.6	4.8	0.5	4.6	
Alkalinity (mg/L CaCO3)	78	< 1	72	130	33	41	29	117	28	
Ammonia (mg/L N)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	
Nitrates (mg/L N)	< 0.05	< 0.05	< 0.05	< 0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	
Nitrites (mg/L N)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Tot Organic Carbon(mg/L)	2.0	< 1.0	2.0	7.0	< 1.0	1.0	< 1.0	15.0	1.0	
Tot Hardness(mg/L CaCO3)	74.3	0.4	67.7	121.0	57.8	62.8	31.6	119.0	30.4	
Tot phosphates (mg/L P)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05	0.04	0.03	
Chloride (mg/L)	0.2	< 0.1	0.1	0.4	0.1	0.2	0.1	0.7	0.2	

CERTIFICATION:

* pH ANALYSED SEPTEMBER 23, 1999, @ 14:15 HRS.

Chemex Labs Ltd.

Analytical Chemists * Geochemists * Registered Assayers

212 Brooksbank Ave., North Vancouver
British Columbia, Canada V7J 2C1
PHONE: 604-984-0221 FAX: 604-984-0218

To: AGRA EARTH & ENVIRONMENTAL LIMITED

BOX 3966, #3 - 3167 TATLOW ROAD
SMITHERS, BC
V0J 2N0

Project : KS00076
Comments: ATTN: SCOTT DAVIDSON

Page Number : 1-A
Total Pages : 1
Certificate Date: 11-OCT-1999
Invoice No. : I9929588
P.O. Number :
Account : OXF

CERTIFICATE OF ANALYSIS A9929588

SAMPLE	PREP CODE		Ag ug/L	Al mg/L	As ug/L	Ba ug/L	Be ug/L	Bi ug/L	Ca mg/L	Cd ug/L	Co ug/L	Cr ug/L	Cu ug/L	Fe mg/L	Hg ug/L	K mg/L	Mg mg/L	Mn ug/L	Mo ug/L	Na mg/L	Ni ug/L
LOWER TENAS-TOT	221	2393	< 0.05	0.029	< 1	28.2	< 0.5	< 0.05	21.9	< 0.1	0.08	2.0	1.8	0.14	< 1	0.25	4.09	5.75	< 0.1	3.15	< 0.2
LOWER TENAS-DIS	221	--	< 0.05	0.006	< 1	27.2	< 0.5	< 0.05	21.7	< 0.1	0.08	3.0	2.0	0.10	< 1	0.25	4.04	3.65	< 0.1	3.10	< 0.2
TRIP BLANK-TOT	221	2393	< 0.05	0.027	< 1	< 0.05	< 0.5	< 0.05	0.05	< 0.1	< 0.02	2.0	0.6	0.04	< 1	< 0.05	< 0.001	0.15	< 0.1	< 0.05	< 0.2
TRIP BLANK-DIS	221	--	< 0.05	0.001	< 1	< 0.05	< 0.5	< 0.05	< 0.05	< 0.1	< 0.02	< 0.5	0.3	< 0.01	< 1	< 0.05	0.005	< 0.05	< 0.1	< 0.05	< 0.2
UPPER TENAS-TOT	221	2393	< 0.05	0.018	< 1	25.0	< 0.5	< 0.05	21.1	< 0.1	0.06	0.5	0.8	0.11	< 1	0.20	3.52	0.95	< 0.1	2.95	< 0.2
UPPER TENAS-DISS	221	--	< 0.05	0.009	< 1	23.4	< 0.5	< 0.05	19.45	< 0.1	0.06	0.5	2.0	0.11	< 1	0.20	3.25	0.80	0.1	2.95	< 0.2
FOUR CREEK-TOT	221	2393	< 0.05	0.061	< 1	79.5	< 0.5	< 0.05	25.6	< 0.1	0.10	2.0	1.2	0.16	< 1	0.50	11.85	0.95	0.1	5.95	0.4
FOUR CREEK-DISS	221	--	< 0.05	0.041	< 1	78.7	< 0.5	< 0.05	25.2	< 0.1	0.08	4.5	1.3	0.13	< 1	0.50	11.75	0.60	0.2	6.45	0.2
UPPER GOATHORN-T	221	2393	< 0.05	0.019	< 1	24.5	< 0.5	< 0.05	18.40	< 0.1	0.08	2.0	1.7	0.12	< 1	0.40	2.03	1.35	0.7	1.40	< 0.2
UPPER GOATHORN-D	221	--	< 0.05	0.010	< 1	23.5	< 0.5	< 0.05	17.80	< 0.1	0.06	0.5	1.8	0.10	< 1	0.35	2.01	1.10	0.7	1.40	0.2
LOWER GOATHORN-T	221	2393	< 0.05	0.018	< 1	50.3	< 0.5	< 0.05	17.75	< 0.1	0.18	2.0	1.1	0.13	< 1	0.40	2.83	2.85	0.5	1.65	< 0.2
LOWER GOATHORN-D	221	--	< 0.05	0.029	< 1	50.1	< 0.5	< 0.05	18.50	< 0.1	0.06	0.5	1.3	0.09	< 1	0.40	3.03	2.00	0.5	2.00	0.2
TELKWA RIVER-TOT	221	2393	< 0.05	0.583	< 1	41.2	< 0.5	< 0.05	9.50	< 0.1	0.40	2.5	2.4	0.80	< 1	0.40	1.490	35.7	0.5	1.00	0.6
TELKWA RIVER-DIS	221	--	< 0.05	0.048	< 1	26.9	< 0.5	< 0.05	9.35	< 0.1	0.04	< 0.5	0.9	0.08	< 1	0.30	1.215	11.60	0.5	0.95	< 0.2
HUBERT CREEK-TOT	221	2393	< 0.05	0.049	< 1	49.6	< 0.5	< 0.05	30.2	< 0.1	0.26	2.0	0.7	1.03	< 1	0.85	7.79	290	0.1	3.25	0.6
HUBERT CREEK-DIS	221	--	< 0.05	0.030	< 1	48.1	< 0.5	< 0.05	30.9	< 0.1	0.22	1.5	1.1	0.69	< 1	0.90	8.11	267	0.3	3.70	0.6
BULKLEY R.-TOT	221	2393	< 0.05	0.217	< 1	27.7	< 0.5	< 0.05	9.10	< 0.1	0.16	2.0	1.6	0.33	< 1	0.35	1.270	14.10	0.4	1.00	< 0.2
BULKLEY R.-DIS	221	--	< 0.05	0.048	< 1	22.7	< 0.5	< 0.05	9.50	< 0.1	0.02	< 0.5	1.6	0.08	< 1	0.35	1.300	5.55	0.6	1.70	< 0.2

CERTIFICATION: Parker Tisch

Chemex Labs Ltd.
Analytical Chemists * Geochemists * Registered Assayers
212 Brooksbank Ave., North Vancouver
British Columbia, Canada V7J 2C1
PHONE: 604-984-0221 FAX: 604-984-0218

To: AGRA EARTH & ENVIRONMENTAL LIMITED ~*

BOX 3966, #3 - 3167 TATLOW ROAD
SMITHERS, BC
V0J 2N0

Project : KS00076
Comments: ATTN: SCOTT DAVIDSON

Page Number :1-B
Total Pages :1
Certificate Date: 11-OCT-1999
Invoice No. : I9929588
P.O. Number :
Account :OXF

CERTIFICATE OF ANALYSIS A9929588

SAMPLE	PREP CODE		P mg/L	Pb ug/L	Sb ug/L	Se ug/L	Sn ug/L	Sr ug/L	Ti ug/L	Tl ug/L	U ug/L	V ug/L	Zn ug/L
LOWER TENAS-TOT	221	393	0.4	< 2	0.20	< 1	< 0.5	89.4	< 1	< 0.05	0.05	< 1	< 0.5
LOWER TENAS-DIS	221	--	< 0.1	10	0.15	< 1	< 0.5	86.7	< 1	< 0.05	0.05	1	< 0.5
TRIP BLANK-TOT	221	393	0.4	< 2	< 0.05	< 1	< 0.5	< 0.05	< 1	< 0.05	< 0.05	< 1	< 0.5
TRIP BLANK-DIS	221	--	< 0.1	< 2	< 0.05	< 1	< 0.5	< 0.05	< 1	< 0.05	< 0.05	< 1	< 0.5
UPPER TENAS-TOT	221	393	0.3	< 2	0.15	< 1	< 0.5	85.6	< 1	< 0.05	0.05	1	< 0.5
UPPER TENAS-DISS	221	--	< 0.1	< 2	0.15	< 1	< 0.5	80.7	< 1	< 0.05	0.05	< 1	0.5
FOUR CREEK-TOT	221	393	0.4	< 2	< 0.05	< 1	< 0.5	147.5	< 1	< 0.05	0.05	< 1	< 0.5
FOUR CREEK-DISS	221	--	< 0.1	< 2	< 0.05	< 1	< 0.5	141.5	< 1	< 0.05	0.05	1	1.5
UPPER GOATHORN-T	221	393	0.5	< 2	0.05	< 1	< 0.5	52.8	1	< 0.05	< 0.05	< 1	0.5
UPPER GOATHORN-D	221	--	< 0.1	< 2	0.05	< 1	< 0.5	51.4	< 1	< 0.05	< 0.05	< 1	1.0
LOWER GOATHORN-T	221	393	0.4	< 2	0.05	< 1	< 0.5	56.4	1	< 0.05	< 0.05	< 1	< 0.5
LOWER GOATHORN-D	221	--	< 0.1	< 2	0.05	< 1	< 0.5	57.0	< 1	< 0.05	< 0.05	< 1	0.5
TELKWA RIVER-TOT	221	393	0.5	< 2	< 0.05	< 1	< 0.5	44.2	20	< 0.05	0.05	< 1	3.5
TELKWA RIVER-DIS	221	--	< 0.1	< 2	< 0.05	< 1	< 0.5	41.3	< 1	< 0.05	< 0.05	< 1	< 0.5
HUBERT CREEK-TOT	221	393	0.4	< 2	< 0.05	< 1	< 0.5	108.0	2	< 0.05	0.05	< 1	< 0.5
HUBERT CREEK-DIS	221	--	< 0.1	< 2	< 0.05	< 1	< 0.5	106.5	< 1	< 0.05	0.05	< 1	1.0
BULKLEY R.-TOT	221	393	0.5	< 2	< 0.05	< 1	< 0.5	37.9	8	< 0.05	< 0.05	< 1	< 0.5
BULKLEY R.-DIS	221	--	< 0.1	< 2	< 0.05	< 1	< 0.5	37.5	< 1	< 0.05	< 0.05	< 1	1.0

CERTIFICATION: Parker Drish

I called Scott and requested edits. He Will forward final copies + email electronic. No work in 2000.
ALLAN, 7 PAGES Feb 29/00. ·ab2
DRAFT 1999 REPORT
SORRY FOR THE DELAYS.
APP. A + FIELD DATA SUMMARY APPENDIX TO BE ADDED

February 15, 2000
CW1537.1

Luscar Ltd.
1600 Oxford Tower
10235 - 101 Street
Edmonton, Alberta T2P 3V4

Attention: Mr. Allan Flemming, P.Eng. Fax: ~~(403)~~ 780 420-5875

Dear Mr. Flemming:

RE: TELKWA COAL PROJECT 1999 BASELINE DATA REPORT

1.0 INTRODUCTION

AGRA Earth & Environmental Limited is pleased to present the 1999 Baseline Surface Water Flow and Water Quality Monitoring Report for the Telkwa Coal Project (TCP). The TCP is a proposed open pit coal mine located near Telkwa, B.C. and owned by Luscar Inc. (Luscar). The location of the mine is illustrated on Figure 1. This report contains the data collected during the 1999 baseline monitoring program and updates the rating curves for sites where discharge measurements were conducted.

2.0 SCHEDULE OF 1999 SITE VISITS

The schedule of site visits for the 1999 field monitoring program is contained in the March 3, 1999 AGRA proposal to conduct the TCP baseline monitoring. A copy of the AGRA proposal is contained in Appendix A for reference. The dates of actual site visits and a listing of the work conducted during the site visits is contained in Table 1. The discharge measurement focus was on the low flow periods.

TABLE 1
1999 Monitoring Site Visits

Week of:	Feb 1	Aug 1	Sept 19	Nov 14
Telkwa River	WQ		WQ	
Upper Tenas Creek	No site access		SM, WQ, Q	S
Lower Tenas Creek	WQ, Q	S	SM, WQ, Q	S
Bulkley River	WQ		WQ	
Hubert Creek	WQ, S	S	WQ, S	S
Four Creek	WQ	S	WQ, Q	S
Upper Goathorn Creek	WQ, Q		SM, WQ, Q	S
Lower Goathorn Creek	WQ		WQ	

Q = Discharge and stage measurements conducted S = Stage measurements conducted
WQ = Water quality sampling conducted SM = Site Maintenance Visit

The purpose of the August field trips was to collect peak flow information from the crest gauges at each site and to survey the equipment and benchmarks at each site for the low flow period.

3.0 SURFACE WATER MONITORING RESULTS

This section contains a summary of the five sites where surface water monitoring was conducted during the 1999 field season. Summary field data for the site visits is contained in Appendix B.

3.1 LOWER TENAS CREEK SITE

The lower Tenas Creek site was visited four times as part of the 1999 monitoring program. The station was operated as a manual sampling with no installation of the automated equipment used in previous years.

The two low flow discharge measurements conducted during February and September yielded discharges of 0.041 m^3/s and 0.163 m^3/s respectively. These discharge measurements have been added to the rating curve and a revised rating curve for this site is shown in Figure 2.

An initial crest gauge installed in late 1998 at the site was replaced during the 1999 sampling season. Level surveys conducted at the site during the 1999 field season did not show significant shift of the benchmarks or the staff gauge. There was evidence of sand deposition noted near the gauge during the November 1999 field visit.

3.2 UPPER TENAS CREEK SITE

The upper Tenas Creek was visited twice during the 1999 monitoring program. There was no site access during the February 1999 field trip. As the crest gauge for this site was not checked and reset during February, this site was not visited during the August field trip.

The crest gauge was checked during September and the maximum stage was observed to be 0.70 m. This value would translate to a discharge of 8.43 m^3/s and is expected to be due to the spring freshet which consistently produces greater discharges than the fall peak flows. The low flow measurement from September 20th was 0.134 m^3/s. An updated rating curve for this site is shown in Figure 3. The two 1999 data points plot above the current stage-discharge relation. AGRA proposes that one high flow measurement be conducted at this site during the 2000 field season to determine whether the rating curve should be shifted upwards. * No.

The September field visit to this site showed that the braces for the staff gauge had snapped but that the staff gauge did not appear to have shifted (based on a review of previous site photographs). Braces at the site were replaced and a third benchmark was added on the right bank side of the stream. Levelling checks showed that there was no significant shift of the benchmarks or the staff gauge during 1999. The breakage of the braces resulted in slight downstream leaning of the staff gauge mounting but this was corrected during the site maintenance visit.

3.3 UPPER GOATHORN CREEK SITE

The upper Goathorn Creek site was visited four times during the 1999 monitoring program. The station was monitored as a manual station with a staff gauge and crest gauge.

The two low flow discharge measurements conducted during February and September yielded discharges of 0.097 m^3/s and 0.337 m^3/s respectively. These discharge measurements have been added to the rating curve and a revised rating curve for this site is shown in Figure 4.

Maintenance of the gauge equipment was conducted during the September visit . The bracing for the staff gauge was reinforced and the staff gauge was lowered by a distance of 0.19 m. A second staff gauge was added to the top of the first staff gauge to allow for visual measurement of peak flow levels during the freshet period. The level check of benchmarks showed that there were no changes in the elevations of the benchmarks. The staff gauge did not show any significant shift during the 1999 season.

problem with chart

3.4 FOUR CREEK SITES

Two sampling locations were operated on Four Creek during the 1999 field season. The low flow discharge measurements were made at the lowest road culvert crossing of Four Creek. Other stage measurements and water quality sampling were conducted at the original stream flow sampling site located approximately 1,800 m upstream of the culvert crossing on Four Creek.

Discharges for the low flow periods were determined by calculation of the discharge through the culvert based on the known inlet water levels and the culvert characteristics. The February low flow measurement revealed that there was only a small quantity of baseflow (< 1L/min) during the sampling trip. The culvert was almost completely iced up. The September low flow discharge for the culvert was calculated to be 0.077 m^3/s.

3.5 HUBERT CREEK SITE

The Hubert Creek site was visited four times during the 1999 monitoring program. Readings for the staff gauge are available from two of the site visits. Visits conducted during September and November did not yield useful data on flow levels due to numerous partial blockages of the culvert inlet by debris.

The crest gauge at the site indicated that there was a recorded stage greater than 1.23 m during the spring 1999 freshet period. This high stage is believed to be partially due to beaver debris blockage of the inlet of the Hubert Creek culvert.

4.0 WATER QUALITY MONITORING RESULTS

In 1999, baseline water chemistry was sampled during the two low flow periods at ten sites in the proposed Telkwa Coal Project area. The data for the February 1999 water quality monitoring was forwarded directly to Luscar as previously arranged. The laboratory results for the September water quality trip are included in Appendix C of this report. No analysis of the testing data, other than to identify specific stations where the BC Water Quality Criteria (Nagpal, 1995) were exceeded. A summary of metals and stations where exceedances occurred are summarized in Table 2. Due to operator error during the September 1999 water quality field trip, triplicate sampling was not conducted. A blank sample obtained from Chemex did not have any exceedances. ??

QA/QC not done properly

TABLE 2: B.C. WATER QUALITY CRITERIA EXCEEDANCE INFORMATION FOR THE SEPTEMBER 20, 1999 SAMPLING TRIP

METAL	B.C. WATER QUALITY CRITERIA	STATIONS WITH TOTAL METALS CONCENTRATIONS GREATER THAN THE B.C. CRITERIA	STATIONS WITH TOTAL METALS CONCENTRATIONS EQUAL TO THE B.C. CRITERIA
Cr	2.0 ug/L	Telkwa River (2.5)	Upper Goathorn Creek, Lower Goathorn Creek, Bulkley River, Hubert Creek, Lower Tenas, Four Creek
Cu	2.0 ug/L	Telkwa River (2.4)	
Fe	0.3 mg/L	Telkwa River (0.8), Hubert Creek (1.03), Bulkley River (0.33)	
Zn	3.0 ug/L	Telkwa River (3.5)	

5.0 CLOSURE

AGRA Earth Environmental Limited is pleased to present this 1999 data summary to Luscar Ltd. AGRA looks forward to continuing to work with Luscar on the Telkwa Coal project over the 2000 season. Should you have any questions concerning this project please do not hesitate to contact the undersigned at (250) 847-8783.

Respectfully Submitted,

Reviewed by,

Scott Davidson, M.Sc., P.Geo.
Project Manager

Gary R.E. Beckstead, M.Sc., P.Eng.
Senior Water Resource Engineer

Dennis Trotter
Senior Toxicologist

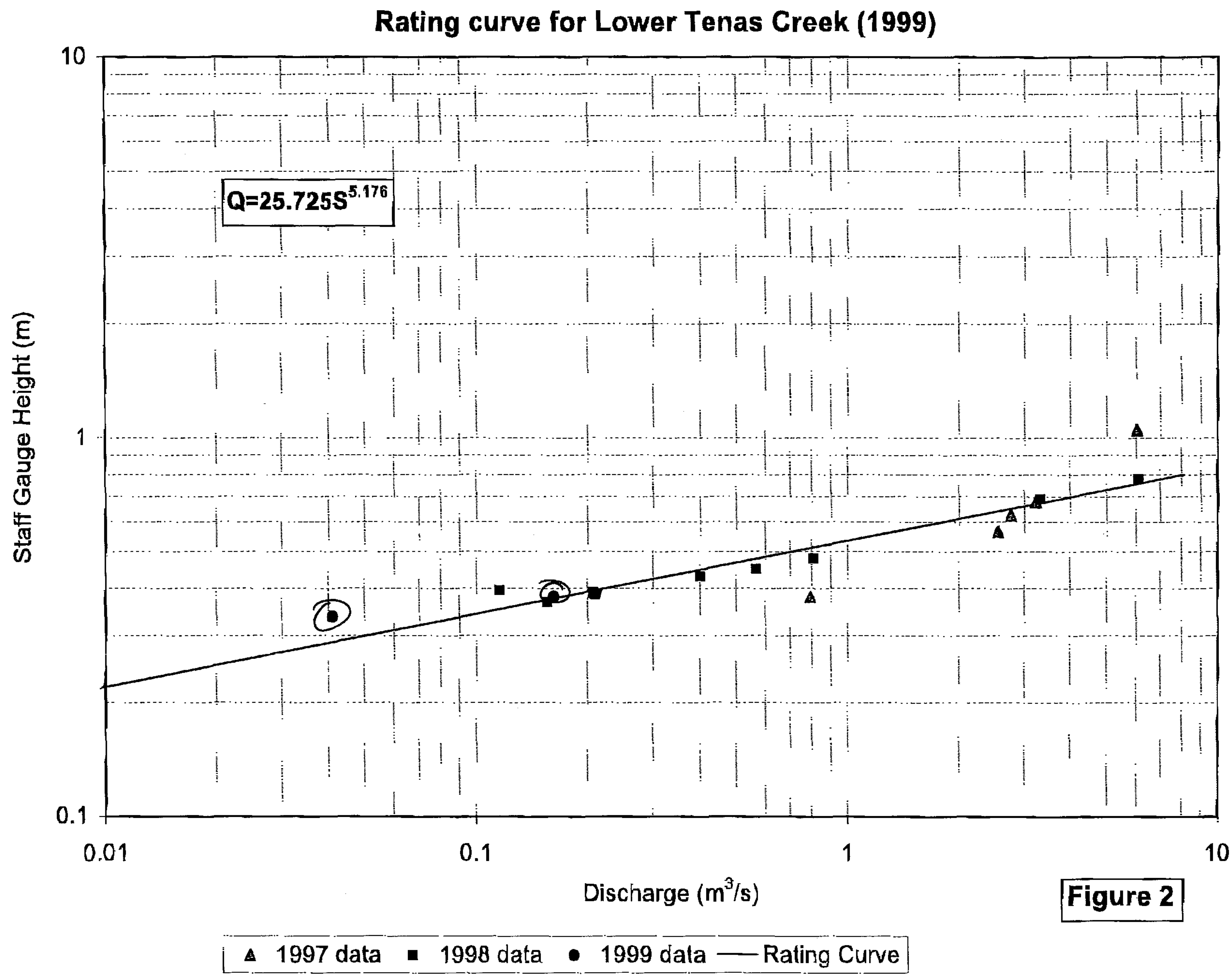
Rating curve for Lower Tenas Creek (1999)
Q=25.725S^5.176
Staff Gauge Height (m)
10
1
0.1
0.01
0.1
1
10
Discharge (m3/s)
1997 data
1998 data
1999 data
Rating Curve

Figure 2

Rating Curve for Upper Tenas Creek (1999)

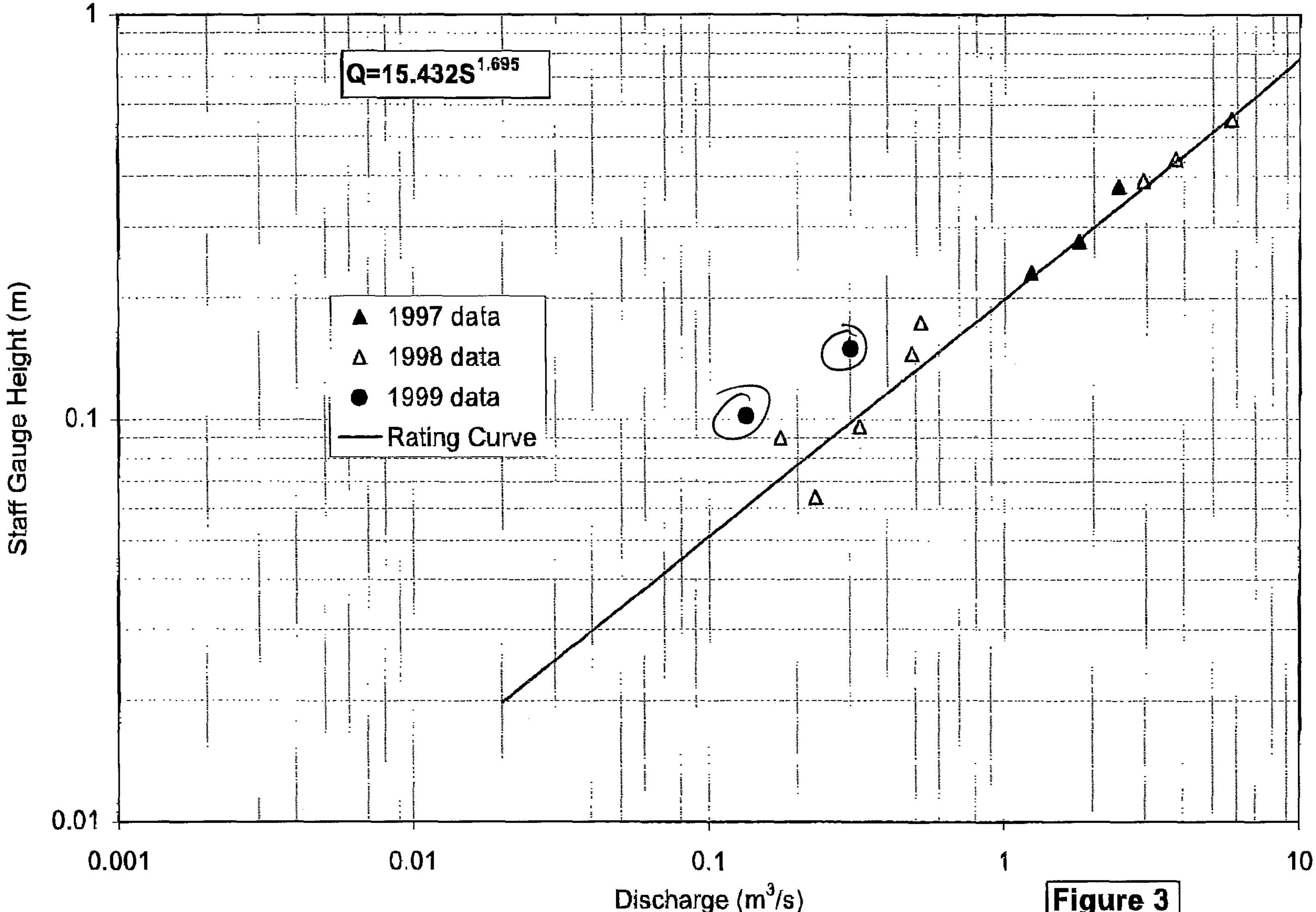

Figure 3

Graph. Did not change from 1998
(slope/intercept

Rating Curve for Upper Goathorn Creek (1999)

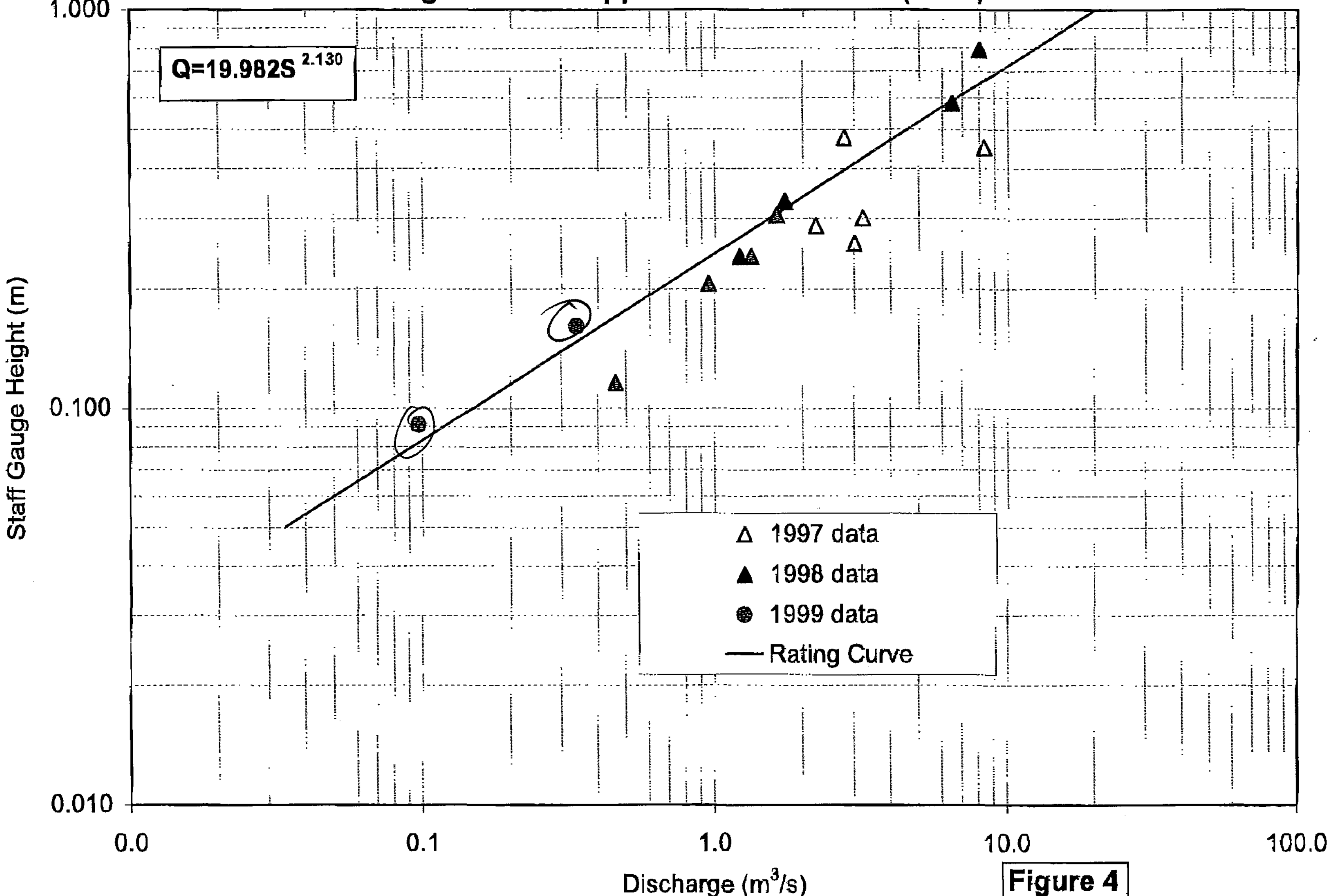

Figure 4

data looks different

AGRA
ENGINEERING GLOBAL SOLUTIONS

AGRA Earth &
Environmental Limited
Box 3966
#3-3167 Tatlow Road
Smithers, B.C. V0J 2N0
Tel (250) 847-8783
Fax (250) 847-9049

June 8, 1999

KS00076

Luscar Ltd.
1600 Oxford Tower
10235 - 101 Street
Edmonton, AB. T5J 3G1

Attention: Allan Flemming, P.Eng.
Project Engineer

RE: 1999 DATA REPORT UPDATE

Dear Mr. Flemming,

AGRA Earth & Environmental Limited (AGRA) is pleased to present LuscarLtd. (Luscar) with this report containing data collected as part of the 1999 Telkwa Coal Surface Water and Water Quality Baseline Monitoring Program. The data presented in this report includes low flow data from February 1999 and the results of the site visits conducted during April and May to re-establish the crest gauges at selected sites.

LOW FLOW MONITORING TRIP

Low flow monitoring was conducted at sites on February 16th and 17th, 1999. During this trip water quality sampling was also completed; the data was directly forwarded from Chemex Labs to Luscar. The list of sites and the sampling completed is presented in Table 1.

Table 1. Low Flow Monitoring Trip Summary

SITE	FLOW CONDITIONS	WATER QUALITY SAMPLING
Telkwa River	Water level was 45 cm below the level of the main staff gauge located on the old bridge pilings.	Samples for total metals, dissolved metals and general nutrient analysis were collected.
Lower Goathorn Creek	There was some flow in the creek below approximately 30 cm of ice.	Samples for total metals, dissolved metals and general nutrient analysis were collected.
Four Creek	No evidence of flow at the lower culvert crossing.	No samples collected.
Upper Goathorn Creek	Water level was 0.1 m below the staff gauge. Discharge was measured to be 0.097 m^3/s.	Samples for total metals, dissolved metals and general nutrient analysis were collected.
Lower Tenas Creek	Staff gauge reading 0.337 m. Discharge was measured to be 0.041 m^3/s.	Samples for total metals, dissolved metals and general nutrient analysis were collected.
Hubert Creek	Staff gauge iced up; Unable to estimate water level. Discharge estimated from outlet velocity and depth to be 0.024 m^3/s.	Samples for total metals, dissolved metals and general nutrient analysis were collected.

RE-ESTABLISHMENT OF CREST GAUGES AND BENCHMARKS

The monitoring program was revised to meet Luscar's request to monitor peak flows at the study streams using only crest gauges. The crest gauges were visited at accessible sites to add cork and to check the relative elevations of staff gauges and crest gauges to site benchmarks. Table 2 contains a summary of the work completed in re-establishing the monitoring gauges.

As a result of weather conditions during April and May, the re-establishment of crest gauges required that multiple field trips be made. The two upper sites on Goathorn Creek and Tenas Creek were not accessable during May due to snow and road conditions. Therefore, AGRA did not re-establish these upper two sites, but chose instead to collect peak flow information from the lower sites on these streams. This was deemed to be the most effective use of available resources and budget given ground conditions. Peak flow levels will be determined during a field trip to be made to sites during July 1999. No crest stage readings for the Upper Goathorn and Upper Tenas sites until the july visit.

Table 2. Site Re-establishment for Peak Flow Determination

SITE	DATE VISITED	WORK COMPLETED
Telkwa River	April 14th, 1999	Water level was 45 cm below the level of the staff crest gauges at the site.
Hubert Creek	April 14th, 1999	Cork added to the crest gauge at the site. Staff gauges and benchmarks leveled for determining offsets.
Tailings Pond	April 16th, 1999	Cork added to the crest gauge at the site. Weir face, staff gauge and benchmarks leveled for determining offsets.
Four Creek	May 12th, 1999	Cork added to the crest gauge at the original site. Staff gauge and benchmarks leveled for determining offsets.
Lower Tenas Creek	May 12th, 1999	Cork added to the crest gauge at the site. Staff gauge and benchmarks leveled for determining offsets.
Lower Goathorn Creek	No work conducted at the site maintained by the WSC .	
Upper Tenas Creek	(May 12th, 1999)	No access to site because of snow and road conditions.
Upper Goathorn Creek	(May 12th, 1999)	No access to site because of snow and road conditions.

AGRA Earth & Environmental Limited is pleased to present this summary of data collection and work completed to date on the Telkwa Coal Project. Digital copies of the collected data will be forwarded to Luscar. Should you require any further information on this project please do not hesitate to contact the undersigned at (250) 847-8783.

Respectfully submitted,

AGRA Earth & Environmental Limited

Scott Davidson, M.Sc., P.Geo.
Project Manager

Reviewed by

Gary R.E. Beckstead, Msc., P.Eng.
Senior Project Manager

AGRA Earth & Environmental

ENGINEERING GLOBAL SOLUTIONS

AGRA Earth &
Environmental Limited
Box 3966
#3, 3167 Tatlow Road
Smithers, BC
Canada V0J 2N0
Tel (250) 847-8783
Fax (250) 847-9049

March 2, 1999
CW1537.1

Luscar Ltd.
1600 Oxford Tower
10235 - 101 Street
Edmonton, Alberta T2P 3V4

Attention: Mr. Allan Flemming, P.Eng. Fax: (403) 420-5875

Dear Mr. Flemming:

Re: Telkwa Coal Mine
Revised 1999 Budget

1.0 SURFACE WATER MONITORING

AEE is pleased to present this revised budget for the 1999 baseline water flow and water quality program for the proposed Telkwa Coal Project. It is the understanding of AEE that during 1999 Luscar should be submitting the Final Project Report to the B.C. Environmental Assessment Office. Following certification of the project, it is the understanding of AEE that the entire surface water and water quality program may need to be revised to meet the construction plan for the mine.

2.0 WORK PROGRAM AND BUDGET

The work program proposed for 1999 is as follows:

Surface Water Flow

- Concentration of the base program on the winter and summer low flow periods.
- Monitoring of low flows on Four Creek, Hubert Creek, Tenas Creek, Upper Goathorn Creek and Lower Goathorn Creek. No monitoring will be conducted on Helps Creek, Telkwa River, and the Bulkley River. Low flow monitoring will result in two site visits. To reduce cost to Luscar, AEE has scheduled the summer low flow period measurement trip to coincide with site visit #3 described below.
- Monitoring of peak flows at the streams using crest gauges already installed at all of the existing sites. To conduct this portion of the required work, AEE will conduct a total of four sites visits planned as follows:

1. Pre-freshet to set up crest and staff gauges and survey to local bench marks (April),
2. Post freshet to record peak flow during period and survey to local bench marks (June),
3. Pre fall high flow period to re-survey benchmarks and survey to local bench marks (late August to early September),

4. Post fall high flow to record peak flow and survey to local bench marks (November).

Water Quality

- Sampling of baseline parameters for the two low flow periods only.

Data Analysis

AEE proposes to conduct data analysis and reporting for the 1999 sampling program following each monitoring trip. A data analysis period has been allowed following each of the five surface flow site visits (one low flow and four peak flow visits) described above. The information reports from each trip will assist Luscar in public meetings by providing the most up to date information on the project.

Project Management

Project management involves dealing with items such as cost control, client liaison, and interfacing with other consultants working for Luscar on the proposed Telkwa Coal Mine. For the 1999 sampling program, AEE proposes to conduct project management on a cost plus basis. The totals for this item in the attached Table 1 represent estimates of the total budget required for project management. AEE will make every effort to ensure that it conducts stringent cost control on the project management for Luscar. Project management for the 1999 program will be conducted by Mr. Scott Davidson, M.Sc., P.Geo. of the Smithers office. Mr. Gary Beckstead, M.Sc., P.Eng. and Mr. Dennis Trotter will provide technical input and review to the project as required.

3.0 CLOSURE

We thank you for the opportunity to provide engineering and environmental services to this project and look forward to continuing to work with Luscar on the proposed Telkwa Coal Mine during 1999. If you have any questions or require further information concerning this project, please call Scott Davidson at (250) 847-8783 or Gary Beckstead at (403)235-8118.

Yours sincerely,

AGRA Earth & Environmental Limited

Reviewed by

Scott Davidson, M.Sc., P.Geo.
Project Manager

Gary R.E. Beckstead, M.Sc., P.Eng.
Senior Water Resource Engineer

C:\files\working\Luscar\1999\revised budget99.wpd
cc. Gary R.E. Beckstead, AEE - Calgary

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Table 1
Budget Estimate for 1999 Hydrometric Monitoring and Water Quality Sampling
Telkwa Coal Project

Task	Assumptions	Month												Total
		Jan	Feb	Mar.	Apr.	May	June	Jul.	Aug	Sept.	Oct	Nov.	Dec.	
Surface Flow Monitoring	1,3,4,6													
Labour		$ -	$ 3,240.00	$ -	$1,350.00	$ -	$ 1,284.00	$ -	$1,284.00	$ -	$ -	$1,080.00	$ -	$ 8,238.00
Disbursements		$ -	$ 378.00	$ -	$ 189.00	$ -	$ 169.00	$ -	$ 189.00	$ -	$ -	$ 189.00	$ -	$ 1,134.00
Water Quality	1,5,6,7													
Sampling		$1,115.00	$ 2,838.00	$ -	$ -	$ -	$ -	$ -	$ 428.00	$ -	$ -	$ -	$ -	$ 4,381.00
Disbursements		$ 310.20	$ 645.00	$ -	$ -	$ -	$ -	$ -	$ 100.00	$ -	$ -	$ -	$ -	$ 1,055.20
Data Analysis	1													
Labour		$ -	$ -	$ 970.00	$ 970.00	$ -	$ 970.00	$ -	$ -	$ 970.00	$ -	$ 970.00	$ -	$ 4,850.00
Disbursements		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Project Management	1,2													
Labour		$ 150.00	$ 150.00	$ 150.00	$ 150.00	$ 150.00	$ 150.00	$ 150.00	$ 150.00	$ 150.00	$ 150.00	$ 150.00	$ 150.00	$ 1,800.00
Disbursements		$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 300.00
Total (Required Work)		$1,600.20	$ 7,276.00	$ 1,145.00	$2,684.00	$ 175.00	$ 2,618.00	$ 175.00	$2,176.00	$ 1,145.00	$ 175.00	$2,414.00	$ 175.00	$ 21,758.20

Assumptions:
1 The above budget is based on the Fw rate schedule
2 Project Management is quoted as an estimated maximum budget and will be billed on a cost plus basis.
3 The summer low flow period extends over August and September
4 The winter low flow period extends over February and March
5 The January water quality sampling costs represent the Selenium sampling
6 Disbursements listed under Water Flow and Water Quality are estimates for sampling equipment and vehicle expenses and do not include 10% handling charge
7 All Laboratory Analysis is to be directly billed to Luscar Ltd.

Fwd to JED at NDH.
For your comment
[illegible]

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

AGRA Earth &
Environmental Limited
Box 3966
#3, 3167 Tatlow Road
Smithers, BC
Canada V0J 2N0
Tel (250) 847-8783
Fax (250) 847-9049

January 29, 1999
CW1537.1

Luscar Ltd.
1600 Oxford Tower
10235 - 101 Street
Edmonton, Alberta T2P 3V4

Attention: **Mr. Allan Flemming, P.Eng.** Fax: (403) 420-5875

Dear Mr. Flemming:

Re: Telkwa Coal Mine
Revised 1999 Budget

1.0 SURFACE WATER MONITORING

As per the January 26th, 1999 discussion between Gary Beckstead of AGRA Earth & Environmental Limited (AEE) and Allan Flemming of Luscar Ltd. (Luscar), AEE is pleased to present this revised budget for the 1999 baseline water flow and water quality program for the proposed Telkwa Coal Project. It is the understanding of AEE that during 1999 Luscar should be submitting the Final Project Report to the B.C. Environmental Assessment Office. Following certification of the project, it is the understanding of AEE that the entire surface water and water quality program may need to be revised to meet the construction plan for the mine.

2.0 WORK PROGRAM AND BUDGET

The revised budget presented in Table 1 is based on the scope of services requested by Luscar at the January 26th, 1999 meeting. The work program proposed for 1999 is as follows:

Surface Water Flow

Jp + L

- Concentration of the base program on the winter and summer low flow periods.
- Monitoring of low flows on Four Creek, Hubert Creek, ~~Helps Creek~~, Upper Goathorn Creek and Lower Goathorn Creek. No monitoring will be conducted on Tenas Creek, Telkwa River, and the Bulkley River.
- Monitoring of peak flows at the streams using crest gauges already installed at all of the existing sites. To conduct this portion of the required work, AEE must visit all sites during April to ensure that the sites are ready for the peak flow period (i.e. Checking of staff gauges and crest gauges). During November time has been allocated for conducting a final site visit to all sites to determine their condition prior to winter.
- A cost option has been prepared to operate the data loggers and pressure transducers at the continuous monitoring sites and to conduct a single high flow discharge measurement.

Water Quality

- Sampling of baseline parameters for the two low flow periods only.
- Sampling of metals for the two low flow periods.

Selenium sampling was requested to be deleted from the scope of work for 1999, however, the sampling for this was completed prior to receiving notification from Luscar. It is the expectation of AEE that the costs of this sampling will be paid by Luscar as the work was conducted at the request of Mr. Jerry Demchuck, the environmental coordinator for the Telkwa Coal Project. All future requests for increased sampling will not be initiated by AEE until a signed order to proceed with the work has been received from Luscar.

Not true.

Reporting

AEE proposes to conduct reporting for the 1999 sampling program following each monitoring trip. A data memo will be issued to Luscar presenting the results of the monitoring trip. This information will assist Luscar in public meetings by providing the most up to date information on the project. The costs of reporting for the optional water flow monitoring program are included in Table 1 as an additional cost of approximately $530.00 per monthly report.

Project Management

Project management involves dealing with items such as cost control, client liaison, responding to requests for extra work, and interfacing with other consultants working for Luscar on the proposed Telkwa Coal Mine. For the 1999 sampling program, AEE proposes to conduct each portion of the project as separate tasks. On receiving a request for extra work, AEE will issue to Luscar for approval, a change of work order along with an expected budget to complete the extra work. Project management for the 1999 program will be conducted by Mr. Scott Davidson, M.Sc., P.Geo. of the Smithers office. Mr. Gary Beckstead and Mr. Dennis Trotter will provide technical input and review to the project as required.

3.0 CLOSURE

We thank you for the opportunity to provide engineering and environmental services to this project and look forward to continuing to work with Luscar on the proposed Telkwa Coal Mine during 1999. If you have any questions or require further information concerning this project, please call Scott Davidson at (250) 847-8783 or Gary Beckstead at (403)235-8118.

Yours sincerely,

AGRA Earth & Environmental Limited

Reviewed by

Scott Davidson, M.Sc., P.Geo.
Project Manager
C:\files\working\Luscar\1999\revised budget99.wpd

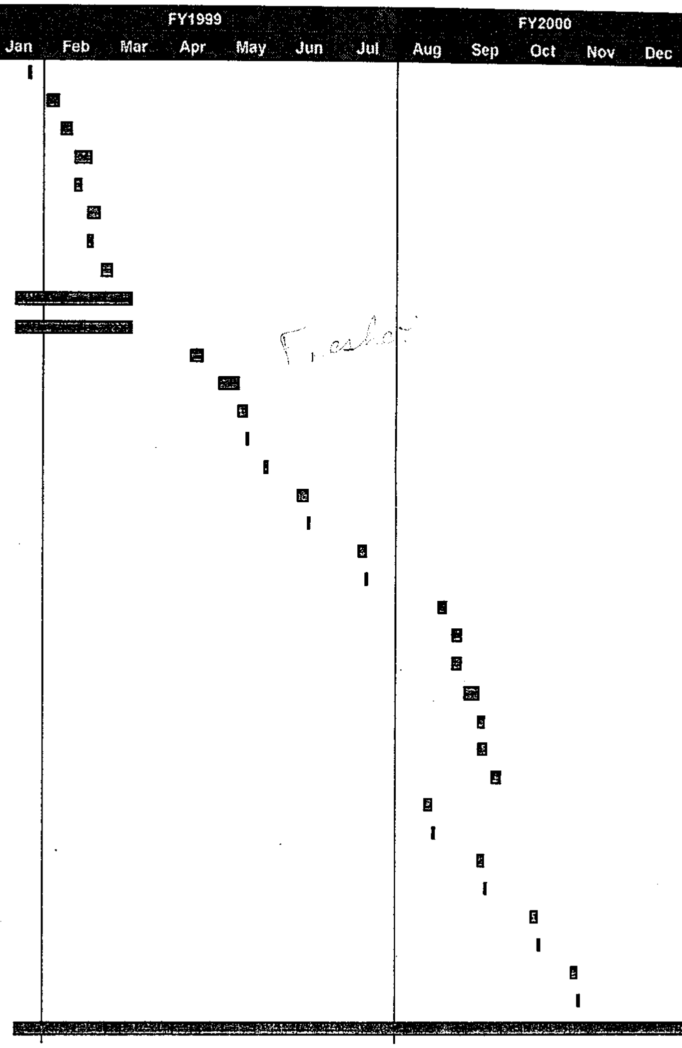
Gary R.E. Beckstead, M.Sc., P.Eng.
Senior Water Resource Engineer

cc. Gary R.E. Beckstead, AEE - Calgary
Jerry Schmidt, AEE - Prince George

CW1537.00 Task 1999 Luscar Ltd.

Task Name	Start Date	Effort	End Date
Selenium Sampling Trip	1/21/99	2.00d	1/21/99
Winter Water Quality Trip	1/31/99	3.00d	2/5/99
Winter Revised Metals Sampling Trip	2/7/99	1.13d	2/12/99
Winter Revised Metals Sampling Trip	2/14/99	1.13d	2/22/99
Winter Low Flow Discharge Measurement	2/14/99	3.00d	2/17/99
Winter Revised Metals Sampling Trip	2/21/99	1.13d	2/26/99
Winter Low Flow Discharge Measurement	2/21/99	3.00d	2/23/99
Winter Revised Metals Sampling Trip	2/28/99	1.13d	3/5/99
Lab Calibration of Pressure Transducers	1/15/99	2.00d	3/15/99
Other Lab Prep Time Associated with Equipment Preparation	1/15/99	4.00d	3/15/99
All Sites Visit	4/15/99	4.00d	4/21/99
Installation of Automated Sites	4/30/99	2.00d	5/10/99
All Sites Visit, Data Download	5/10/99	3.00d	5/14/99
Data Analysis	5/14/99	1.00d	5/14/99
High Flow Discharge Measurement	5/24/99	4.00d	5/25/99
All Sites Visit and Data Download	6/10/99	3.00d	6/15/99
Data Analysis	6/15/99	1.00d	6/15/99
All Sites Visit and Data Download	7/12/99	3.00d	7/15/99
Data Analysis	7/16/99	1.00d	7/16/99
Summer Water Quality Trip	8/23/99	3.00d	8/26/99
Summer Revised Metals Sampling Trip	8/30/99	0.75d	9/3/99
Low Flow Discharge Measurement	8/30/99	3.00d	9/3/99
Summer Revised Metals Sampling Trip ??	9/6/99	0.75d	9/13/99
Summer Revised Metals Sampling Trip	9/13/99	0.75d	9/16/99
Low Flow Discharge Measurement	9/13/99	3.00d	9/17/99
Summer Revised Metals Sampling Trip	9/20/99	0.75d	9/24/99
All Sites Visit and Data Download	8/16/99	3.00d	8/19/99
Data Analysis	8/20/99	1.00d	8/20/99
All Sites Visit and Data Download	9/13/99	3.00d	9/16/99
Data Analysis	9/17/99	1.00d	9/17/99
All Sites Visit, Data Download	10/11/99	5.00d	10/14/99
Data Analysis	10/15/99	1.00d	10/15/99
Decommissioning of Sites/All Sites Visit	11/1/99	2.00d	11/4/99
Data Analysis	11/5/99	1.00d	11/5/99
Project Management	1/15/99	5.75d	12/31/99

why diff. dates?



Hubert
Four Creek (couldn't
L T
U G
L G quality (WSC) did

AGRA Earth & Environmental
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?? diff

sel

Table 1
Budget Estimate for 1999 Hydrometric Monitoring and Water Quality Sampling
Telkwa Coal Project

closing

Task	Assumptions	Jan	Feb	Mar.	Apr.	May	June	Jul.	Aug	Sept	Oct	Nov.	Dec.	Total
Required Flow Monitoring	1,2,3,4,8,9													
Labour		$ -	$ 3,240.00	$ -	$2,160.00	$ -	$ -	$ -	$1,284.00	$ 1,284.00	$ -	$ 856.00		$ 8,824.00
Disbursements		$ -	$ 378.00	$ -	$ 189.00	$ -	$ -	$ -	$ 189.00	$ 189.00	$ -	$ 69.30		$ 1,014.30
Optional Flow Monitoring	1,4,7,8,9													
Labour		$ -	$ -	$ -	$1,560.00	$ 3,974.00	$ 1,814.00	$ 1,814.00	$1,814.00	$ 1,814.00	$1,814.00	$1,376.00		$ 15,980.00
Disbursements		$ -	$ -	$ -	$ 300.00	$ 249.00	$ 249.00	$ 249.00	$ 249.00	$ 249.00	$ 249.00	$ 249.00		$ 2,043.00
Water Quality	1,2,3,5,8,9,10													
Sampling		$1,115.00	$ 2,838.00	$ 493.00	$ -	$ -	$ -	$ -	$1,674.00	$ 1,545.00	$ -	$ -	$ -	$ 7,665.00
Disbursements		$ 310.20	$ 645.00	$ 169.00	$ -	$ -	$ -	$ -	$ 407.00	$ 407.00	$ -	$ -	$ -	$ 1,938.20
Reporting	1,6,7													
Labour		$ -	$ 785.00	$ 635.00	$ 472.50	$ -	$ -	$ -	$ 597.50	$ 1,232.50	$ -	$ 472.50	$ -	$ 4,195.00
Disbursements		$ -	$ 100.00	$ 100.00	$ 100.00	$ -	$ -	$ -	$ 100.00	$ 100.00	$ -	$ 100.00	$ -	$ 600.00
Project Management	1,8													
Labour		$ 780.00	$ 405.00	$ 405.00	$ 405.00	$ 405.00	$ 405.00	$ 405.00	$ 405.00	$ 405.00	$ 405.00	$ 405.00	$ 405.00	$ 5,235.00
Disbursements		$ 100.00	$ 100.00	$ 100.00	$ 100.00	$ 100.00	$ 100.00	$ 100.00	$ 100.00	$ 100.00	$ 100.00	$ 100.00	$ 100.00	$ 1,200.00
Total (Required Work)		$2,305.20	$ 8,491.00	$ 1,902.00	$3,426.50	$ 505.00	$ 505.00	$ 505.00	$4,756.50	$ 5,262.50	$ 505.00	$2,002.80	$ 505.00	$ 30,671.50
Total (Optional Work)		$ -	$ -	$ -	$1,860.00	$ 4,223.00	$ 2,063.00	$ 2,063.00	$2,063.00	$ 2,063.00	$2,063.00	$1,625.00	$ -	$ 18,023.00

take out

diff trips

somewhat high

one time

too high

Assumptions:
1 The above budget are based on the Fw rate schedule
2 The summer low flow period extends over August and September
3 The winter low flow period extends over February and March
4 The Optional Water Flow Sampling would result in 1 monthly monitoring visit per month and 1 discharge measurement during May 1999
5 The January water quality sampling costs represent the Selenium sampling
6 Reporting costs are for the preparation of summary reports following completion of required project tasks
7 Reporting Costs from the Optional Water Flow program would be approximately $530.00 per monthly update report
8 Internal Disbursements are to be billed at Cost Plus 10% with information on these disbursements provided to Luscar Ltd..
9 Disbursements listed under Water Flow and Water Quality are estimates for sampling equipment and vehicle expenses and do not include 10% handling charge.
10 All Laboratory Analysis is to be directly billed to Luscar Ltd.

drop summer routine

4 Automated sites 3-4000 each

water quality at Luscar sites only

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

CC: JED for comment

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

AGRA Earth & Environmental Limited
221 - 18th Street S.E.
Calgary, Alberta
Canada T2E 6J5
Tel (403) 248-4331
Fax (403) 248-1590

January 21, 1999
CW1537.901.1

DRAFT

Way, way too much.

Luscar Ltd.
1600 Oxford Tower
10235 - 101 Street
Edmonton, Alberta T2P 3V4

Attention: Mr. Allan Flemming, P.Eng. Fax: (403) 420-4089

Dear Mr. Flemming:

Re: Telkwa Coal Mine
1999 Budget

1.0 SURFACE WATER MONITORING

As per the January 19th, 1999 discussion between Gary Beckstead of AGRA Earth & Environmental Limited (AEE) and Allan Flemming of Luscar Ltd. (Luscar), AEE is pleased to present this "**draft**" budget for the 1999 baseline water flow and water quality program for the proposed Telkwa Coal Project. This draft will be discussed with you at your office on January 26th, 1999. It is the understanding of AEE that during 1999 Luscar should be submitting the Final Project Report to the B.C. Environmental Assessment Office. Following certification of the project, it is the understanding of AEE that the entire surface water and water quality program will need to be revised.

2.0 WORK PROGRAM AND BUDGET

AEE's proposed 1999 work program is intended to allow for revision of the program during the year. Table 1 presents the monthly budget breakdown for 1999.

The work program proposed for 1999 is as follows:

Surface Water Flow

- Three winter low flow discharge measurements on the Telkwa River;
- Five free flow period discharge measurements at all sites[1];
- An initial site visit during spring followed by an installation trip to sites; and
- Seven trips to perform routine maintenance and downloading of continuous sites.

[1] The Telkwa River will only be measured during three of the five free flow discharge measurement trips

Water Quality

- Four trips are scheduled for seasonal baseline water quality sampling;
- One sediment collection trip is included with the seasonal baseline trips; and
- High frequency revised metals sampling program started in 1998 is currently scheduled for continuation in 1999[2].

Reporting

AEE proposes to conduct reporting for the 1999 sampling program at approximately four month intervals. By separating the reporting into smaller pieces, AEE expects to be able to realize cost savings over the previous annual report preparation costs. The issuing of three data reports during 1999 will also allow for easier revision of the sampling program following submittal of the Final Project Report and project certification.

Project Management

Project management involves dealing with items such as cost control, client liaison, responding to requests for extra work, and interfacing with other consultants working for Luscar on the proposed Telkwa Coal Mine. AEE has found that the project management required for the proposed Telkwa Coal Mine exceeded the original budget estimate. Based on an analysis of previous work, AEE has revised its method of project management for the 1999 sampling program. AEE feels that the revisions made to project management will simplify tracking of costs for each phase of the project.

Previous requests for extra work conducted by AEE on the Telkwa Coal project were often accompanied by a directive to bill the work to the existing sampling program budget. For the 1999 sampling program, AEE proposes to conduct each portion of the project as separate tasks. On receiving a request for extra work, AEE will issue to Luscar for approval, a change of work order along with an expected budget to complete the extra work.

only because original budget was small.

3.0 CLOSURE

We thank you for the opportunity to provide engineering and environmental services to this project and look forward to continuing to work with Luscar on the proposed Telkwa Coal Mine during 1999. It is the understanding that AEE and Luscar will discuss this draft budget during

---

2 The revised sampling program is intended to determine the optimum sampling frequency for project. Following the winter and spring sampling trips, AEE should have sufficient data to determine the optimum sampling frequency allowing for modification of the water quality program.

a meeting scheduled for Tuesday, January 26th, 1999. Other items which I would like to discuss with you on Tuesday include:

- miscellaneous disbursement charge (% of fees); and
- possible shift of Project Manager to Scott Davidson in Smithers.

If you have any questions or require further information prior to this meeting, please call Gary Beckstead at (403)235-8118.

Yours sincerely,

AGRA Earth & Environmental Limited

Scott Davidson, M.Sc., P.Geo.
Smithers Office Manager

Gary R.E. Beckstead, M.Sc., P.Eng.
Senior Project Manager

GREB/km

attach.

P:\PROJECT\Cw\1537.1\Proj_Mgt\Budget\L_AF0120_budgot99.wpd

(Low #2)
① Four
② Hubert/Helps
③ Goatham (2)

Staff guages for high flow
+option for datalogger

low flow (2 times)
high flow (1 times)

winter
Quality low flow

data reports after low flow
Not big reports

Purchase Order

Tenas
Telkwa
Bulkley

— no % of disbursements
itemize

DRAFT

Table 1
Budget Estimate for 1999 Hydrometric Monitoring and Water Quality Sampling
Telkwa Coal Project

Task	Personnel	Month												Total
		Jan	Feb	Mar.	Apr.	May	June	Jul.	Aug	Sept	Oct	Nov.	Dec.	
Flow Monitoring														
Labour		$	$ 4,425.00	$ 3,160.00	$ 2,160.00	$ 3,546.00	$ 4,036.00	$ 3,088.00	$ 3,086.00	$ 1,802.00	$ 2,660.00	$ 1,376.00		$ 29,341.00
Disbursements		$	$ 501.60	$ 165.00	$ 69.30	$ 398.00	$ 622.50	$ 737.00	$ 440.00	$ 69.30	$ 289.30	$ 69.30		$ 3,259.30
Water Quality														
Sampling		$ 1,115.00	$ 3,013.00	$ 743.00	$ -	$ 1,265.00	$ 2,160.00	$ 2,332.00	$ 835.00	$ 1,940.00	$ -	$ -	$ -	$ 13,403.00
Disbursements		$ 310.20	$ 4,442.90	$ 675.40	$ -	$ 5,183.20	$ 1,350.80	$ 4,901.60	$ 1,350.80	$ 5,989.50	$ -	$ -	$ -	$ 24,204.40
Reporting														
Labour		$ -	$ -	$ -	$ -	$ 1,350.00	$ -	$ -	$ -	$ 2,600.00	$ -	$ -	$ 3,620.00	$ 7,570.00
Disbursements		$ -	$ -	$ -	$ -	$ 120.00	$ -	$ -	$ -	$ 120.00	$ -	$ -	$ 120.00	$ 360.00
Project Management														
Labour		$ 780.00	$ 780.00	$ 780.00	$ 780.00	$ 780.00	$ 780.00	$ 780.00	$ 780.00	$ 780.00	$ 780.00	$ 780.00	$ 780.00	$ 9,360.00
Disbursements		$ -	$60.00	$60.00	$60.00	$60.00	$60.00	$60.00	$60.00	$60.00	$60.00	$60.00	$60.00	$ 660.00
Total		$ 2,205.20	$ 13,222.50	$ 5,583.40	$ 3,089.30	$ 12,700.20	$ 8,909.30	$ 11,898.60	$ 6,653.80	$ 13,360.80	$ 3,789.30	$ 2,285.30	$ 4,580.00	$ 88,157.70
Personnel		$ 1,895.00	$ 8,218.00	$ 4,683.00	$ 2,940.00	$ 6,941.00	$ 6,976.00	$ 6,200.00	$ 4,703.00	$ 7,122.00	$ 3,440.00	$ 2,156.00	$ 4,400.00	$ 59,674.00
Disbursements		$ 310.20	$ 5,004.50	$ 900.40	$ 129.30	$ 5,759.20	$ 1,933.30	$ 5,698.60	$ 1,850.80	$ 6,238.80	$ 349.30	$ 129.30	$ 180.00	$ 28,483.70

Assumptions:
The above budget is based on the Fw rate schedule
$60.00/month Unit 1292 laptop computer charge will be applied to this project from February to December
Project Management is based on an average of 3 hours per month for each of Scott Davidson, Jesey Harper, & Gary Beckstead
Water quality analysis costs following the Revised Metals Sampling Analysis are expected to drop in total costs to ~15K/year

Allan: For Your Info.:
Incidental Disbursements

If 5% of fees	94.75	410.9	234.15	147	347.05	348.8	310	235.15	356.1	172	107.8	220	$ 2,983.70
If 3% of fees	56.85	246.54	140.49	88.2	208.23	209.28	186	141.09	213.66	103.2	64.68	132	$ 1,790.22

TRANSMISSION REPORT

THIS DOCUMENT WAS CONFIRMED
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		TOTAL	0:01'58"	4		

NOTE:
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MB : SEND TO MAILBOX PG : POLLING A REMOTE MP : MULTI-POLLING RM : RECEIVE TO MEMORY

cc: JED Grant

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

AGRA Earth &
Environmental Limited
221 - 18th Street S.E.
Calgary, Alberta
Canada T2E 6J5
Tel (403) 248-4331
Fax (403) 248-1590

January 21, 1999
CW1537.901.1

DRAFT

Way, way too much.

Luscar Ltd.
1600 Oxford Tower
10235 - 101 Street
Edmonton, Alberta T2P 3V4

To: Jerry Demchuk

Attention: Mr. Allan Flemming, P.Eng.

For Comment

Dear Mr. Flemming:

Allan

Re: Telkwa Coal Mine
1999 Budget

1.0 SURFACE WATER MONITORING

As per the January 19th, 1999 discussion between Gary Beckstead of AGRA Earth & Environmental Limited (AEE) and Allan Flemming of Luscar Ltd. (Luscar), AEE is pleased to present this "draft" budget for the 1999 baseline water flow and water quality program for the proposed Telkwa Coal Project. This draft will be discussed with you at your office on January 26th, 1999. It is the understanding of AEE that during 1999 Luscar should be submitting the Final Project Report to the B.C. Environmental Assessment Office. Following certification of the project, it is the understanding of AEE that the entire surface water and water quality program will need to be revised.

2.0 WORK PROGRAM AND BUDGET

AEE's proposed 1999 work program is intended to allow for revision of the program during the year. Table 1 presents the monthly budget breakdown for 1999.

The work program proposed for 1999 is as follows:

__Surface Water Flow__

- Three winter low flow discharge measurements on the Telkwa River;
- Five free flow period discharge measurements at all sites[1];
- An initial site visit during spring followed by an installation trip to sites; and
- Seven trips to perform routine maintenance and downloading of continuous sites.

---

1 The Telkwa River will only be measured during three of the five free flow discharge measurement trips

Cc: JED at Norecol.
(403) 777-4150
FYI

6 pages

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

AGRA Earth & Environmental Limited
221 - 18th Street S.E.
Calgary, Alberta
Canada T2E 6J5
Tel (403) 248-4331
Fax (403) 248-1590

FAXED 1/29/99

January 29, 1999
CW1537.101

Luscar Ltd.
1600 Oxford Tower
Edmonton, AB T5J 3G1

Attention: **Mr. Allan Flemming, P.Eng.**
Manager, Special Projects

Dear Mr. Flemming:

Telkwa

Re: Lakewood and Geneq Dataloggers in Relation to the Y2K Problem

We have recently been in contact with Lakewood Systems Ltd. and Geneq Inc. with regard to the problems which may occur as a result of the operation of their dataloggers into the year 2000. The status of each datalogger make is discussed below.

Lakewood has indicated that there will be no hardware modifications required. However, new software will be required to run the Lakewood dataloggers. The current LS-4 software will not allow the datalogger to be programmed correctly, nor will it allow the datalogger's time clock to be set correctly. All users must update their software to LS-4 Version 4.5 prior to the year 2000. This software will be posted on the Lakewood website (http://www.lakewood.com) in the near future and can be downloaded free of charge.

The Unidata Starloggers supplied by Geneq will not have a date problem with the year 2000 as the Starloggers calculate dates based on the number of scans from 1980. Therefore, the year will be calculated correctly. More specific information is available from the Unidata web site (http://www.unidata.com.au). Version 2 and 3 of the Starlog software are Y2K compliant. These programs are updated on a continual basis and are available on the website.

AEE will continue to monitor the progress made with the Y2K software at Lakewood. We will also ensure that the most current software is downloaded from each of these websites and used in future flow monitoring at Telkwa.

Should additional information be required with regard to this problem, you can contact Doug Calvert at Lakewood ((403)462-9110) or via e-mail at mail@lakewood.com or Steve Biduk at Geneq ((604)739-0889).

Sincerely,

AGRA Earth & Environmental Limited

Kristi McKay, M.Sc., P.Eng.
Water Resources Engineer

Reviewed by:

Gary R.E. Beckstead, M.Sc., P.Eng.
Reviewer

cc. Scott Davidson, AEE - Smithers

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AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

AGRA Earth &
Environmental Limited
221 - 18th Street S.E.
Calgary, Alberta
Canada T2E 6J5
Tel (403) 248-4331
Fax (403) 248-1590

January 19, 1999
CW1537.901

Luscar Ltd.
1600, Oxford Tower
10235 - 101 Street
Edmonton, Alberta T2P 3V4

Attention: Mr. Allan Flemming, P.Eng.

Dear Mr. Flemming:

Re: Telkwa Coal Mine
Hydrological Analyses

Further to our letter of October 6, 1998, and our discussions, some additional costs have appeared which were not included in that letter. These costs are as follows:

1. Chemex Labs water quality analyses ($4,788.30, as per the subsequent October 30, 1998 invoice).

2. Fees for Westmacott, McKay, Dick, Beckstead ($823.75) for completion of the 200 year flood assessment that Jerry Demchuk had commissioned. This report was finalized on September 28, 1998, immediately prior to the October 6 letter.

3. A significant portion of the 36 hours of Dennis Trotter's time in the October 30, 1998 invoice concerned ongoing discussions and data analysis in response to requests from Steve Day.

These subsequent costs of $9,212.05 plus GST had not been included in the forecast total. We should not require the entire amount to complete the outstanding deliverable, namely the 1998 monitoring report. For preliminary budgeting purposes, let us say that the total budget be increased to $210,000 from $203,853.64.

The 1998 monitoring report is nearing completion. It will be ready for internal technical review by January 20. It should be ready for final issue by January 29, 1999.

Scott Davidson and I are preparing an outline of tasks and associated costs for the 1999 program, as discussed with you earlier. We hope to have a draft ready by January 22, 1999. We can discuss the draft when we meet in your office on January 26, 1999.

We thank you for the opportunity to provide engineering and environmental services to this project. If you have any questions or require further information, please call the undersigned at 235-8118.

Yours sincerely,

AGRA Earth & Environmental Limited

Gary R.E. Beckstead, M.Sc., P.Eng.
Senior Project Manager

GREB/km

cc: Scott Davidson, AEE - Smithers

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AGRA Earth & Environmental

FACSIMILE TRANSMITTAL

#221 - 18 Street S.E.
CALGARY, ALBERTA, CANADA T2E 6J5
Phone NO. (403) 248-4331
FAX NO. (403) 248-1590
DIRECT 235-8118

TO: AL FLEMING
COMPANY: LUSCAR LTD.
FAX NO.: 1-403-420-5875
SENDER: GARY BECKSTEAD FILE NO.: 1537.101-E
FAX OPERATOR: GREB DATE: 98 1125
NO. OF PAGES: 5 (including this page)

AL:

1. DRAFT RESPONSE LETTER TO OBEDKOFF re: 1997 MONITORING PROGRAM IS ATTACHED, FOR YOUR REVIEW & COMMENT.
2. STATUS REPORT FROM OUR SMITHERS OFFICE ATTACHED, FYI.
3. THAT INVOICE WAS PAID NOV. 23/98 THANKS!

REGARDS,

Gary

November 9, 1998
CW1537.101

DRAFT

Luscar Ltd./Manalta Coal Ltd.
7th Floor, 700 - 9th Avenue SW
Calgary, Alberta T2P 3V4

Attention: Mr. Al Fleming, P.Eng.

Dear Mr. Fleming:

Re: Response to BC Ministry of Environment Lands and Parks letter July 23, 1998
Telkwa Coal Mine Surface Water Monitoring Program 1997

Further to our discussions with Jerry Demchuk, Environmental Advisor to Luscar/Manalta on November 5, 1998, AGRA Earth & Environmental Limited (AEE) is pleased to respond to the comments presented in the above-noted letter. We appreciate Mr. Obedkoff's comments and suggestions in the spirit of improving the quality of the surface water monitoring program where it is required. Many of his concerns relate to the volume of data available following the first year of the program. Where possible these comments will be considered in the analysis and assessment of the year 2 monitoring report, which will be prepared soon.

AEE has tried to purchase the Manual of Standard Operating Procedures for Hydrometric Surveys in British Columbia through our contacts in Prince George and Smiths over the past year; however the document has not been available until recently. We have now ordered copies and will use this publication for reference. Thanks to Mr. Obedkoff for the "heads up" that the publication is now available.

The responses to each of the individual comments for specific sections of the 1997 Surface Water Monitoring Report are presented below.

1.2 *Federal Water Survey of Canada (WSC) and Resources Inventory Branch (RIB) personnel should also be consulted for advice on hydrometric data collection procedures.*

AEE has established communications Ed Link of the WSC office in Terrace. We have discussed procedures with him and will continue to use him as a resource, when and if required.

It is our understanding that the RIB is located only in Victoria. Subject to your consent AEE will make contact with Mr. Obedkoff of the RIB.

2.1 *Include the WSC hydrometric station on Simpson Creek (08EE012). Is site C below the Tenas North Pit? If not, it should be below its outflow.*

DRAFT

AEE used data for Simpson Creek in the derivation of a regional flood frequency relationship. Otherwise, to date the data for this stream has not been used extensively as the Simpson Creek drainage basin lies outside the basin draining the Telkwa Project area. However, we will consider the use of the data further should the need arise.

Site C is located on Four Creek east of north tip of North Tenas pit. The location of the outflow point from the pit is unknown at this time. (get pit design from Al/Jerry and find out where outflow is.) Gaugung site locations will be reviewed critically to ensure location provides useful/reliable information once the project reaches the Certificate level.

3.1.3 *Stage-discharge curves must be based on measured points only.*

Only 7 months duration of data were available at the time the year one data report was prepared. IN the preparation of the 2nd year monitoring report, additional measurements from the 1998 field season will be available and used to confirm the results from the previous year. AS such it may prove necessary to evaluate and revise some of the data from the previous year based on the results from 1998. We appreciate the comment on this particular data plot, and will check the data again.

3.1.4 *The datalogger record is not coincident with staff gauge readings, except for three points; the calculated discharges are thus questionable. The datalogger must be calibrated at the site with hydrometric levelling of staff gauges and benchmarks. The datalogger and staff gauge level readings must be coincident, if not, an error must be applied to form corrected gauge heights before discharges are calculated.*

The data logger was tied in to local benchmarks. These surveys were conducted in 1997 and 1998. At this site there is a possibility that some stage readings may be relative to one staff gauge and some to another staff gauge. (Two staff gauges were established att he site to cover low and high stages. The data will be reviewed to ensure that the proper staff gauge was referenced and so that the transducer and staff gauge records correlate properly.

3.1.5 *Consult WSC or RIB personnel for a cost estimate of a cableway.*

WSC staff in Terrace have been consulted regarding the construction of a cableway across the Telkwa River. Cost estimates have been prepared, and were provided to MCL/LL on date. Long term site location needs to be determined relative to planned discharge (outfalll) points at which time a cableway will be considered. In the meantime the discharge data from the Telkwa River gauge can be added to the WSC Gaothorn Creek gauge data to give estimates of river discharges in the lower reach of the river.

3.3.4 *As per comments for 3.1.4*

DRAFT

AEE will take a second look at the data for Four Creek.

3.9.1 *What is the hydrologic purpose of an ephemeral stream hydrometric station for this project? If the gauge is for mines operations or water management, then it has a purpose.*

The Tailings Pond gauge was established on the ephemeral stream (called Tailings Pond Creek) below the proposed pond outlet and approximately 500 m downstream of present tailings disposal area. The intent of the data gathering for this station was to provide discharge data to facilitate the derivation of a water balance. for the proposed tailings pond. It should be noted that as the design of the facility has progressed, the size of the proposed tailings pond has shrunk from 100 ha to 30 ha

5.0 *Delete the last sentence of the third paragraph. The stage data collected may not lead to good quality discharge data.*

AEE will take under advisement the comments provided relative to sections 3.1.4 and 3.3.4. These items will be reviewed as discussed above. Also, as more discharge data is obtained, the rating curves will be improved. This will provide an opportunity to review previous estimates of discharge from the historical stream gauge height records.

We thank you for the opportunity to provide engineering and environmental services to this project. If you have any questions or require further information, please call the undersigned at 235-8118.

Yours sincerely,

AGRA Earth & Environmental Limited

Gary R.E. Beckstead, M.Sc., P.Eng.
Senior Project Manager

Scott Davidson, M.Sc., P.Geo.
Geomorphologist

DRAFT

SCD/GREB/km

Attach.

cc: Jerry Demchuk, Norecol Dames & Moore

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Manalta Coal / Luscar minesite Fall 1998

Upper Goathorn - XS Nov 10. Staff gauge @ site

Upper Tenas - XS Nov. 10 Staff gauge @ site

Four Creek - automated depth logger removed Nov 9
· Staff gauge at site
· no XS, water level too low.

Lower Tenas - XS Nov. 10. Staff gauge @ site
- automated depth logger removed Nov 10

Helps Cr. - automated depth logger removed Nov 24
- Staff gauge @ site

Telkwa R - automated depth logger removed Nov 24
· staff gauge at site

North Site - logger downloaded Nov 9. Plans to remove Nov 25.

Tailings Pond - logger not re-installed after June 10 (dry).
Little/No fall flows at site

Water Chemistry at all sites Nov 9/10
Metals sampling at Lower Goathorn, Lower Tenas + Telkwa R
on Nov 9, Nov 16, Nov 24 with two weeks of metals
sampling remaining.

Please call Jessy Harper 847-8783 (area code 250) if
you have any questions.

AGRA
Earth & Environmental Limited
~~Box 3968~~
#3, 3167 Tatlow Road
Smithers, B.C. V0J 2N0

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

AGRA Earth &
Environmental Limited
221 - 18th Street S.E.
Calgary, Alberta
Canada T2E 6J5
Tel (403) 248-4331
Fax (403) 248-1590

October 6, 1998
CW1537.901

Manalta Coal Ltd./Luscar Ltd.
7th Floor, 700 - 9th Avenue SW
Calgary, Alberta T2P 3V4

Attention: Mr. Al Fleming, P.Eng. **Fax: 269-8075**

Dear Mr. Fleming:

Re: Budget Update
Telkwa Coal Mine
Hydrological Analyses

Further to our telephone conference call on October 2, 1998 with you and Jerry Demchuk, AGRA Earth & Environmental Limited (AEE) is pleased to provide you with a summary of the hydrological work you requested for the remainder of the calendar year. It is understood that Manalta Coal Ltd. (MCL, and/or its present owner, Luscar Ltd.) wish to have a single amendment to the existing contract for the remainder of this year's work related to the Telkwa Coal Mine Project.

A total of $25,182 is required to complete activities presently authorized by MCL for 1998. Table 1, attached, summarizes the individual tasks.

This estimate reflects the present monitoring program and does not include provision for changes to stations or station locations that may be required following granting of the Project Certificate.

The present contract value is $170,697.05, as amended by Change Order #5 (Oct. 2, 1997). Billings under this contract have totalled $178,671.64. As discussed October 2, 1998, the project is therefore over-billed $7,974.59. The outstanding work presented in Table 1 totals $25,182.00. The required adjustment to the contract is therefore $33,156.59. The resultant contract value following the revision is therefore $203,853.64.

If the program is continued to February 1999, the following additional components would be required: metals sampling ($8,720), regular monitoring and water quality sampling and analysis ($4,622 or less, depending on access and whether streams are flowing or frozen solid) , low-flow discharge measurements on the Telkwa River (potentially 2 measurements at $1,200 per measurement) and additional data analysis and reporting ($4,000). The total for extending the program to February, 1999 is estimated at $19,742 (on top of the 1998 budget discussed above).

2.0 SCHEDULE

AEE will complete the work (i.e., reporting) by January 31, 1999. The actual field work will be completed by the end of November or the first week of December, 1998.

3.0 CLOSURE

We thank you for the opportunity to provide engineering and environmental services to this project. If you have any questions or require further information, please call the undersigned at 235-8118.

Yours sincerely,

AGRA Earth & Environmental Limited

Gary R.E. Beckstead, M.Sc., P.Eng.
Senior Project Manager

GREB/km

Attach.

cc: Scott Davidson, AEE - Smithers

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TABLE 1
Remaining Tasks and Costs for 1998
Surface Water Monitoring Program

Task	Description	Cost
1	Metals Sampling. Additional metals sampling program, scheduled for late October and early November, 1998[1], as per the June 16, 1998 letter.	$8720
2	Regular flow Monitoring. Flow measurement, water quality sampling and analysis and data download from dataloggers[1] at the end of October as per October 24, 1997 fax to J. Demchuk'.	$4622
3	Regular flow Monitoring. Flow measurement data download from dataloggers and removal of water level transducers and dataloggers for the winter season at the end of November or the first week of December as per October 24, 1997 fax to J. Demchuk.	$1190
4	Reporting. Preparation of annual data report to the end of December, 1998 and incorporate the 1997 and 1998 data into a single summary report, as directed.	$10,000
5	Project Management. QA/QC and financial management of the work, as per October 24, 1997 fax to J. Demchuk..	$2190
Total		**$25,182**

1 The work for Tasks 1 and 2 will be scheduled at the same time to reduce travel and time expenditures. Special laboratory analyses of water quality samples are included in Tasks 1 and 2.

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

NOTICE OF TRANSMITTAL

221 - 18 Street SE
Calgary, Alberta T2E 6J5
Phone: (403) 235-8118
Fax: (403) 248-1590
E-mail: gbeckstead@agraee.com

TO: Luscar Ltd.
1600 Oxford Tower,
10235 - 101 St.
Edmonton , AB
T2P 3V4

DATE: February 11, 1999
OFFICE: Calgary
PROJECT NO.: CW1537
PROJECT NAME: Telkwa Coal Mine

ATTENTION: Mr. Al Fleming
PHONE: (780) 420-4080

THE ENCLOSED DOCUMENTS AND/OR DRAWINGS ARE SUBMITTED:

- ☐ FOR YOUR APPROVAL
- ☑ AS REQUESTED
- ☐ FOR YOUR REVIEW AND COMMENT
- ☐ FOR YOUR INFORMATION
- ☐ FOR YOUR SIGNATURE
- ☐

DELIVERED BY: ☐ MAIL ☑ COURIER ☐ HAND

COPIES	DRAWING NO.	DESCRIPTION
2	Bound Copies	Reports entitled "Telkwa Coal Mine Surface Water Monitoring Program 1998"
1	Unbound Copy	Report entitled "Telkwa Coal Mine Surface Water Monitoring Program 1998"

REMARKS: Please find the above mentioned reports enclosed. A CD with the report and figures will be sent in tomorrow's courier. One copy of the report has been forwarded to Mr. Jerry Demchuk at his request.

SUBMITTED BY: [signature]
for: Gary Beckstead, M.Sc., P.Eng.

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AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

NOTICE OF TRANSMITTAL

221 - 18 Street SE
Calgary, Alberta T2E 6J5
Phone: (403) 235-8118
Fax: (403) 248-1590
E-mail: gbeckstead@agraee.com

TO: Luscar Ltd.
1600 Oxford Tower,
10235 - 101 St.
Edmonton , AB
T2P 3V4

DATE: February 11, 1999
OFFICE: Calgary
PROJECT NO.: CW1537
PROJECT NAME: Telkwa Coal Mine

ATTENTION: Mr. Al Fleming **PHONE:** (780) 420-4080

THE ENCLOSED DOCUMENTS AND/OR DRAWINGS ARE SUBMITTED:

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- ☐ FOR YOUR INFORMATION
- ☐ FOR YOUR SIGNATURE
- ☐

DELIVERED BY: ☐ MAIL ☑ COURIER ☐ HAND

COPIES	DRAWING NO.	DESCRIPTION
1	CD	Report and Figures for Telkwa Surface Water Monitoring 1998

SUBMITTED BY: GKruegor

for: Gary Beckstead, M.Sc., P.Eng.

cc: Mr. Jerry Demchuk
1610, 734 - 7 Avenue SW
Calgary, AB T2P 3P8

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PITEAU ENGINEERING LTD.

HYDROGEOLOGICAL AND GEOTECHNICAL CONSULTANTS
Suite 100, 4500 - 16th Avenue NW
Calgary, Alberta, Canada T3B 0M6

Telephone: *(403) 286-2522*
Facsimile: *(403) 247-4811 / (403) 247-0779*
E-mail: *komex@komex.com*

TO FAX #:	269-8075
COMPANY:	Manalta Coal Ltd.
ATTENTION:	~~Al Vanderputten~~ Fleming
DATE:	June 27, 1997
PROJ. #:	3773-13
FROM:	Bob Clarkson
NO. OF PAGES: (INCLUDING COVER PAGE)	10

Al,

Please find attached a draft copy of our proposed workplan/cost estimate for the 1997 geotechnical/hydrogeological program at Telkwa. Figure 1 has not been included, but the piezometer locations are the same as identified during the meeting.

Once you have had a chance to review, please give either Fred or myself a call to discuss.

Regards,

Bob Clarkson

J:\3773\3773-13\CORR\FAX1.DOC

PITEAU ENGINEERING LTD.
HYDROGEOLOGICAL AND GEOTECHNICAL CONSULTANTS

SUITE 100, 4500 - 16TH AVENUE N.W.
CALGARY, ALBERTA
CANADA T3B 0M6
TELEPHONE (403) 286-2522
FAX (403) 247-4811 or 247-0779
e-mail: komex@komex.com

June 24 1997

OUR FILE: KI97-3773-13

Manalta Coal Ltd.
7th Floor, 700 - 9th Ave. SW
Calgary, Alberta
T2P 3V4

Attention: Mr. Allan Vanderputten, P.Eng.

Dear Sir:

Re: ***Work Plan for Geotechnical and Hydrogeological Services 1997 Program, Tenas Creek Area, British Columbia***

1.0 INTRODUCTION

Piteau Engineering Ltd. (Piteau) is pleased to present our draft proposal and workplan for the above project. This proposal addresses the 1997 geotechnical, hydrogeologic and hydrologic workplans for the Tenas Pit and Pit 3 areas, and was developed in consultation with Manalta Coal Ltd. (Manalta) based on our meeting of June 13, 1997. These workplans fulfill the groundwater and water quality information requirements outlined on the draft project specifications for the Telkwa Coal project provided to us by Manalta.

The purpose of the 1997 geotechnical work program is to assess geotechnical conditions in the area of the Pit 3 waste dumps, the coal processing plant, and at the proposed location of the bridge crossing of the Telkwa River. The overall objective of the 1997 hydrogeological work program is to improve the level of understanding of baseline groundwater conditions in the areas of Tenas Pit and particularly Pit 3. The hydrological work will focus on development of a water balance for the post mining condition at Tenas Pit and Pit 3.

Information and data from previous investigations (Klohn Leonoff, 1985, Piteau 1994a and 1994b, Piteau 1995, Piteau 1996a and 1996b, and Piteau 1997a, 1997b, and 1997c) shall be referenced as much as possible to assist in attaining these objectives.

2.0 PROPOSED FIELD INVESTIGATIONS

The field investigations proposed within each facility area are briefly discussed below. As in previous geotechnical/hydrogeological investigations completed for the Telkwa coal project, the rotary drill to be used by Manalta for their coal exploration program will be adapted for the deep borehole drilling and proposed monitoring well installations. Moreover, piezometers will be installed within coal exploration boreholes. A backhoe will be utilized for the geotechnical investigations at the Pit 3 waste dumps, plant site and bridge crossing, coupled with interpretation of general overburden type and depth to bedrock from exploration holes.

Proposed hydrogeological borehole/monitoring well locations are shown in Figure 1.

2.1 PIT 3

2.1.1 Geotechnical Investigation of Waste Dumps

The objective of the geotechnical investigation is to determine the lithology and basic soil parameters of the dump foundation. The investigation shall consist of the following:

- reconnaissance of the dump sites to verify terrain conditions, map surface water and springs, and to examine soil and rock exposures;
- excavation of approximately 5 test pits, up to 5 m deep, along the existing road in the central area of the dump to log soil units and collect soil samples; and,
- laboratory testing of soil samples, including moisture content, Atterberg limits, grain size and penetrometer strengths.

Depth to bedrock will be determined from exploration drill holes.

A brief report will be prepared documenting the investigations, geotechnical conditions, overall suitability of the site, and any limitations on dump development.

2.1.2 Hydrogeological Investigation

In view of the fairly complex hydrogeological setting at Pit 3, and in particular the potential importance of faults and fractures on groundwater flow, it is proposed that the groundwater monitoring network be expanded with the installation of six double piezometer nests (site # 3, 10, 15, 24, 28, and 52, see Figure 1). If possible, at one or two piezometer nest locations, efforts will be made to install a piezometer(s) directly within or adjacent to an identified fault zone.

The deeper piezometer will be completed in coal seam 2 while the shallow piezometer will be installed in coal seam 4. However at sites # 28 and #52, it is anticipated the deeper piezometer will be installed in seam 1. Following piezometer development, hydraulic conductivity testing will be performed. The piezometers will be sampled to determine groundwater quality, as well as to assess horizontal groundwater flow patterns, and vertical hydraulic gradients between the two coal seams.

Groundwater quality monitoring will be also be completed at the other existing piezometers (5 in total) completed within the Pit 3 area (i.e., T96R series piezometers). Groundwater samples will be analyzed for the same suite of chemical parameters previously analyzed for, and as specified by the B.C. Ministry of Environment.

Results from the 1997 hydrogeological program, together with hydrogeological information gathered from the aquifer test (discussed below) will be used to develop a better conceptual understanding of groundwater flow and groundwater quality within Pit 3.

2.1.3 Aquifer Testing Program

One of the key hydrogeological issues pertaining to the Telkwa Coal project is the potential influence of regional faults and fractures on groundwater flow. Moreover, related to this is the potential for impact of mining activities on local water wells. To address these issues, it is recommended that an aquifer test be conducted at a test well located within a suitable area of Pit 3 (location to be finalized).

Although the final design of the test well will be determined in the field, based on hydrogeological conditions, it is recommended that the pilot hole be drilled to a diameter of 200 mm (8"). This borehole diameter will permit installation of 150 mm (6") diameter water well casing and use of a submersible pump (5 or 7 hp) sufficient to adequately stress the aquifer. The decision as to whether to install well screen (compared with open hole) will be assessed during the borehole drilling. It is our understanding the test well will be drilled using a local water well contractor and that Manalta will be responsible for overseeing drilling activities. Consequently, we have not included costs for supervision of the drilling of the test hole.

It is recommended that the aquifer test consist of a 48 hour constant rate drawdown component followed by a 48 hour recovery component. In the event aquifer boundary conditions are identified, the drawdown component of the test would be extended to at least 72 hours. The constant rate test should be preceded by a 4 hour step drawdown test to evaluate well efficiency and to determine a suitable rate for the constant yield test. During the aquifer test, groundwater levels will be monitored in selected observation wells in Pit 3 and if possible, in domestic wells located within 2 km of the test well. Groundwater levels will be monitored manually using electric water level tapes as well as using pressure transducers and data loggers. A turbine and digital flow meter would be used to monitor groundwater pumping rates.

policy! requires

Results from the aquifer test will permit determination of the hydraulic properties (i.e., transmissivity and storativity) of coal seam 2. This information will be used to refine estimates of the groundwater flow velocity in the coal seams and may provide insight into the role and importance of fractures and faults within the Pit 3 area. Potential effects of mining activities on nearby domestic wells will also be assessed.

2.1.4 Geotechnical Logging of Rock Core

There is an opportunity for collection of geotechnical information of rock core during exploration drilling operations. It is thus proposed that a geotechnical engineer from Piteau (Vancouver) spend one day on-site with Manalta geologists to provide training for the collection of geotechnical data (as required) during their drilling and logging operations.

2.1.5 HYDROLOGICAL ASSESSMENT

Tanas ✓ missing ?

A preliminary water balance will be developed for Pit 3. The pit water balance methodology will be based on the procedures previously developed for Pits 7 and 8 (Piteau, 1994a). Estimates of groundwater inflows will be combined with estimates of surface water runoff to establish filling rates. As was the case for Pits 7 and 8, a sensitivity analysis will be conducted to establish the range of possible filling rates, taking into account uncertainties in groundwater inflow rates and wet/dry year scenarios. Sect 2.4

2.2 COAL PROCESSING PLANT - GEOTECHNICAL INVESTIGATION

The objective of the geotechnical investigation is to provide data for confirming the feasibility of two potential sites and to develop preliminary designs. The investigation will consist of the following:

- excavation of approximately 6 test pits, 5 m deep, to be located along the perimeter of the 43 m x 16 m plant site configuration - log soil units and collect soil samples; and,
- laboratory testing of soil samples, comprising moisture content, Atterberg limits, grain size and penetrometer strengths, and if softer clay soils are found unconsolidated undrained triaxial and consolidation tests.

Depth to bedrock will be determined from exploration drill holes.

A brief report will be prepared documenting geotechnical conditions, and discussing options and providing relevant design parameters for the plant foundation.

2.3 BRIDGE ON TELKWA RIVER - GEOTECHNICAL INVESTIGATION

The objective of the geotechnical investigation is to confirm the geotechnical feasibility of crossing the river and to provide data for preliminary foundation design. The investigation will consist of the following:

- excavation of approximately 6 tests pits, 5 m deep, at 2 or 3 locations on each side of the river crossing to log soil units and collect soil samples;
- drilling 2 boreholes with the exploration rig: one on each bank (to bedrock or to 30 m deep in gravel, or 50 m deep in clay), logging of drill cuttings to determine soil type (gravels vs. sand vs. silt/clay); and,
- laboratory testing of soil samples, comprising moisture content, Atterberg limits, grain size and penetrometer strengths, and if softer clay soils are found, perform unconsolidated undrained triaxial and consolidation tests.

A brief report will be prepared on the investigation and geotechnical conditions encountered, and providing relevant foundation design parameters.

2.4 TENAS PIT

2.4.1 HYDROGEOLOGICAL INVESTIGATION

It is proposed that the groundwater monitoring network be expanded with the installation of two double piezometer nests near the north end of Tenas Pit (Figure 1). The deeper piezometer will be completed in coal seam 1 while the shallow piezometer will be installed in coal seam "c". Following piezometer development, hydraulic conductivity testing will be performed. The piezometers will be sampled to determine groundwater quality, and to estimate horizontal groundwater flow patterns, and vertical hydraulic gradients between the two coal seams.

Groundwater quality monitoring shall also be completed at all other existing piezometers (19 in total) completed within the Tenas Pit area (i.e., T95R, T96R, and TOB96 series piezometers).

Information garnered from the 1997 hydrogeological program will augment the existing hydrogeological database that exists for the Tenas Pit.

2.4.2 HYDROLOGICAL ASSESSMENT

A preliminary water balance will be developed for the Tenas Pit. The approach for the water balance will be the same as described for Pit 3 in Section 2.1.5.

3.0 COST ESTIMATE

The estimated cost of the investigation program is $118,405, exclusive of the GST. A detailed cost breakdown is provided on Table 1.

In developing these costs the following assumptions were made:

- all survey work (i.e., ground surface and top of piezometer casing elevation) will be arranged by Manalta;
- costs for borehole drilling, piezometer construction materials and excavation of test pits are not included;
- contractor costs for the drilling/installation of the test well and aquifer testing are not included; and,
- Piteau only charges for costs actually incurred. Any cost savings generated through more rapid program completion would be passed onto Manalta; conversely any additional costs due to unexpected or difficult subsurface conditions or down time from poor weather, would be charged at extra cost at the units rate listed in Table 1.

Additional assumptions in the cost estimate are presented in Table 1.

4.0 SCHEDULE AND REPORTING

The schedule of the work will coincide with Manalta's exploration program, which is presently understood to consist of a 3 week on/3 week off rotation, beginning July 15, 1997. Therefore, it is anticipated scheduling for the geotechnical/hydrogeological field work and reporting will be as follows:

- July 21 to August 2, - Borehole drilling and piezometer installations (Pit 3 area); geotechnical investigations;
- Late-August to mid-September, - borehole drilling and piezometer installations (Tenas Pit area); aquifer testing program; groundwater sampling; and,
- October 30, - submission of draft reports summarizing results from the hydrogeological and geotechnical programs completed in 1997.

It is our understanding that results from the hydrogeological/hydrological investigations will form the basis for a stand alone report summarizing baseline hydrogeological conditions at the Tenas Pit and Pit 3. The reports will essentially augment the previous detailed baseline report prepared by Piteau (1997a). Information from the geotechnical investigations will be presented under separate cover.

5.0 CLOSURE

We trust this cost proposal is suitable for your present needs. If you have any questions, please do not hesitate to contact either of the undersigned or Dr. Tad Dabrowski.

Respectfully,

PITEAU ENGINEERING LTD.

Frederic B. Claridge, M.S., P.Eng.

Robert S. Clarkson, M.Sc., P.Geol.

REFERENCES

Klohn Leonoff Consulting Engineers, 1985. *Crows Nest Resources Ltd., Telkwa Coal Project, Stage II Geotechnical, Hydrogeological & Hydrological Design Report.*

Piteau Engineering Ltd., 1997a. *Baseline Hydrogeological Investigations in the Tenas Pit, Waste Dumps, and Mine Pit 3, Telkwa Coal Project.* Unpublished report prepared for Manalta Coal Ltd. KI97-3773-12. January 1997.

Piteau Engineering Ltd., 1997b. *Geotechnical and Hydrogeological Assessment Proposed Tailings Pond Area, Telkwa Coal Project.* Unpublished report prepared for Manalta Coal Ltd. KI97-3773-12. January 1997.

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Piteau Engineering Ltd., 1996b. *Surficial Geology Map of the Telkwa Property.* Unpublished Preliminary Map prepared for Manalta Coal Limited. KI93-3773-11. April, 1996.

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Piteau Engineering Ltd., 1994b. *Baseline Data Surface Water and Groundwater Telkwa Coal Project.* Unpublished report prepared for Manalta Coal Limited. KI93-3773-1. June, 1994.

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DRAFT

TABLE 1
COST ESTIMATE

FACILITY/WORK TASK	PRINCIPAL ENGINEERS		HYDROGEOLOGIST/ENGINEER			TECHNOLOGIST	DRAFTING/ CLERICAL	DISBURSEMENTS	TOTAL ($)
	F. Clarkdge $100.00/hr	T. Dabrowski $110.00/hr	B. Clarkson $80.00/hr	M. Fitch $77.50/hr	R. Armstrong $65.00/hr	$55.00/hr	$50.00/hr		
1. Pit #1 Waste Dumps									
Reconnaissance and Test Pits					12			350	1,130
Geotech. Lab Tests								600	600
Stability Analysis					8				520
Reporting	4				15		5	400	2,025
Vehicle Rental (assume 1 day)								150	150
Living Expenses (assume 1 day)								110	110
Travel Expense								1,200	1,200
Sub-total	4				35		5	2,610	5,735
2. Plant Site									
Test Pits					12			200	980
Lab Tests								600	600
Reporting	4				25		5	200	2,475
Vehicle Rental (assume 2 days)								300	300
Living Expenses (assume 2 days)								220	220
Sub-total	4				37		5	1,520	4,576
3. Bridge Crossing of Telkwa River									
Test Pits and Drilling					20				1,300
Lab Tests								600	600
Reporting	4				30		10	400	3,250
Vehicle Rental (assume 2 days)								300	300
Living Expenses (assume 2 days)								220	220
Sub-total	4				50		10	1,520	5,670
4. Geotechical Logging of Rock Core									
Training/on-site supervision						14			770
Vehicle Rental (1 day)								150	150
Living Expenses (1 day)								110	110
Travel Expense								1,000	1,000
Sub-total						14		1,260	2,030
5.1 Pit 3 - Hydrogeological/Hydrological Investigations									
Piezometer Installations (6 double piezometer nests; 12 piezometers in total)									
Supervision			72						5,760
K Tests (12 piezometers)			24			24		250	3,480
Groundwater Sampling/Analysis (1996 and 1997 piezometers; 23 in total)			20			20		10,925	13,625
Water Balance			10	30		6	4	100	1,540
Reporting		6	50			26	30	500	8,635
Vehicle Rental (14 days)								2,100	2,100
Living Expenses (16 man days)								1,760	1,760
Travel Expense (assume 1 person mob/demob in July; assume 2 persons mob/demob in August)								3,600	3,600
Sub-total		6	176	30		77	34	19,235	39,810
5.2 Pit 3 - Aquifer Test									
Stepdrawdown Test			6						480
Aquifer Test (assume 48 hour drawdown and 48 hour recovery)			40			40		2,000	7,400
Groundwater Sampling/Analysis (2 samples from test well)								900	900
Equipment Rentals(Pressure transducers, data loggers, field parameter kit, water level, etc.)									0
Reporting			40			10	6	200	4,250
Vehicle Rental (5 days)								760	750
Living Expenses (10 man days)								1,100	1,100
Travel Expense (NC, assume mob during August program)								2,400	2,400
Sub-total			86			50	6	7,350	17,280

DRAFT

TABLE 1
COST ESTIMATE

FACILITY/WORK TASK	PRINCIPAL ENGINEERS		HYDROGEOLOGIST/ENGINEER			TECHNOLOGIST	DRAFTING/ CLERICAL	DISBURSEMENTS	TOTAL ($)
	F. Claridge $100.00/hr	T. Dabrowski $110.00/hr	B. Clarkson $80.00/hr	M. Fitch $77.50/hr	R. Armstrong $65.00/hr	$55.00/hr	$50.00/hr		
5.3 Tenas Pit - Hydrogeological/Hydrological Investigations									
Piezometer Installations (2 double piezometer nests; 4 piezometers in total)									
Supervision			22						1,760
K Tests (4 piezometers)			6			8			1,080
Groundwater Sampling/Analysis (1995, 1996 and 1997 piezometers; 19 in total)			25			25		11,000	14,375
Water Balance			8	30		8	4	100	1,380
Reporting		2	30			10	12		3,770
Vehicle Rental (5 days)								750	750
Living Expenses (10 man days)								1,100	1,100
Travel Expense (NC, assume mob during August program)									
Sub-total		2	93	30		51	16	12,950	24,815
5. REPORTING AND MANAGEMENT									
Reporting (Final/Review)	16	16	35		10	8	20	500	8,750
Management/Coordination	16	4	16					200	3,520
Field Program Preparation			16						1,280
Meetings	8	6	16				4	300	3,240
Computer Usage								2,200	2,200
Sub-total	40	28	83		10	8	28	3,200	18,990
TOTAL	*52*	*34*	*438*	*60*	*132*	*200*	100	*49,845*	*118,405* +GST

Notes:
1. Vehicle Expense = $150/day
2. Living Expense (accommodation and meals) = $110/day
3. Groundwater chemical analysis (as per B.C. Environment requirements) = $475/sample.
4. Geotechnical laboratory analysis moisture content = $4/sample; Atterberg limits = $66/sample; grain size and hydrometer = $160/sample; standard proctor density = $146/sample.
5. It is assumed the drilling rig for the coal exploration program will be available for deep borehole drilling, geotechnical sampling, and monitoring well installations in the Tenas Creek Pit area; therefore drilling costs have not been included.
6. Costs for the backhoe and drill rig required for Tasks 1, 2, and 3 are not included.
7. Piezometer installation assumes the boreholes have been drilled and a drill rig is available to install construction materials. Any delays in the piezometer installation outside of Komex's control will be charged at the unit rates listed.
8. It is assumed that all survey work (i.e., ground surface elevation, top of piezometer casing elevation, and piezometer stick-up will be the responsibility of Manalta.

(403)-420-4089

Attn: Allan Fleming

PITEAU ENGINEERING LTD.

HYDROGEOLOGICAL AND GEOTECHNICAL CONSULTANTS
Suite 100, 4500 - 16th Avenue NW
Calgary, Alberta, Canada T3B 0M6

Telephone: (403) 286-2522
Facsimile: (403) 247-4811 / (403) 247-0779
E-mail: komex@komex.com
Website: www.komex.com

TO: Jerry Demchuk
COMPANY: Norecol
FAX #: 777-4150

FROM: Rob Armstrong
DATE: January 12, 1999
PROJ. #: 3773-17
NO. OF PAGES: 3
(Including Cover Page)

rarmstrong@calgary.komex.com

Re: Telkwa Coal Project: Remaining Issues

This fax is to describe the scope of work developed in our January 8, 1999, meeting. The scope of work for the three issues we discussed is as follows:

Hydrology of Four Creek

There is concern over diversions on the ecosystem (most importantly fish) on Four Creek. The hydrology component will examine the pre- and post-development flows in the creek. Discussions with Dave Bustard will be required to determine the sensitivity of the aquatic community to these flow changes.

The hydrology for the Telkwa project collected to date has largely ignored the hydrology data collected on-site, since this data was previously too sporadic and of insufficient duration to answer questions concerning long-term hydrology (such as 1:200 year low flow events). However, given that a question specific to Four Creek has been posed, it will be necessary to integrate the regional flow information and the Four Creek monitoring data provided by Agra. Using this information, estimated monthly average and low flows (pre- and post-development) will be calculated. ← Luscar to do stats.

If the proposed diversions are likely to cause problems for the fishery, it may be necessary to examine alternate filling scenarios for the Tenas pits. For example, a structure could be constructed which would divert water to the pit only when a minimum flow level was achieved. This will require recalculation of the filling times for the Tenas pits.

Residual Moisture Content of Haul Road Surface No. Cirrus consultants

An estimate of the residual moisture content of the Haul road surface (soil surface) is required for the dust fall modelling. At present the model has been performed for a moisture content range of 4 to 11%, and the predicted dust fall has proven to be sensitive within that range. A literature review is required, along with some preliminary analysis specific to the weather conditions at the Telkwa area, to refine the data input.

Weathering Characteristics of Waste Rock

There is empirical evidence that the waste rock that will be generated at Telkwa is susceptible to breakdown due to weathering. It has therefore been suggested that the waste rock dumps will be self sealing as the waste rock weathers, resulting in surface water running off the dumps, rather than infiltrating them. A review of all current data available on the waste rock is required, with the purpose of predicting the breakdown of the waste rock dump faces, the resulting permeability of the dump surface, and the resistance of the dump face to erosion.

Closure

Since these issues are all significantly different, we suggest that three separate letter reports would be suitable. We propose to issue a draft of the reports by February 5, 1999. Final copies to be issued 1 week after comments are received back from yourself. The cost estimate to perform this work is attached. Since this scope of work is a bit loose we emphasize that it is only an estimate, and believe that the cost will range between $5,000 and $10,000.

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PITEAU ENGINEERING LTD.	ESTIMATE OF ENGINEERING COSTS	FILE: Telkwa
CLIENT: Luscar	Residual Moisture Content of Road Material and	DATE: 12-Jan-99
PROJECT NO.: 3773-17	Weathering of Waste Rock Dump	BY: RCA
LOCATION: Telkwa	Desk Top Investigation	REV: A

ITEM	DESCRIPTION		ENGINEERING QTY	UNITS	RATE	EXTENSION				
1	RESIDUAL MOISUTRE CONTENT IN ROAD MATERIAL									
	Literature Review		15	Hours	$60	$900	900			
	Report		8	Hours	$75	$600	600			
	Sr. Review		4	Hours	$110	$440	440			
	Client Support		8	Hours	$75	$600	600			
		0	35			SUB TOTAL		$2,540	2540	0
2	WASTE ROCK WEATHERING									
	Review Existing Data		10	Hours	$60	$600	600			
	Review Other Mine Experience		10	Hours	$60	$600	600			
	Report		8	Hours	$75	$600	600			
	Sr. Review		4	Hours	$110	$440	440			
		32	32			SUB TOTAL		$2,240	2240	2240
3	HYDROLOGY OF FOUR CREEK (Junior Hydrologist: $60, Senior Hydrologist: $85, Principal Water Resources Engineer: $110)									
	Review Existing Data	4	4	Hours	$85	$340	340			
		2	2	Hours	$60	$120	120			
	Integration of regional data and Agra data	4	~~8~~ 8	Hours	$85	$680	680 340			
		4	4	Hours	$60	$240	240			
	Examine diversion alternatives (if fisheries problem)	4 ~~8~~	8	Hours	$85	$680	680 340			
		4 8	8	Hours	$60	$480	480 240			
	Report	8	8	Hours	$60	$480	480			
		4	4	Hours	$85	$340	340			
	Sr. Review	4	4	Hours	$110	$440	440			
		38	56			SUB TOTAL		$3,800	3800	2880
	COMPUTER OVERHEAD	70	~~117~~	Hours	$2.50			$293	293	175
	SECRETARY (5%)							$429	429	256
	Subtotals		117	Hours				$9,302		5551
	Contingency (10%)							$930		555
	GRAND TOTAL							$10,232		6106

PITEAU ENGINEERING LTD.

HYDROGEOLOGICAL AND GEOTECHNICAL CONSULTANTS

Suite 100, 4500 - 16th Avenue NW
Calgary, Alberta, Canada T3B 0M6

Telephone:	*(403) 286-2522*
Facsimile:	*(403) 247-4811 / (403) 247-0779*
E-mail:	*komex@komex.com*
Website:	*www.komex.com*

TO FAX #:	**(~~403~~) 420-5878** 780.
COMPANY:	**Luscar**
ATTENTION:	**Allan Flemming**
DATE:	**Jan 26, 1999**
PROJ. #:	**3773-17**
FROM:	**Murray Fitch**
NO. OF PAGES:	~~1~~8.

(INCLUDING COVER PAGE)

⇒ JED
(403) 777-4150

Re: Final Draft Letter - Four Creek Hydrology

Allan,

Please find attached a final draft of the letter. It is basically complete – lacking only the unfaxable (because of size) Figure 1. If this meets your requirements, I can courier it out whenever you say the word. If not, please call me at (403)286-2522.

Murray

\\CENTRAL\DATAS\X\PROJECTS\3773\3773-17\CORR\fjn1f6x.doc

⇒ Jerry D.

PITEAU ENGINEERING LTD.
HYDROGEOLOGICAL AND GEOTECHNICAL CONSULTANTS

SUITE 100, 4500 - 16TH AVENUE N.W.
CALGARY, ALBERTA
CANADA T3B 0M6
TELEPHONE (403) 286-2522
FAX (403) 247-4811 or 247-0779
e-mail: komex@komex.com

February 26, 1999

OUR FILE: 3773-17

Luscar Coal Ltd.
10235 - 101 St.
Edmonton, AB
T5J 3G1

(fax) 780.420.5878
(tel) 780.420.4080

Attention: Allan Flemming, P.Eng.

Dear Mr. Flemming:

Re: Hydrology of Four Creek

INTRODUCTION

A previous report, *Water Management for the Telkwa Coal Project* (Piteau 1998, henceforward referred to as WMTCP), addressed the issue of hydrology in and around the proposed Telkwa Coal Project. In order to ensure the rapid filling of abandoned pits, the diversion of a number of creeks is anticipated. One of these, Four Creek, was identified by the British Columbia Ministry of Environment, Lands and Parks (MELP) as being of concern from a fisheries perspective. This letter addresses the issue of the hydrologic implications of the diversion of a portion of the upper drainage of Four Creek.

HYDROLOGY OF FOUR CREEK

Figure 1 shows the drainage sub-basins of Four Creek[1]. For analysis purposes, flows have been considered at the following locations:

---

[1] A discrepancy exists between the drainage area used in this report and that used in the WMTCP report. Previously, a drainage area of 13 km^2 was calculated using 1:50,000 topographical maps - 1:20,000 scale maps used in this report suggest a 10 km^2 drainage area.

1: the proposed diversion location into the Tenas Main Pit
2: two thirds of the drainage area
3: the mouth of Four Creek (confluence with Goathorn Creek)

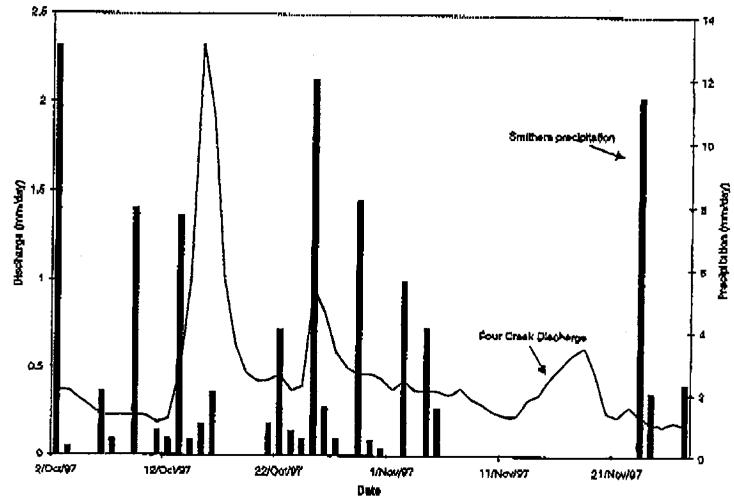

Figure 2: Four Creek discharge and Smithers Precipitation for 1997

Four Creek flow data was collected in 1997 (October-November) and 1998 (June-November). Of greatest hydrologic (and fisheries) concern are the relatively rare low flow events. The data record for Four Creek is not sufficiently long to permit the calculation of low-flow statistics, and thus the record must be supplemented by longer-term precipitation data and/or regional hydrologic data. These are discussed below.

CORRELATION OF TELKWA AREA RUNOFF AND SMITHERS PRECIPITATION

In general, the correlation between precipitation recorded at Smithers Airport and discharges in Simpson, Goathorn and Four Creeks is only fair. The discrepancy is more pronounced in the 1997 record than in 1998. Figure 2 and Figure 3 show the relationship between Four Creek discharges and Smithers precipitation for 1997 and 1998. Large precipitation events are not reflected in the discharge record, particularly after October 22. In addition, discharge in Four Creek increased in mid-November when no precipitation was recorded at Smithers.

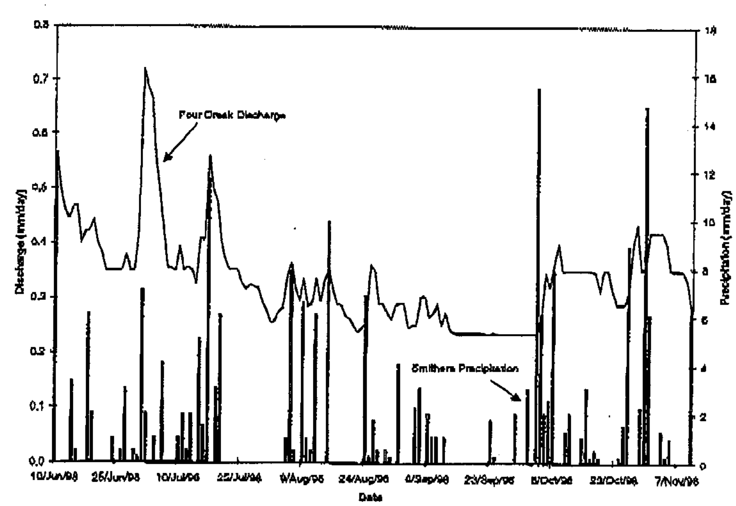

Figure 3: Four Creek Discharge and Smithers Precipitation for 1998

The timing of runoff and precipitation events for 1998 have a closer relationship than in 1997. Storm events in Smithers are generally reflected in the Four Creek discharge record. However, the magnitude of runoff response to precipitation is not well represented. Several large late-season precipitation events only result in minor increases in Four Creek discharge, as compared to early July where runoff is at its peak with only moderate precipitation recorded at Smithers. The record suggests that, at least on a daily time scale, precipitation recorded at Smithers is not representative of the precipitation received at Telkwa.

Over the longer-term (monthly or annually), however, the precipitation, however, the Smithers and Telkwa precipitation data appeared to correlate reasonably well. In the WMTCP report, precipitation recorded at Smithers (elevation 523 masl; 55 years of data) was compared to precipitation recorded at Telkwa (elevation 683 masl; 26 years of data) and Telkwa Coal Mine Road (elevation 670 masl; 3 years of data). Both Telkwa stations were discontinued over 10 years ago, however, the data suggests that the Telkwa area receives roughly 11% less precipitation than Smithers. Thus, the Smithers precipitation data was reduced by 11%, which was used to estimate precipitation, surface runoff and infiltration into the coal pits.

COMPARISON OF HYDROLOGY OF FOUR AND GOATHORN CREEKS

The WMTCP report identified four key gauged drainages in the Telkwa area:

- Canyon Creek Near Smithers (Environment Canada station #08EE014)
- Kathlyn Creek above Simpson Creek (08EE010)
- Simpson Creek at the Mouth (08EE012)
- Goathorn Creek near Telkwa (08EE008)

Two of Environment Canada's gauging stations, Canyon Creek and Kathlyn Creek, have been discontinued. Flow data for Goathorn, Simpson, and Four Creek are presented in Figure 4 and Figure 5. The data are presented as unit runoff (in mm). Thus, flows in the creeks have been corrected for drainage basin size.

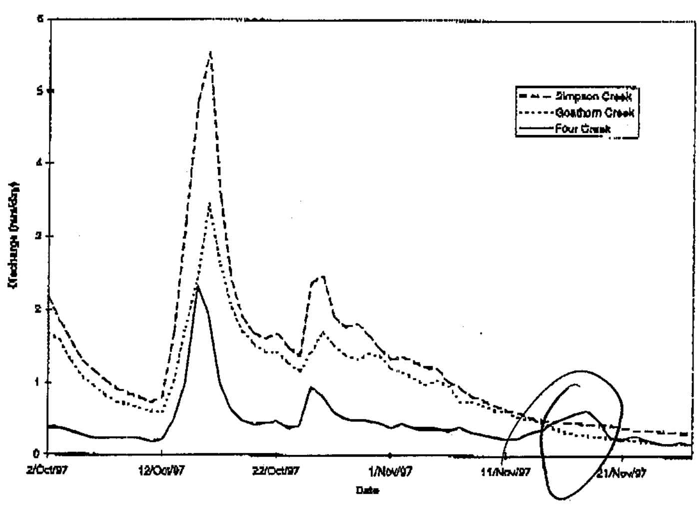

Figure 4: Comparison of Four, Simpson and Goathorn Creek average daily discharge for 1997

Data from Simpson Creek suggest that this basin is very "peaky" - a trait which was less marked in the Goathorn and Four Creek data. Thus, it appears that Goathorn Creek is a more appropriate comparison for Four Creek, and will be used in subsequent analyses.

Thus, to transform long-term Goathorn Creek data for use at the Four Creek site, a comparison of the 1997 data at the two sites was made[2]. The cumulative runoff at the Four Creek station was 23 mm, and at Goathorn Creek, 54 mm. This gives a ratio of 22.9/54.2 = 0.42. For 1998, the cumulative runoff for Four and Goathorn Creeks were 52 and 156 mm respectively, yielding a ratio of 0.33. The ratios for the 1997 and 1998 discharge records were averaged to produce a value of 0.38, which was applied to the Goathorn Creek data as a transformation.

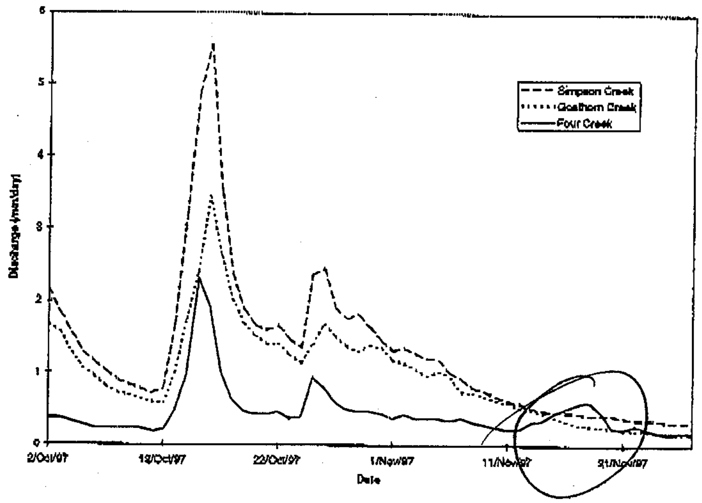

Figure 5: Comparison of Four, Simpson and Goathorn Creek average daily discharge for 1997

Table 1 shows the runoff coefficients for Goathorn and Four Creeks. These coefficients were calculated using Smithers precipitation data (decreased by 11% to account for differences between Smithers and Telkwa, as described previously). Runoff coefficients for Four Creek do not change from 1997 to 1998, remaining at 28%. In the WMTCP report, a runoff coefficient of 30% was adopted. This latter figure was challenged by the BC MELP, as 30% is a lower coefficient than has been determined in nearby gauged basins. However, the limited Four Creek flow data

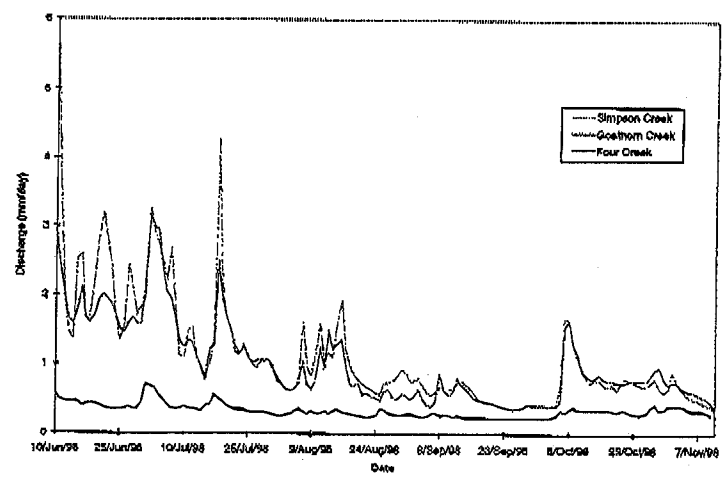

Figure 6: Comparison of Four, Goathorn and Simpson Creek Average Daily Discharge for 1998

Table 1 – Runoff coefficients for Four Creek and Goathorn Creek.

	1997			1998		
Basin	****Smithers Precipitation***	***Runoff***	***Runoff Coefficient***	****Smithers Precipitation***	***Runoff***	***Runoff Coefficient***
Four Creek	82 mm	23 mm	0.28	187 mm	52 mm	0.28
Goathorn Creek	82 mm	54 mm	0.65	187 mm	156 mm	0.83

Notes: Period of record for 1997 is October 2 to November 27.
Period of record for 1998 is June 10 to November 10.
* Decreased by 11% to transform to Telkwa area.

available suggest that a 30% runoff coefficient is indeed reasonable. The runoff coefficients for Goathorn Creek (relative to Smithers rainfall data) vary from 65% in 1997 to 83% in 1998. Our experience and knowledge of the area suggests that these figures are too high, since they imply that the Goathorn basin produces almost three times as much runoff (per square kilometre) as Four Creek. There are a number of potential sources for this discrepancy.

First, both basin aspect and elevation are expected to have a significant effect on discharge. The Goathorn Creek Basin has an altitude range of 1745 m (from 550 to 2295 masl) whereas the Four Creek basin has a range of only 670 m (from 700 to 1370 masl). If an orographic precipitation enhancement factor of roughly 40% per 1000 m is assumed (an average value for the Canadian Rocky Mountains, Quick and Pipes, 1996), then the Goathorn Creek watershed should receive significantly more precipitation. In addition, the Four Creek basin generally faces the northeast, where as the Goathorn Creek Basin faces both the northeast and the northwest. This variance in aspect will cause differences in snowpack accumulation and ablation.

Secondly, the influence of groundwater may be more pronounced in Goathorn Creek as it extends lower in the basin. Springs surfacing from fractures may augment flows in Goathorn Creek at elevations below the Goathorn/Four Creek confluence (700 masl).

Another factor is that Goathorn Creek is augmented by glacial runoff where as Four Creek is non-glaciated. Although the ice melt contribution during October and November is not expected to be great, there should be some water coming from glaciers due to pressure melting and perhaps internal storage.

TIMING OF RUNOFF

In general, the timing of the discharge record for Goathorn and Four Creeks compare favourably, as is illustrated in Figures 5 through 7. This suggests that the basins respond to meteorological events in a similar fashion, and thereby justifies the use of transformed Goathorn Creek discharge data as a surrogate for Four Creek data. Applying a time lag (at the daily scale) to the discharge does not improve this relationship.

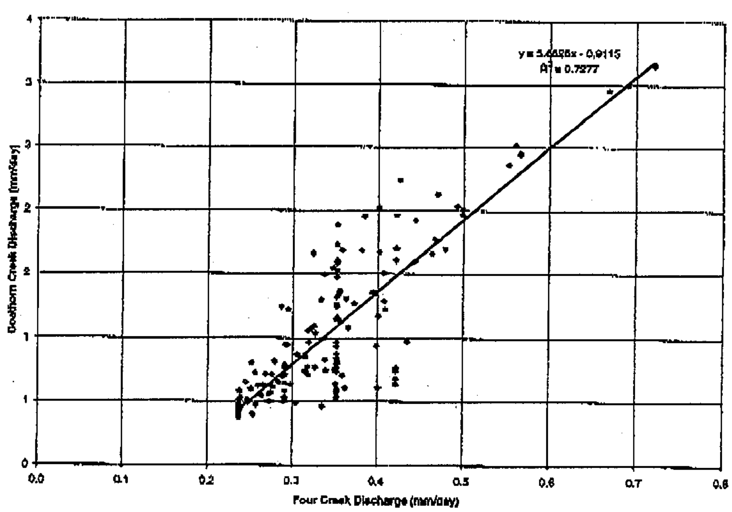

Figure 7: Relationship between Goathorn Creek and Four Creek average daily discharge

LOW FLOW ANALYSIS

Figure 8 shows the probabilities of mean annual low flows in Goathorn Creek. The data plotted are the lowest mean daily flows in Goathorn Creek (one mean daily flow for each year of record). For subsequent analysis purposes, the 1 in 10 year (10% probability) mean daily runoff of 0.045 mm/day was used as the reference. The runoff ratio of 0.38 was applied to estimate the 1 in 10 year low flow for Four Creek, giving a value of 0.017 mm/day. The average daily discharge for Goathorn Creek is 1.15 mm/day. Applying the ratio gives an estimated average daily runoff of 0.43 mm/day for Four Creek.

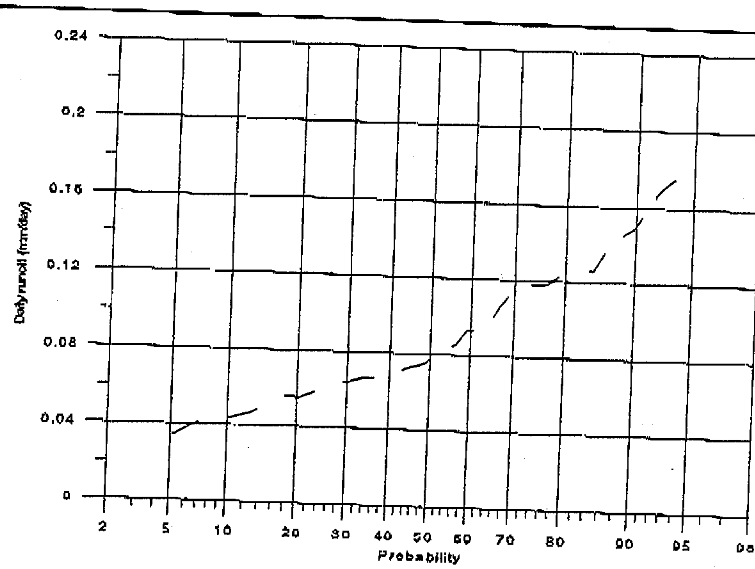

Figure 8: Mean daily low flow distribution in Goathorn Creek

The proposed diversion of the Four Creek tributary results in a reduction of roughly 18% of the total discharge area of Four Creek. Assuming that all areas of the basin behave in the same manner hydrologically, it can be assumed that the total discharge of Four Creek would also be reduced by 18%. Table 1 shows the estimated average daily and 1 in 10 year low flow for Four Creek at three stream locations assuming pre- and post-diversion scenarios. The influence of the proposed diversion on the flow of Four Creek is displayed graphically in the Appendix.

Table 2 - Estimated discharges for various locations along Four Creek.

Location	*% of original drainage area*	*Estimated Minimum 1 in 10 year Discharge (L/s)*		*Estimated Average Daily Discharge (L/s)*	
		with diversion	*without diversion*	*with diversion*	*without diversion*
At diversion	58	0.7	0.6	8.4	15
2/3 of basin length	74	0.9	1.3	22	30
At mouth	82	1.6	1.9	40	49

CONCLUSION

The use of Goathorn Creek data as a surrogate for Four Creek is reasonable provided that a transformation is applied (a value of 0.38 was used in this analysis). The two basins respond in a similar fashion in terms of timing, however, the Goathorn basin produces greater unit runoff. This may be a result of elevation, aspect, groundwater and/or icemelt.

The impact of the diversion on flows in Four Creek varies between the upper reaches and the mouth. At the mouth, only 18% of the original drainage is removed by diversion. At the point of diversion, however, 42% of the drainage (and hence flow) is removed. It is important to note that there is significant natural variability in the creek, ranging from a 1 in 10-year minimum of 1.9 L/s (assuming no diversion) to an average of 49 L/s.

It is possible to construct a diversion structure, which would guarantee a minimum flow in the creek. Only flows exceeding this minimum would be diverted into the pits. Withdrawals to the pits could therefore be restricted to higher flow periods, making the impact of the diversion relatively minor compared to natural creek variability.

Respectfully,

PITEAU ENGINEERING LTD.

Murray Fitch, M.A.Sc., P.Eng.
Senior Hydrologist

REFERENCES

Piteau, 1998. *Water Management for the Telkwa Coal Project.* Unpublished report prepared for Manalta Coal Ltd. Project #3773-16.

Quick, M.C, and Pipes, A.P., 1996. *U.B.C. Watershed Model Manual, Version 4.0,* Department of Civil Engineering, University of British Columbia.

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PITEAU ENGINEERING LTD.

HYDROGEOLOGICAL AND GEOTECHNICAL CONSULTANTS
Suite 100, 4500 - 16th Avenue NW
Calgary, Alberta, Canada T3B 0M6

Telephone: *(403) 286-2522*
Facsimile: *(403) 247-4811 / (403) 247-0779*
E-mail: *komex@komex.com*
Website: *www.komex.com*

TO FAX #: 780.420.5878
COMPANY: Luscar
ATTENTION: Allan Flemming

DATE: Feb. 16, 1999
PROJ. #: 3773-17
FROM: Murray Fitch
NO. OF PAGES: 5
(INCLUDING COVER PAGE)

Allan,

Please find attached our first cut at a report on the effects of diversions of Four Creek. I recommend that the report be passed on to David Bustard for comments on potential fisheries impacts.

As I mentioned in our telephone conversation, there remains the issue of 1998 Four Creek monitoring data, which would give us a way to assess the relationship between low flows in Goathorn and Four Creeks. I believe that it is prudent that we wait for Agra to review this data prior to finalizing the report.

We have not included a map of the site, which is in production but was delayed due to problems in assessing drainage areas. Agra originally established the Four Creek gauge basin area using 1:50,000 topographic maps - the more recent maps provided by Manalta/Luscar have allowed us to more precisely define the drainage area. The upshot is some of the notes on the map are incorrect. I should also add that some of the numbers in the report will also change slightly, but I thought it more important to get you the report now despite the minor errors.

The major conclusion of the report should not change. In brief, the impact of the diversion will be relatively small in the lower watershed, and could be further minimized through the construction of a structure which would allow diversions only during higher flows. In the upper watershed, the effects of the diversion on flows are more substantial - it remains for the aquatics people to determine if these are changes would be significant for fish. Certainly, the natural variability of flows in the creek would appear to be a significant stressor for fish, particularly in the upper reaches.

If you have questions, please do not hesitate to call me or Alexi Zawadzki at (403)247-0200.

Murray Fitch

new release to come out by Feb 24/99

PITEAU ENGINEERING LTD.
HYDROGEOLOGICAL AND GEOTECHNICAL CONSULTANTS

SUITE 100, 4500 - 16TH AVENUE N.W.
CALGARY, ALBERTA
CANADA T3B 0M6
TELEPHONE (403) 286-2522
FAX (403) 247-4811 or 247-0779
e-mail: komex@komex.com

February 16, 1999

OUR FILE: 3773-17

Luscar Coal Ltd.
10235 - 101 St.
Edmonton, AB
T5J 3G1
(fax) 780.420.5878 (tel) 780.420.4080

Attention: Allan Flemming, P.Eng.

Dear Mr. Flemming:

Re: Hydrology of Four Creek

Introduction

We have reviewed the hydrology of Four Creek, and have reached the following preliminary findings. The following is intended for your review. We would be happy to incorporate the findings into a letter which would be suitable for dissemination to other parties such as BC MELP.

Figure 1 shows the drainage sub-basins of Four Creek. For analysis purposes, we have considered flows at the following locations:

1: the proposed diversion location into the Tenas Main Pit
2: two thirds of the drainage area
3: the mouth of Four Creek (confluence with Goathorn Creek)

Hydrology of Four Creek

The Telkwa Report Project (~~official~~ name) presented a detailed analysis of the hydrology of the Telkwa region. Four key watercourses were identified in this work:

- Canyon Creek Near Smithers - 08EE014
- Kathlyn Creek above Simpson Creek - 08EE010

- Simpson Creek at the Mouth - 08EE012
- Goathorn Creek near Telkwa - 08EE008

Piteau has subsequently received flow measurement data from Agra for 1997 (Oct. 2-Nov. 27) and 1998 (Jun. 9-Oct. 19). Ideally this short-term data could be used in conjunction with regional flow data to accurately characterize the hydrology of Four Creek. However, our analysis of the Four Creek data shows that the 1997 data appears generally plausible, but the 1998 discharges are too low to be credible[1].

thus / Fri of last week revised rating curve. - re-issue 4-Creek

Comparison of hydrology of Four and Goathorn Creeks (1997)

Two of the Environment Canada gauging stations, Canyon Creek and Kathlyn Creek, have been discontinued. Flow data for Goathorn, Simpson, and Four Creek are presented in Figure 1. The data are presented as unit runoff (in mm). Thus, flows in the creeks have been corrected for drainage basin size. Basins with identical runoff coefficients (the percentage of precipitation which runs off into a creek) would plot as identical lines, regardless of basin size.

Data from Simpson Creek suggest that this basin is very "peaky" - a trait which was less marked in the Goathorn and Four Creek data. Thus, it appears that Goathorn Creek is a more appropriate comparison for Four Creek, and will be used in subsequent analyses.

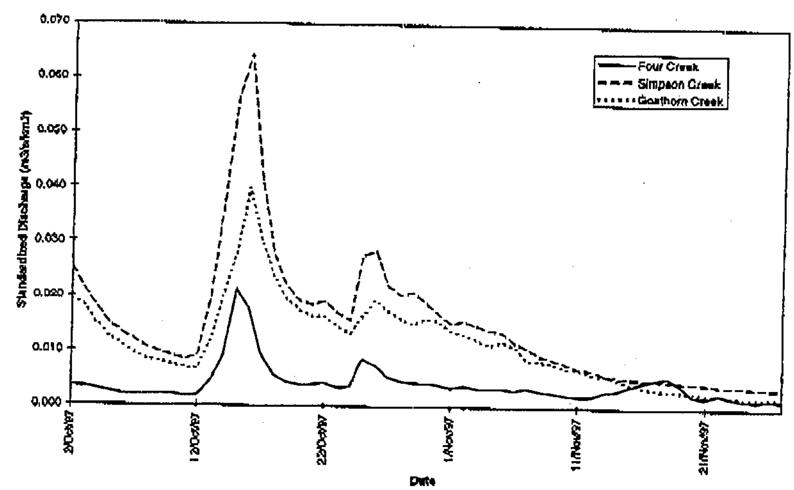

Figure 1: Comparison of Four Creek, Goathorn Creek and Simpson Creek Average Daily Discharge

Flow data for Goathorn Creek in 1997 was reported to be unreliable after November 15 due to ice conditions. Thus, to transform long-term Goathorn Creek data for use at the Four Creek site, a comparison of the 1997 data at the two sites was made. The cumulative runoff at the Four Creek station was 22.9 mm, and at Goathorn Creek, 54.2 mm. Thus, a ratio of 22.9/54.2 = 0.42 was applied to Goathorn data as a transformation. This implies that the Goathorn basin produces more than three times as much runoff (per square kilometre). There are a number of ~~potential sources of error~~ reasons for this discrepancy. in this estimate.

First, Goathorn Creek is augmented by glacial runoff where as Four Creek is ice-free (termed *nival*). Although the ice melt contribution during October and November is not expected to be great, there will be some water coming from glaciers due to pressure melting and perhaps internal storage. A second source of error may be from the estimation of drainage area. Agra had

[1] Agra has indicated to us that the 1998 data had not been quality controlled (Kristi McKay, pers. comm.). This quality control is in process.

which is correct

estimated the drainage area of Four Creek as being 13 km^2 using 1:50,000 topographical maps. Komex had estimated the drainage area as being 10 km^2 using 1:20,000 maps provided by Manalta Coal Ltd/Luscar. The ramifications of an overestimation of drainage area are that discharge per unit area is underestimated. This may be the case as it is estimated that Four Creek produces three times less runoff than neighbouring Goat Creek. — Goathorn.

Figure 2 shows the probabilities of mean annual low flows in Goathorn Creek. The data plotted are the lowest mean daily flows in Goathorn Creek (one mean daily flow for each year of record). For subsequent analysis purposes, the 1 in 10 year (10% probability) mean daily runoff of 0.045 mm/day was used as the reference. The runoff ratio of 0.32 was applied to estimate the 1 in 10 year low flow for Four Creek, giving a value of 0.012 mm/day. The average daily discharge for Goathorn Creek is 1.15 mm/day. Applying the ratio gives an estimated average daily discharge of 0.373 mm/day for Four Creek.

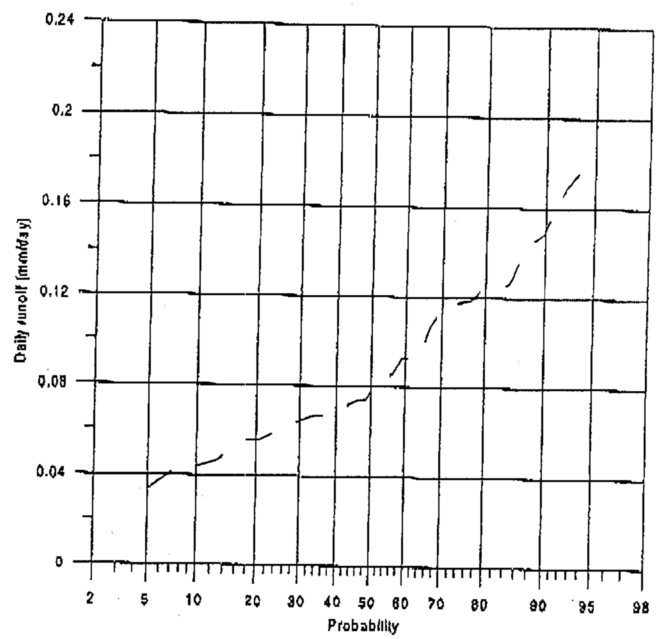

Figure 2: Mean Daily Low Flow Distribution in Goathorn Creek

The proposed diversion of the Four Creek tributary results in a reduction of roughly 18% of the total discharge area of Four Creek. Assuming that all areas of the basin behave in the same manner hydrologically, it can be assumed that the total discharge of Four Creek would also be reduced by 17% or 18%. Table 1 shows the estimated average daily and 1 in 10 year low flow for Four Creek at three stream locations assuming pre- and post-diversion scenarios.

Table 1 - Estimated discharges for various locations along Four Creek.

Location	*% of original drainage area*	*Estimated Minimum 1 in 10 year Discharge (L/s)*		*Estimated Average Daily Discharge (L/s)*	
		with diversion	*without diversion*	*with diversion*	*without diversion*
At diversion	58	0.35	0.60	8.00	13.80
2/3 of basin length	74	0.89	1.20	21.20	28.65
At mouth	82	1.48	1.80	37.76	46.05

Conclusion

The impact of the diversion on flows in Four Creek varies between the upper reaches and the mouth. At the mouth, only 18% of the original drainage is removed by diversion. At the point of diversion, however, 42% of the drainage (and hence flow) is removed. It is important to note that there is significant natural variability in the creek, ranging from a 1 in 10 year minimum of 1.8 L/s (assuming no diversion) to an average of 46 L/s.

It is possible to construct a diversion structure which would guarantee a minimum flow in the creek. Only flows exceeding this minimum would be diverted into the pits. Withdrawals to the pits could therefore be restricted to higher flow periods, making the impact of the diversion relatively minor compared to natural creek variability.

Respectfully,

PITEAU ENGINEERING LTD.

Murray Fitch

Murray Fitch, M.A.Sc., P.Eng.
Senior Hydrologist

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Appendix B: Baseflow Separation Results

Attachment B: Baseflow Separation Results
Tenas Hydrometeorological Baseline Report

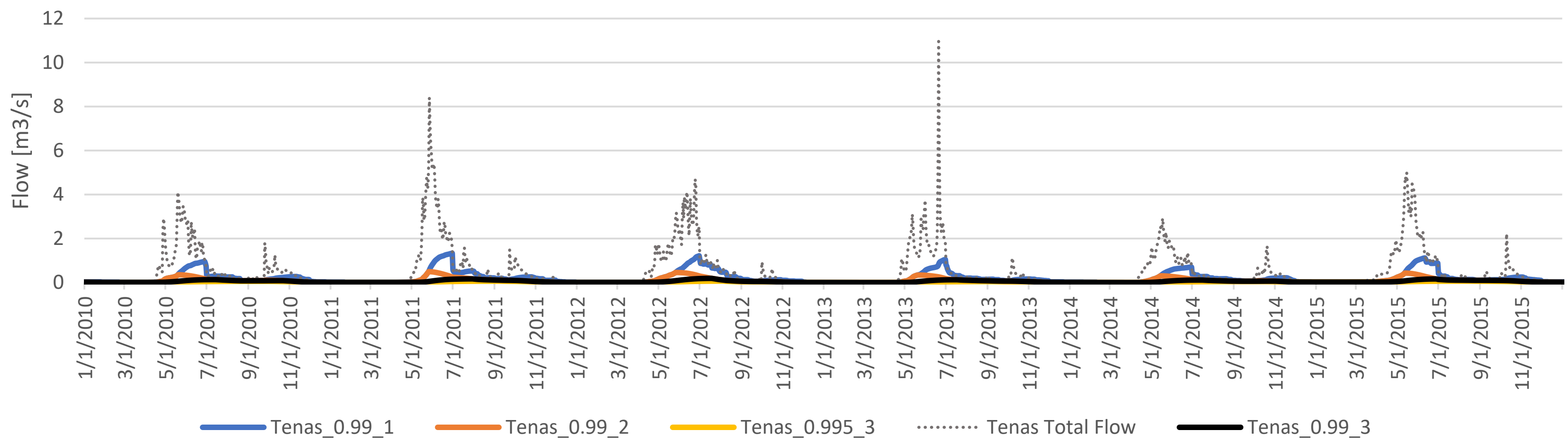


Figure A- 1: Tenas Creek Baseflow Separation results with varied Filter Parameter and Number of Passes

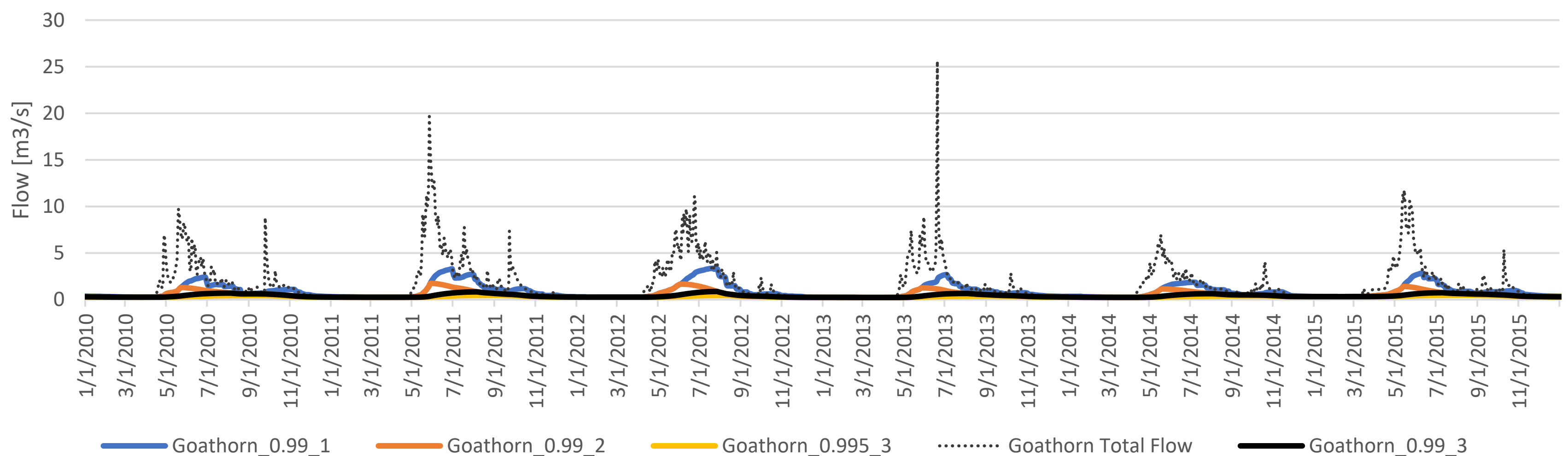


Figure A- 2: Goathorn Creek Baseflow Separation results with varied Filter Parameter and Number of Passes

Attachment B: Baseflow Separation Results
Tenas Hydrometeorological Baseline Report

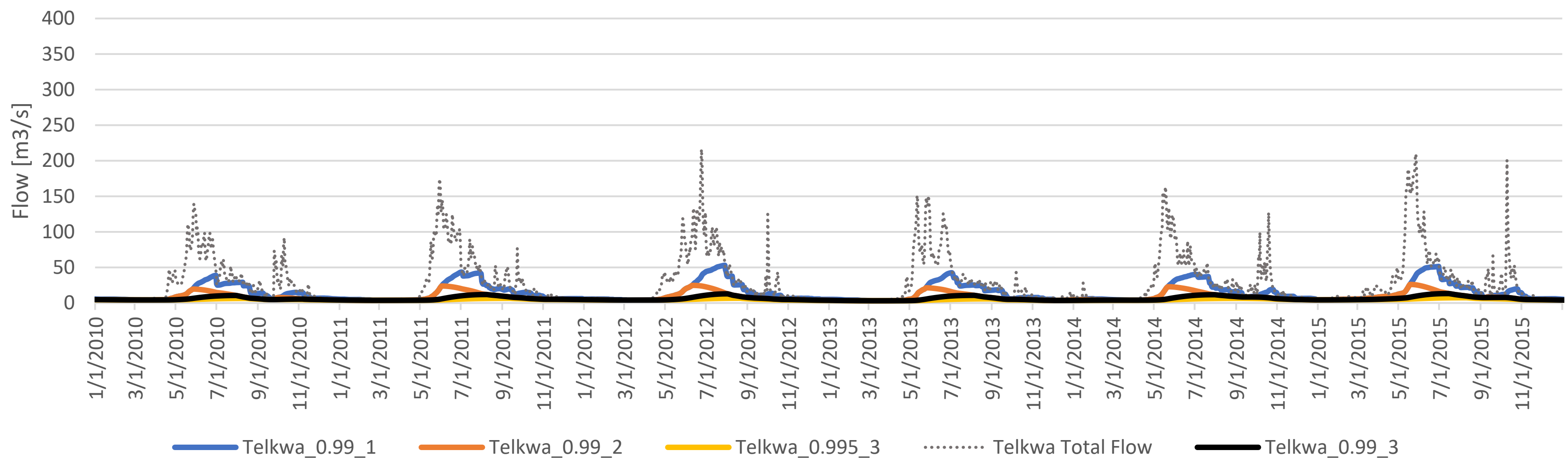


Figure A- 3: Telkwa River Baseflow Separation results with varied Filter Parameter and Number of Passes

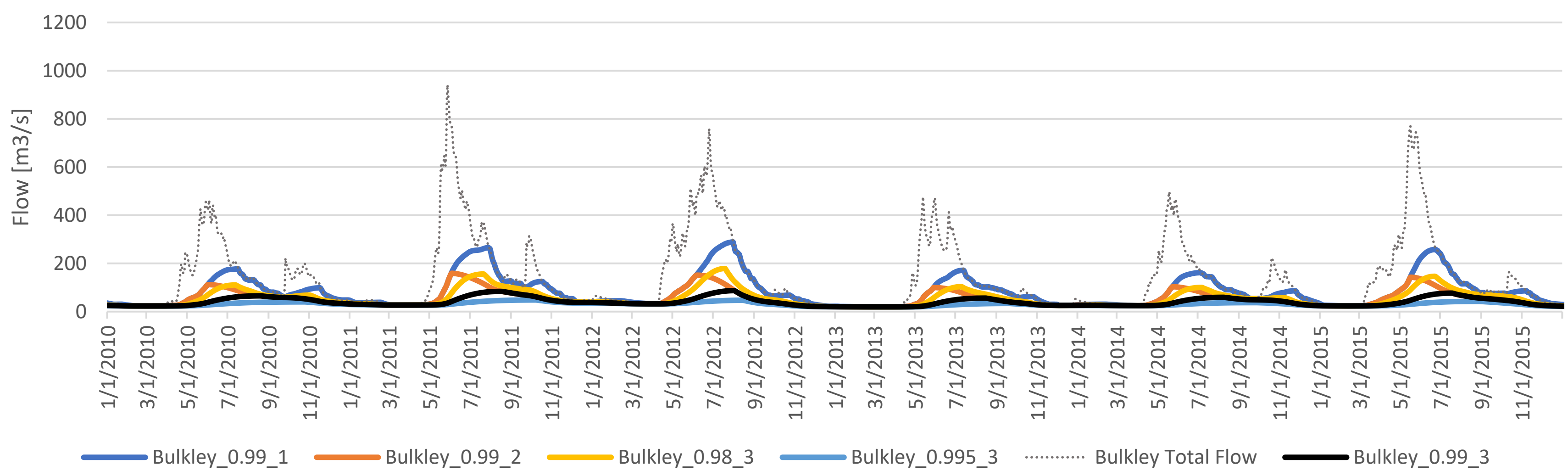


Figure A- 4: Bulkley River Baseflow Separation results with varied Filter Parameter and Number of Passes

Appendix C: AGRA 1999 Data Summaries

Attachment C: AGRA Data Analysis
Tenas Hydrometeorological Baseline Report

Table C-1. Tenas Creek Summary Sheet

Description: Lower Tenas Creek downstream of the Tenas Pit

Site ID:	Lower Tenas Ck	Start Date:	08-May-97
Operator:	TELKWA COAL	End Date:	10-Nov-98
Frequency:	DISCONTINUOUS	Discharge:	In Stream
Monitored:	YES	Water Level:	Level Survey

Comments:
The continuous discharge times series was calculated from 1-hour interval water level recordings.

1997 and 1998 Spot Measurement Summary

Date & Time	Discharge (m^3/s)	Staff Gauge (m)	Flow Measurement Method
08-May-1997	2.55	0.566	Current meter
16-May-1997	6.04	1.05	Current meter
22-May-1997	2.76	0.624	Current meter
13-Jun-1997	3.22	0.676	Current meter
24-Apr-1998	0.810	0.480	Current meter
14-May-1998	3.31	0.690	Current meter
27-May-1998	6.10	0.780	Current meter
23-Jun-1998	0.566	0.450	Current meter
21-Jul-1998	0.399	0.430	Current meter
19-Aug-1998	0.208	0.390	Current meter
09-Sep-1998	0.210	0.385	Current meter
25-Sep-1998	0.156	0.368	Current meter
10-Nov-1998	0.116	0.395	Current meter

ND: No Data

Figure: 1997 - 1998 Spot Discharge and Daily Discharge in Lower Tenas Creek

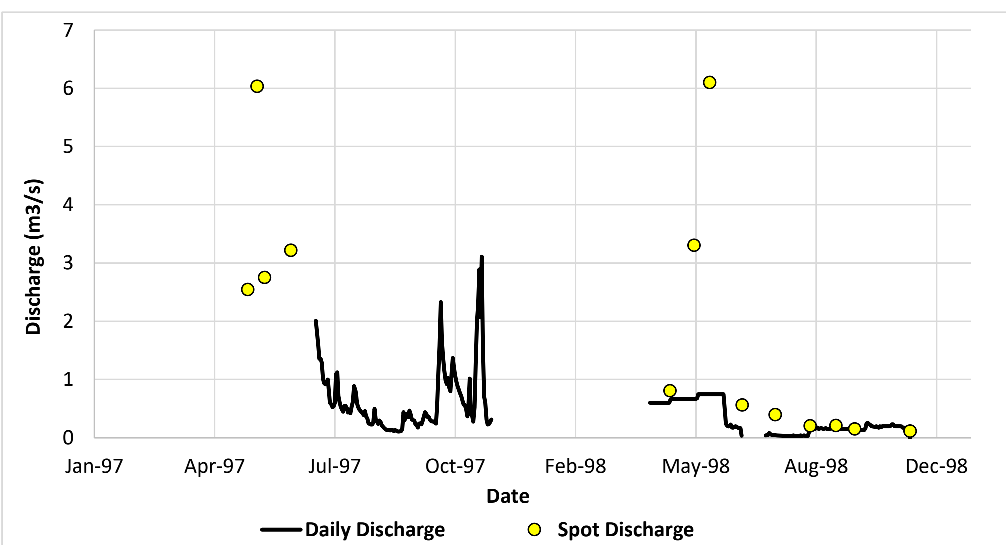


Table C-2. Four Creek Summary Sheet

Description: Four Creek above the confluence with Goathorn Creek			
Site ID:	Lower Four Ck	Start Date:	09-May-97
Operator:	TELKWA COAL	End Date:	10-Nov-98
Frequency:	DISCONTINUOUS	Discharge:	In Stream
Monitored:	YES	Water Level:	Level Survey

Comments:

The continuous discharge times series was calculated from 1-hour interval datalogger recordings.

1997 and 1998 Spot Measurement Summary

Date & Time	Discharge (m^3/s)	Staff Gauge (m)	Flow Measurement Method
09-May-1997	0.384	0.336	Current meter
15-May-1997	0.786	0.421	Current meter
21-May-1997	0.269	0.268	Current meter
11-Jun-1997	0.0810	0.193	Current meter
28-Apr-1998	0.569	0.375	Current meter
30-Apr-1998	0.545	0.372	Current meter
13-May-1998	0.271	0.326	Current meter
26-May-1998	0.313	0.335	Current meter
10-Jun-1998	0.0117	0.180	Current meter
23-Jun-1998	0.00495	0.153	Current meter
24-Jun-1998	0.00739	0.165	Current meter
10-Jul-1998	0.00865	0.170	Current meter
22-Jul-1998	0.00813	0.168	Current meter
29-Jul-1998	0.00628	0.160	Current meter
18-Aug-1998	0.00628	0.160	Current meter
09-Sep-1998	0.00670	0.162	Current meter
10-Nov-1998	0.01474	0.188	Current meter

ND: No Data

Figure: 1997 - 1998 Spot Discharge and Daily Discharge in Lower Four Creek

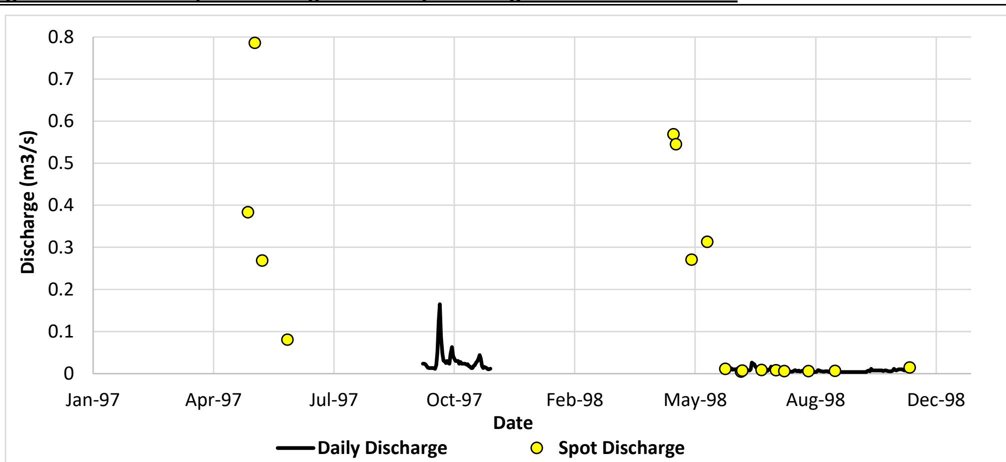
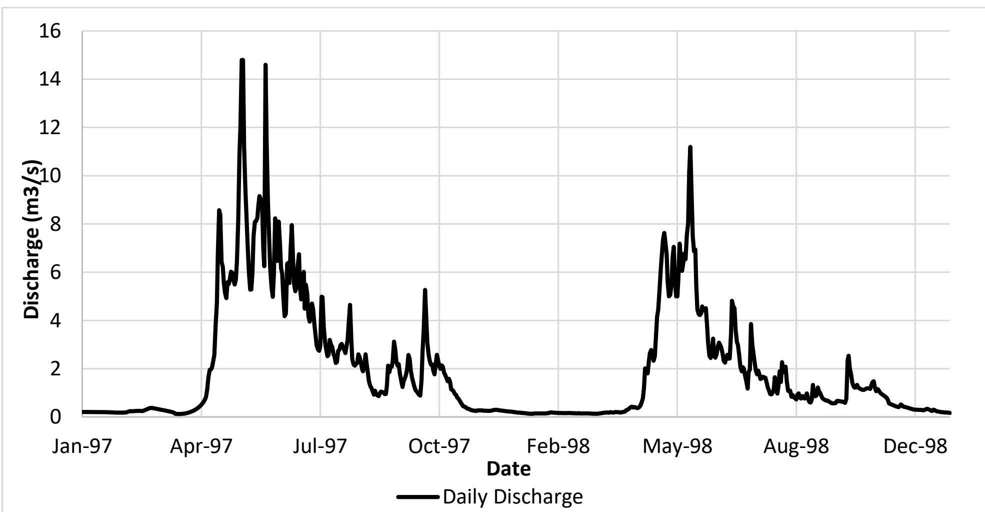


Table C-3. Goathorn Creek Summary Sheet

Description: Goathorn Creek near Telkwa					
Site ID:	WSC 08EE008	Start Date:	01-Jan-97		
Operator:	WATER SURVEY OF CANADA	End Date:	31-Dec-98		
Frequency:	CONTINUOUS	Discharge:	In Stream		
Monitored:	YES	Water Level:	Level Survey		
Comments:		**1997 and 1998 Spot Measurement Summary**			
Continuous daily discharge time series generated by WSC.		Date & Time	Discharge (m^3/s)	Staff Gauge (m)	Flow Measurement Method
		ND	ND	ND	ND
		ND: No Data (Data provided by Water Survey of Canada)			

Figure: 1997 - 1998 Daily Discharge in Goathorn Creek (WSC 08EE008)



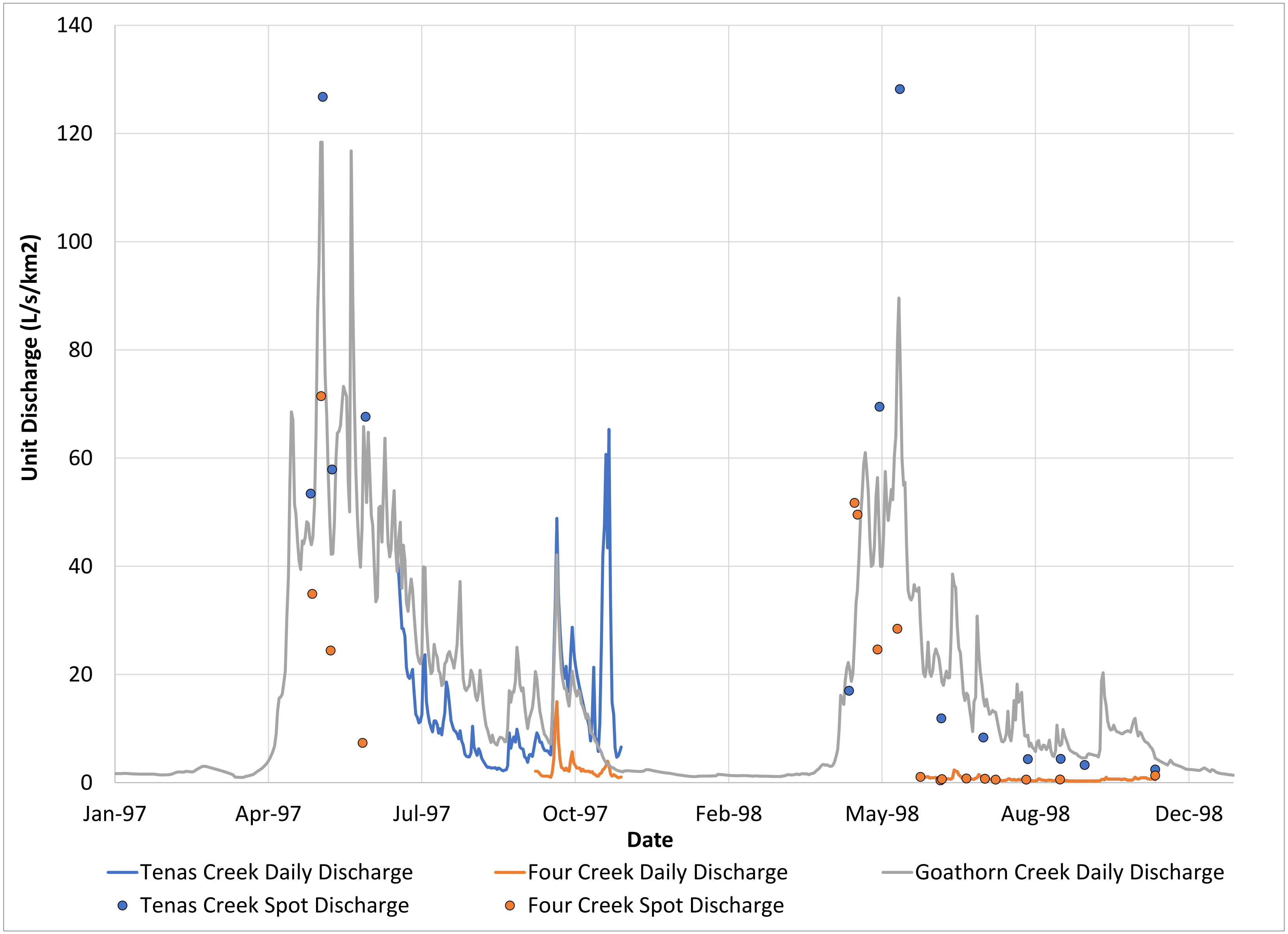


Figure C-1. Daily and Spot Unit Discharge at Each Station

Table C-4. Time Series of Daily Discharge at Each Station

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
01-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.21	1.69
02-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.21	1.69
03-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.21	1.70
04-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.21	1.70
05-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.21	1.70
06-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.21	1.70
07-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.21	1.71
08-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.22	1.72
09-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.22	1.73
10-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.21	1.69
11-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.21	1.67
12-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.21	1.66
13-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.21	1.64
14-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.20	1.62
15-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.20	1.62
16-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.20	1.61
17-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.20	1.61
18-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.20	1.60
19-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.20	1.60
20-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.20	1.60
21-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.20	1.61
22-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.20	1.61
23-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.20	1.60
24-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.20	1.59
25-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.20	1.58
26-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.20	1.58
27-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.20	1.58
28-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.19	1.54
29-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.19	1.50
30-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.18	1.46
31-Jan-97	ND	ND	ND	ND	ND	ND	0.00	0.18	1.45
01-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.18	1.44
02-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.18	1.45
03-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.18	1.46
04-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.18	1.47
05-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.19	1.50
06-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.19	1.52
07-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.20	1.58

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
08-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.21	1.70
09-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.23	1.84
10-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.24	1.92
11-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.25	2.00
12-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.25	1.99
13-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.25	1.98
14-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.25	1.98
15-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.25	1.97
16-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.26	2.08
17-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.26	2.08
18-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.26	2.07
19-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.26	2.04
20-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.25	2.00
21-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.26	2.04
22-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.28	2.24
23-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.30	2.40
24-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.32	2.56
25-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.34	2.72
26-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.36	2.88
27-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.38	3.04
28-Feb-97	ND	ND	ND	ND	ND	ND	0.00	0.38	3.04
01-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.38	3.04
02-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.37	2.94
03-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.36	2.88
04-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.35	2.80
05-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.34	2.72
06-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.33	2.64
07-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.32	2.56
08-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.31	2.48
09-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.30	2.40
10-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.29	2.32
11-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.28	2.24
12-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.27	2.16
13-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.26	2.08
14-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.25	1.98
15-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.24	1.90
16-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.22	1.76
17-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.21	1.68
18-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.20	1.60
19-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.18	1.46

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
20-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.14	1.10
21-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.13	1.04
22-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.13	1.02
23-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.12	0.99
24-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.13	1.00
25-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.13	1.00
26-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.13	1.04
27-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.15	1.16
28-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.15	1.22
29-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.16	1.26
30-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.17	1.36
31-Mar-97	ND	ND	ND	ND	ND	ND	0.00	0.18	1.44
01-Apr-97	ND	ND	ND	ND	ND	ND	0.00	0.19	1.48
02-Apr-97	ND	ND	ND	ND	ND	ND	0.00	0.22	1.72
03-Apr-97	ND	ND	ND	ND	ND	ND	0.00	0.24	1.88
04-Apr-97	ND	ND	ND	ND	ND	ND	0.00	0.27	2.16
05-Apr-97	ND	ND	ND	ND	ND	ND	0.00	0.29	2.32
06-Apr-97	ND	ND	ND	ND	ND	ND	0.00	0.31	2.48
07-Apr-97	ND	ND	ND	ND	ND	ND	0.00	0.34	2.72
08-Apr-97	ND	ND	ND	ND	ND	ND	0.00	0.37	2.96
09-Apr-97	ND	ND	ND	ND	ND	ND	0.00	0.41	3.28
10-Apr-97	ND	ND	ND	ND	ND	ND	0.00	0.45	3.60
11-Apr-97	ND	ND	ND	ND	ND	ND	0.00	0.51	4.08
12-Apr-97	ND	ND	ND	ND	ND	ND	0.00	0.56	4.48
13-Apr-97	ND	ND	ND	ND	ND	ND	0.00	0.65	5.20
14-Apr-97	ND	ND	ND	ND	ND	ND	0.00	0.74	5.92
15-Apr-97	ND	ND	ND	ND	ND	ND	0.00	0.84	6.74
16-Apr-97	ND	ND	ND	ND	ND	ND	0.00	1.13	9.04
17-Apr-97	ND	ND	ND	ND	ND	ND	0.00	1.65	13.20
18-Apr-97	ND	ND	ND	ND	ND	ND	0.00	1.96	15.68
19-Apr-97	ND	ND	ND	ND	ND	ND	0.00	1.98	15.84
20-Apr-97	ND	ND	ND	ND	ND	ND	0.00	2.05	16.40
21-Apr-97	ND	ND	ND	ND	ND	ND	0.00	2.29	18.32
22-Apr-97	ND	ND	ND	ND	ND	ND	0.00	2.58	20.64
23-Apr-97	ND	ND	ND	ND	ND	ND	0.00	3.80	30.40
24-Apr-97	ND	ND	ND	ND	ND	ND	0.00	4.75	38.00
25-Apr-97	ND	ND	ND	ND	ND	ND	0.00	6.81	54.48
26-Apr-97	ND	ND	ND	ND	ND	ND	0.00	8.57	68.56
27-Apr-97	ND	ND	ND	ND	ND	ND	0.00	8.38	67.04
28-Apr-97	ND	ND	ND	ND	ND	ND	0.00	6.44	51.52

Attachment C: AGRA Data Analysis
Tenas Hydrometeorological Baseline Report

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
29-Apr-97	ND	ND	ND	ND	ND	ND	0.00	6.21	49.68
30-Apr-97	ND	ND	ND	ND	ND	ND	0.00	5.58	44.64
01-May-97	ND	ND	ND	ND	ND	ND	0.00	5.14	41.12
02-May-97	ND	ND	ND	ND	ND	ND	0.00	4.93	39.44
03-May-97	ND	ND	ND	ND	ND	ND	0.00	5.59	44.72
04-May-97	ND	ND	ND	ND	ND	ND	0.00	5.52	44.16
05-May-97	ND	ND	ND	ND	ND	ND	0.00	5.68	45.44
06-May-97	ND	ND	ND	ND	ND	ND	0.00	6.03	48.24
07-May-97	ND	ND	ND	ND	ND	ND	0.00	5.98	47.84
08-May-97	ND	ND	ND	ND	ND	ND	0.00	5.66	45.28
09-May-97	ND	ND	ND	ND	ND	ND	0.00	5.50	44.00
10-May-97	ND	ND	ND	ND	ND	ND	0.00	5.68	45.44
11-May-97	ND	ND	ND	ND	ND	ND	0.00	6.43	51.44
12-May-97	ND	ND	ND	ND	ND	ND	0.00	8.09	64.72
13-May-97	ND	ND	ND	ND	ND	ND	0.00	10.90	87.20
14-May-97	ND	ND	ND	ND	ND	ND	0.00	12.00	96.00
15-May-97	ND	ND	ND	ND	ND	ND	0.00	14.80	118.40
16-May-97	ND	ND	ND	ND	ND	ND	0.00	14.80	118.40
17-May-97	ND	ND	ND	ND	ND	ND	0.00	11.20	89.60
18-May-97	ND	ND	ND	ND	ND	ND	0.00	9.42	75.36
19-May-97	ND	ND	ND	ND	ND	ND	0.00	8.46	67.68
20-May-97	ND	ND	ND	ND	ND	ND	0.00	7.13	57.04
21-May-97	ND	ND	ND	ND	ND	ND	0.00	5.99	47.92
22-May-97	ND	ND	ND	ND	ND	ND	0.00	5.28	42.24
23-May-97	ND	ND	ND	ND	ND	ND	0.00	5.29	42.32
24-May-97	ND	ND	ND	ND	ND	ND	0.00	5.99	47.92
25-May-97	ND	ND	ND	ND	ND	ND	0.00	7.49	59.92
26-May-97	ND	ND	ND	ND	ND	ND	0.00	8.08	64.64
27-May-97	ND	ND	ND	ND	ND	ND	0.00	8.12	64.96
28-May-97	ND	ND	ND	ND	ND	ND	0.00	8.25	66.00
29-May-97	ND	ND	ND	ND	ND	ND	0.00	8.77	70.16
30-May-97	ND	ND	ND	ND	ND	ND	0.00	9.16	73.28
31-May-97	ND	ND	ND	ND	ND	ND	0.00	9.03	72.24
01-Jun-97	ND	ND	ND	ND	ND	ND	0.00	8.92	71.36
02-Jun-97	ND	ND	ND	ND	ND	ND	0.00	6.95	55.60
03-Jun-97	ND	ND	ND	ND	ND	ND	0.00	6.26	50.08
04-Jun-97	ND	ND	ND	ND	ND	ND	0.00	14.60	116.80
05-Jun-97	ND	ND	ND	ND	ND	ND	0.00	11.30	90.40
06-Jun-97	ND	ND	ND	ND	ND	ND	0.00	8.87	70.96
07-Jun-97	ND	ND	ND	ND	ND	ND	0.00	7.33	58.64

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
08-Jun-97	ND	ND	ND	ND	ND	ND	0.00	6.17	49.36
09-Jun-97	ND	ND	ND	ND	ND	ND	0.00	5.41	43.28
10-Jun-97	ND	ND	ND	ND	ND	ND	0.00	4.98	39.84
11-Jun-97	ND	ND	ND	ND	ND	ND	0.00	5.92	47.36
12-Jun-97	ND	ND	ND	ND	ND	ND	0.00	8.23	65.84
13-Jun-97	ND	ND	ND	ND	ND	ND	0.00	7.43	59.44
14-Jun-97	ND	ND	ND	ND	ND	ND	0.00	6.47	51.76
15-Jun-97	ND	ND	ND	ND	ND	ND	0.00	8.10	64.80
16-Jun-97	ND	ND	ND	ND	ND	ND	0.00	7.20	57.60
17-Jun-97	ND	ND	ND	ND	ND	ND	0.00	6.17	49.36
18-Jun-97	ND	ND	ND	ND	ND	ND	0.00	5.95	47.60
19-Jun-97	ND	ND	ND	ND	ND	ND	0.00	4.99	39.92
20-Jun-97	ND	ND	ND	ND	ND	ND	0.00	4.18	33.44
21-Jun-97	ND	ND	ND	ND	ND	ND	0.00	4.29	34.32
22-Jun-97	ND	ND	ND	ND	ND	ND	0.00	6.35	50.80
23-Jun-97	ND	ND	ND	ND	ND	ND	0.00	6.39	51.12
24-Jun-97	ND	ND	ND	ND	ND	ND	0.00	5.56	44.48
25-Jun-97	ND	ND	ND	ND	ND	ND	0.00	6.86	54.88
26-Jun-97	ND	ND	ND	ND	ND	ND	0.00	7.96	63.68
27-Jun-97	ND	ND	ND	ND	ND	ND	0.00	6.51	52.08
28-Jun-97	ND	ND	ND	ND	ND	ND	0.00	5.53	44.24
29-Jun-97	ND	ND	ND	ND	ND	ND	0.00	5.22	41.76
30-Jun-97	ND	ND	ND	ND	ND	ND	0.00	5.40	43.20
01-Jul-97	ND	ND	ND	ND	ND	ND	0.00	6.26	50.08
02-Jul-97	ND	ND	ND	ND	ND	ND	0.00	6.75	54.00
03-Jul-97	ND	ND	ND	ND	ND	ND	0.00	5.39	43.12
04-Jul-97	0.58	2.01	42.22	ND	ND	ND	0.00	4.88	39.04
05-Jul-97	0.57	1.82	38.2	ND	ND	ND	0.00	5.67	45.36
06-Jul-97	0.56	1.59	33.47	ND	ND	ND	0.00	6.02	48.16
07-Jul-97	0.54	1.36	28.5	ND	ND	ND	0.00	4.49	35.92
08-Jul-97	0.54	1.36	28.49	ND	ND	ND	0.00	5.49	43.92
09-Jul-97	0.53	1.29	27.06	ND	ND	ND	0.00	5.14	41.12
10-Jul-97	0.51	1.01	21.29	ND	ND	ND	0.00	4.17	33.36
11-Jul-97	0.5	0.94	19.65	ND	ND	ND	0.00	3.96	31.68
12-Jul-97	0.5	0.92	19.25	ND	ND	ND	0.00	4.36	34.88
13-Jul-97	0.5	0.95	20	ND	ND	ND	0.00	4.71	37.68
14-Jul-97	0.51	1	20.98	ND	ND	ND	0.00	4.47	35.76
15-Jul-97	0.49	0.79	16.53	ND	ND	ND	0.00	3.86	30.88
16-Jul-97	0.46	0.6	12.63	ND	ND	ND	0.00	3.36	26.88
17-Jul-97	0.46	0.58	12.11	ND	ND	ND	0.00	2.98	23.84

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
18-Jul-97	0.45	0.53	11.08	ND	ND	ND	0.00	2.81	22.48
19-Jul-97	0.45	0.54	11.29	ND	ND	ND	0.00	2.75	22.00
20-Jul-97	0.46	0.6	12.65	ND	ND	ND	0.00	2.94	23.52
21-Jul-97	0.51	1.09	22.9	ND	ND	ND	0.00	4.99	39.92
22-Jul-97	0.52	1.13	23.65	ND	ND	ND	0.00	4.97	39.76
23-Jul-97	0.48	0.72	15.04	ND	ND	ND	0.00	3.70	29.60
24-Jul-97	0.46	0.6	12.69	ND	ND	ND	0.00	3.10	24.80
25-Jul-97	0.45	0.53	11.13	ND	ND	ND	0.00	2.77	22.16
26-Jul-97	0.44	0.48	10.1	ND	ND	ND	0.00	2.52	20.16
27-Jul-97	0.43	0.45	9.41	ND	ND	ND	0.00	2.58	20.64
28-Jul-97	0.45	0.55	11.46	ND	ND	ND	0.00	3.20	25.60
29-Jul-97	0.45	0.55	11.46	ND	ND	ND	0.00	3.00	24.00
30-Jul-97	0.45	0.51	10.74	ND	ND	ND	0.00	2.90	23.20
31-Jul-97	0.43	0.44	9.16	ND	ND	ND	0.00	2.60	20.80
01-Aug-97	0.44	0.48	10.02	ND	ND	ND	0.00	2.51	20.08
02-Aug-97	0.43	0.42	8.85	ND	ND	ND	0.00	2.24	17.92
03-Aug-97	0.45	0.54	11.3	ND	ND	ND	0.00	2.29	18.32
04-Aug-97	0.46	0.61	12.88	ND	ND	ND	0.00	2.75	22.00
05-Aug-97	0.5	0.89	18.64	ND	ND	ND	0.00	2.80	22.40
06-Aug-97	0.49	0.82	17.19	ND	ND	ND	0.00	2.97	23.76
07-Aug-97	0.47	0.69	14.4	ND	ND	ND	0.00	3.03	24.24
08-Aug-97	0.45	0.55	11.51	ND	ND	ND	0.00	2.90	23.20
09-Aug-97	0.44	0.5	10.54	ND	ND	ND	0.00	2.80	22.40
10-Aug-97	0.44	0.46	9.72	ND	ND	ND	0.00	2.65	21.20
11-Aug-97	0.43	0.45	9.49	ND	ND	ND	0.00	2.90	23.20
12-Aug-97	0.43	0.43	8.97	ND	ND	ND	0.00	3.20	25.60
13-Aug-97	0.42	0.39	8.13	ND	ND	ND	0.00	4.00	32.00
14-Aug-97	0.44	0.46	9.63	ND	ND	ND	0.00	4.65	37.20
15-Aug-97	0.42	0.37	7.7	ND	ND	ND	0.00	3.20	25.60
16-Aug-97	0.41	0.33	6.96	ND	ND	ND	0.00	2.40	19.20
17-Aug-97	0.39	0.25	5.32	ND	ND	ND	0.00	2.18	17.44
18-Aug-97	0.38	0.23	4.92	ND	ND	ND	0.00	2.13	17.04
19-Aug-97	0.38	0.23	4.8	ND	ND	ND	0.00	2.20	17.60
20-Aug-97	0.38	0.23	4.78	ND	ND	ND	0.00	2.24	17.92
21-Aug-97	0.39	0.26	5.48	ND	ND	ND	0.00	2.60	20.80
22-Aug-97	0.44	0.5	10.43	ND	ND	ND	0.00	2.50	20.00
23-Aug-97	0.41	0.32	6.69	ND	ND	ND	0.00	2.30	18.40
24-Aug-97	0.39	0.28	5.8	ND	ND	ND	0.00	2.00	16.00
25-Aug-97	0.38	0.24	5.06	ND	ND	ND	0.00	1.90	15.20
26-Aug-97	0.4	0.3	6.28	ND	ND	ND	0.00	2.10	16.80

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
27-Aug-97	0.39	0.27	5.68	ND	ND	ND	0.00	2.60	20.80
28-Aug-97	0.38	0.22	4.53	ND	ND	ND	0.00	2.20	17.60
29-Aug-97	0.37	0.19	4.02	ND	ND	ND	0.00	1.80	14.40
30-Aug-97	0.36	0.17	3.52	ND	ND	ND	0.00	1.50	12.00
31-Aug-97	0.35	0.15	3.12	ND	ND	ND	0.00	1.30	10.40
01-Sep-97	0.34	0.13	2.81	ND	ND	ND	0.00	1.20	9.60
02-Sep-97	0.34	0.14	2.88	ND	ND	ND	0.00	1.05	8.40
03-Sep-97	0.34	0.13	2.74	ND	ND	ND	0.00	0.93	7.44
04-Sep-97	0.34	0.13	2.72	ND	ND	ND	0.00	1.10	8.80
05-Sep-97	0.34	0.13	2.76	ND	ND	ND	0.00	0.95	7.60
06-Sep-97	0.34	0.13	2.78	ND	ND	ND	0.00	0.90	7.20
07-Sep-97	0.33	0.12	2.45	ND	ND	ND	0.00	0.87	6.96
08-Sep-97	0.34	0.13	2.73	ND	ND	ND	0.00	0.99	7.94
09-Sep-97	0.34	0.12	2.55	ND	ND	ND	0.00	1.05	8.40
10-Sep-97	0.33	0.11	2.36	ND	ND	ND	0.00	1.04	8.32
11-Sep-97	0.33	0.11	2.21	ND	ND	ND	0.00	1.02	8.16
12-Sep-97	0.33	0.11	2.34	ND	ND	ND	0.00	0.95	7.60
13-Sep-97	0.33	0.11	2.38	ND	ND	ND	0.00	0.95	7.62
14-Sep-97	0.35	0.15	3.14	ND	ND	ND	0.00	1.27	10.16
15-Sep-97	0.43	0.44	9.23	ND	ND	ND	0.00	2.13	17.04
16-Sep-97	0.4	0.3	6.38	ND	ND	ND	0.00	1.86	14.88
17-Sep-97	0.42	0.37	7.76	ND	ND	ND	0.00	2.10	16.80
18-Sep-97	0.43	0.4	8.48	ND	ND	ND	0.00	2.09	16.72
19-Sep-97	0.42	0.36	7.51	ND	ND	ND	0.00	2.34	18.72
20-Sep-97	0.44	0.47	9.87	ND	ND	ND	0.00	3.13	25.04
21-Sep-97	0.42	0.4	8.38	ND	ND	ND	0.00	2.78	22.24
22-Sep-97	0.4	0.31	6.6	ND	ND	ND	0.00	2.27	18.16
23-Sep-97	0.4	0.3	6.33	ND	ND	ND	0.00	2.12	16.96
24-Sep-97	0.4	0.3	6.23	ND	ND	ND	0.00	2.19	17.52
25-Sep-97	0.38	0.23	4.75	ND	ND	ND	0.00	1.78	14.24
26-Sep-97	0.38	0.22	4.6	ND	ND	ND	0.00	1.51	12.08
27-Sep-97	0.36	0.18	3.76	ND	ND	ND	0.00	1.25	10.00
28-Sep-97	0.38	0.24	5.14	ND	ND	ND	0.00	1.49	11.92
29-Sep-97	0.39	0.25	5.22	ND	ND	ND	0.00	1.60	12.80
30-Sep-97	0.38	0.23	4.86	ND	ND	ND	0.00	1.73	13.84
01-Oct-97	0.4	0.3	6.21	ND	ND	ND	0.00	2.00	16.00
02-Oct-97	0.42	0.38	7.94	0.21	0.02	2.12	0.00	2.57	20.56
03-Oct-97	0.43	0.44	9.21	0.21	0.02	2.12	0.00	2.40	19.20
04-Oct-97	0.43	0.41	8.56	0.2	0.02	1.99	0.00	1.96	15.68
05-Oct-97	0.41	0.36	7.48	0.2	0.02	1.63	0.00	1.65	13.20

Attachment C: AGRA Data Analysis
Tenas Hydrometeorological Baseline Report

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
06-Oct-97	0.42	0.36	7.51	0.19	0.01	1.28	0.00	1.46	11.68
07-Oct-97	0.4	0.31	6.55	0.19	0.01	1.23	0.00	1.26	10.08
08-Oct-97	0.4	0.29	5.99	0.19	0.01	1.23	0.00	1.11	8.88
09-Oct-97	0.4	0.28	5.9	0.19	0.01	1.23	0.00	1.07	8.56
10-Oct-97	0.4	0.28	5.92	0.19	0.01	1.23	0.00	0.99	7.92
11-Oct-97	0.39	0.26	5.49	0.18	0.01	1.11	0.00	0.92	7.34
12-Oct-97	0.38	0.24	5.12	0.18	0.01	1.01	0.00	0.89	7.15
13-Oct-97	0.44	0.54	11.38	0.2	0.02	1.89	0.00	1.55	12.40
14-Oct-97	0.52	1.13	23.72	0.24	0.05	4.67	0.00	2.68	21.44
15-Oct-97	0.55	1.57	33.06	0.28	0.13	11.39	0.00	3.69	29.52
16-Oct-97	0.6	2.33	48.89	0.3	0.16	14.99	0.00	5.27	42.16
17-Oct-97	0.56	1.66	34.87	0.26	0.09	7.99	0.00	4.00	32.00
18-Oct-97	0.54	1.36	28.52	0.23	0.05	4.31	0.00	3.10	24.80
19-Oct-97	0.52	1.15	24.21	0.22	0.03	2.82	0.00	2.59	20.72
20-Oct-97	0.51	0.99	20.74	0.21	0.03	2.65	0.00	2.34	18.72
21-Oct-97	0.5	0.92	19.31	0.21	0.02	2.27	0.00	2.17	17.36
22-Oct-97	0.51	1.03	21.54	0.22	0.03	2.72	0.00	2.18	17.44
23-Oct-97	0.49	0.86	18.05	0.21	0.02	2.27	0.00	1.94	15.52
24-Oct-97	0.49	0.8	16.85	0.21	0.02	2.12	0.00	1.77	14.16
25-Oct-97	0.52	1.12	23.57	0.23	0.05	4.26	0.00	2.17	17.36
26-Oct-97	0.54	1.37	28.73	0.25	0.06	5.73	0.00	2.58	20.64
27-Oct-97	0.53	1.19	25.1	0.23	0.04	3.76	0.00	2.33	18.64
28-Oct-97	0.52	1.06	22.33	0.22	0.04	3.19	0.00	2.12	16.96
29-Oct-97	0.5	0.96	20.14	0.22	0.03	2.72	0.00	2.00	16.00
30-Oct-97	0.5	0.88	18.52	0.22	0.03	2.72	0.00	2.14	17.12
31-Oct-97	0.49	0.83	17.35	0.22	0.03	2.72	0.00	2.08	16.64
01-Nov-97	0.48	0.77	16.14	0.21	0.02	2.14	0.00	1.83	14.64
02-Nov-97	0.48	0.71	14.98	0.21	0.03	2.5	0.00	1.76	14.08
03-Nov-97	0.47	0.64	13.46	0.21	0.02	2.12	0.00	1.63	13.04
04-Nov-97	0.46	0.57	11.95	0.21	0.02	2.12	0.00	1.49	11.92
05-Nov-97	0.45	0.56	11.73	0.21	0.02	2.12	0.00	1.59	12.72
06-Nov-97	0.44	0.5	10.49	0.21	0.02	2.12	0.00	1.47	11.76
07-Nov-97	0.42	0.37	7.72	0.2	0.02	1.93	0.00	1.15	9.20
08-Nov-97	0.45	0.57	11.93	0.2	0.02	2.06	0.00	1.13	9.04
09-Nov-97	0.51	1.02	21.37	0.2	0.02	1.63	0.00	1.07	8.56
10-Nov-97	0.42	0.4	8.35	0.19	0.02	1.51	0.00	0.95	7.62
11-Nov-97	0.42	0.37	7.87	0.19	0.01	1.23	0.00	0.92	7.39
12-Nov-97	0.39	0.28	5.79	0.19	0.01	1.23	0.00	0.82	6.56
13-Nov-97	0.44	0.52	11.01	0.2	0.02	1.66	0.00	0.77	6.16
14-Nov-97	0.53	1.25	26.19	0.2	0.02	1.81	0.00	0.70	5.60

Attachment C: AGRA Data Analysis
Tenas Hydrometeorological Baseline Report

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
15-Nov-97	0.58	2	42.02	0.21	0.03	2.38	0.00	0.60	4.80
16-Nov-97	0.6	2.26	47.52	0.21	0.03	2.67	0.00	0.52	4.16
17-Nov-97	0.63	2.89	60.68	0.22	0.03	3.13	0.00	0.46	3.68
18-Nov-97	0.59	2.07	43.43	0.23	0.04	4	0.00	0.43	3.44
19-Nov-97	0.64	3.11	65.32	0.22	0.04	3.26	0.00	0.42	3.32
20-Nov-97	0.55	1.57	32.98	0.19	0.02	1.6	0.00	0.37	2.96
21-Nov-97	0.47	0.71	14.83	0.19	0.01	1.23	0.00	0.35	2.80
22-Nov-97	0.46	0.6	12.66	0.19	0.02	1.48	0.00	0.34	2.72
23-Nov-97	0.4	0.31	6.49	0.19	0.01	1.31	0.00	0.31	2.48
24-Nov-97	0.38	0.23	4.73	0.18	0.01	1.13	0.00	0.29	2.32
25-Nov-97	0.38	0.24	4.95	0.18	0.01	0.92	0.00	0.28	2.24
26-Nov-97	0.39	0.27	5.71	0.18	0.01	1	0.00	0.27	2.16
27-Nov-97	0.96	0.32	6.63	0.18	0.01	1.05	0.00	0.26	2.08
28-Nov-97	ND	ND	ND	ND	ND	ND	0.00	0.25	2.00
29-Nov-97	ND	ND	ND	ND	ND	ND	0.00	0.28	2.20
30-Nov-97	ND	ND	ND	ND	ND	ND	0.00	0.28	2.20
01-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.28	2.22
02-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.28	2.24
03-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.28	2.20
04-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.27	2.16
05-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.27	2.16
06-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.27	2.14
07-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.26	2.10
08-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.26	2.08
09-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.26	2.07
10-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.26	2.10
11-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.27	2.14
12-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.28	2.24
13-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.30	2.40
14-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.31	2.44
15-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.30	2.40
16-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.29	2.34
17-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.29	2.30
18-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.28	2.24
19-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.27	2.17
20-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.26	2.08
21-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.26	2.06
22-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.25	2.00
23-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.24	1.94
24-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.24	1.92

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
25-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.24	1.90
26-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.23	1.84
27-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.22	1.78
28-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.22	1.76
29-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.22	1.74
30-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.21	1.66
31-Dec-97	ND	ND	ND	ND	ND	ND	0.00	0.20	1.62
01-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.19	1.55
02-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.19	1.50
03-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.18	1.46
04-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.18	1.42
05-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.17	1.38
06-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.17	1.35
07-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.31
08-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.26
09-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.23
10-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.19
11-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.16
12-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.14	1.15
13-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.14	1.14
14-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.14	1.14
15-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.14	1.14
16-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.18
17-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.21
18-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.22
19-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.23
20-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.24
21-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.25
22-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.24
23-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.25
24-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.24
25-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.24
26-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.26
27-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.26
28-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.28
29-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.20	1.58
30-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.19	1.54
31-Jan-98	ND	ND	ND	ND	ND	ND	0.00	0.19	1.52
01-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.19	1.48
02-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.18	1.44

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
03-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.18	1.42
04-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.17	1.39
05-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.17	1.38
06-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.17	1.36
07-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.17	1.34
08-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.17	1.34
09-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.17	1.32
10-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.31
11-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.30
12-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.30
13-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.31
14-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.17	1.34
15-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.17	1.36
16-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.17	1.34
17-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.30
18-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.28
19-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.26
20-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.23
21-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.21
22-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.26
23-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.25
24-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.23
25-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.22
26-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.22
27-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.21
28-Feb-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.20
01-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.18
02-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.18
03-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.18
04-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.18
05-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.18
06-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.18
07-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.18
08-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.18
09-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.18
10-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.18
11-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.18
12-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.15	1.22
13-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.16	1.26
14-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.17	1.33

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
15-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.18	1.47
16-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.19	1.49
17-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.18	1.47
18-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.18	1.42
19-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.18	1.46
20-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.19	1.50
21-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.20	1.60
22-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.19	1.55
23-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.19	1.48
24-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.20	1.58
25-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.21	1.69
26-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.21	1.66
27-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.20	1.63
28-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.21	1.65
29-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.19	1.49
30-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.20	1.56
31-Mar-98	ND	ND	ND	ND	ND	ND	0.00	0.21	1.68
01-Apr-98	ND	ND	ND	ND	ND	ND	0.00	0.22	1.74
02-Apr-98	ND	ND	ND	ND	ND	ND	0.00	0.24	1.89
03-Apr-98	ND	ND	ND	ND	ND	ND	0.00	0.27	2.19
04-Apr-98	ND	ND	ND	ND	ND	ND	0.00	0.30	2.41
05-Apr-98	ND	ND	ND	ND	ND	ND	0.00	0.33	2.65
06-Apr-98	ND	ND	ND	ND	ND	ND	0.00	0.38	3.02
07-Apr-98	ND	ND	ND	ND	ND	ND	0.00	0.42	3.33
08-Apr-98	0.46	0.6	12.61	ND	ND	ND	0.00	0.42	3.39
09-Apr-98	0.46	0.6	12.61	ND	ND	ND	0.00	0.40	3.22
10-Apr-98	0.46	0.6	12.61	ND	ND	ND	0.00	0.42	3.32
11-Apr-98	0.46	0.6	12.61	ND	ND	ND	0.00	0.39	3.15
12-Apr-98	0.46	0.6	12.61	ND	ND	ND	0.00	0.38	3.03
13-Apr-98	0.46	0.6	12.61	ND	ND	ND	0.00	0.38	3.05
14-Apr-98	0.46	0.6	12.61	ND	ND	ND	0.00	0.41	3.27
15-Apr-98	0.46	0.6	12.61	ND	ND	ND	0.00	0.48	3.86
16-Apr-98	0.46	0.6	12.61	ND	ND	ND	0.00	0.61	4.87
17-Apr-98	0.46	0.6	12.61	ND	ND	ND	0.00	0.77	6.13
18-Apr-98	0.46	0.6	12.61	ND	ND	ND	0.00	1.19	9.52
19-Apr-98	0.46	0.6	12.61	ND	ND	ND	0.00	2.02	16.16
20-Apr-98	0.46	0.6	12.61	ND	ND	ND	0.00	1.94	15.52
21-Apr-98	0.46	0.6	12.61	ND	ND	ND	0.00	1.81	14.48
22-Apr-98	0.46	0.6	12.61	ND	ND	ND	0.00	2.34	18.72
23-Apr-98	0.46	0.6	12.61	ND	ND	ND	0.00	2.64	21.12

Attachment C: AGRA Data Analysis
Tenas Hydrometeorological Baseline Report

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
24-Apr-98	0.46	0.6	12.61	ND	ND	ND	0.00	2.78	22.24
25-Apr-98	0.47	0.66	13.88	ND	ND	ND	0.00	2.59	20.72
26-Apr-98	0.47	0.67	14.06	ND	ND	ND	0.00	2.34	18.72
27-Apr-98	0.47	0.67	14.06	ND	ND	ND	0.00	2.52	20.16
28-Apr-98	0.47	0.67	14.06	ND	ND	ND	0.00	3.22	25.76
29-Apr-98	0.47	0.67	14.06	ND	ND	ND	0.00	4.15	33.20
30-Apr-98	0.47	0.67	14.06	ND	ND	ND	0.00	4.44	35.52
01-May-98	0.47	0.67	14.06	ND	ND	ND	0.00	5.23	41.84
02-May-98	0.47	0.67	14.06	ND	ND	ND	0.00	6.11	48.88
03-May-98	0.47	0.67	14.06	ND	ND	ND	0.00	6.66	53.28
04-May-98	0.47	0.67	14.06	ND	ND	ND	0.00	7.34	58.72
05-May-98	0.47	0.67	14.06	ND	ND	ND	0.00	7.63	61.04
06-May-98	0.47	0.67	14.06	ND	ND	ND	0.00	7.25	58.00
07-May-98	0.47	0.67	14.06	ND	ND	ND	0.00	6.74	53.92
08-May-98	0.47	0.67	14.06	ND	ND	ND	0.00	5.62	44.96
09-May-98	0.47	0.67	14.06	ND	ND	ND	0.00	5.00	40.00
10-May-98	0.47	0.67	14.06	ND	ND	ND	0.00	5.05	40.40
11-May-98	0.47	0.67	14.06	ND	ND	ND	0.00	5.46	43.68
12-May-98	0.47	0.67	14.06	ND	ND	ND	0.00	6.60	52.80
13-May-98	0.47	0.67	14.06	ND	ND	ND	0.00	7.05	56.40
14-May-98	0.47	0.67	14.06	ND	ND	ND	0.00	5.85	46.80
15-May-98	0.47	0.67	14.06	ND	ND	ND	0.00	5.00	40.00
16-May-98	0.47	0.67	14.06	ND	ND	ND	0.00	5.00	40.00
17-May-98	0.47	0.68	14.26	ND	ND	ND	0.00	5.73	45.84
18-May-98	0.48	0.74	15.64	ND	ND	ND	0.00	7.19	57.52
19-May-98	0.48	0.74	15.64	ND	ND	ND	0.00	6.52	52.16
20-May-98	0.48	0.74	15.64	ND	ND	ND	0.00	6.06	48.48
21-May-98	0.48	0.74	15.64	ND	ND	ND	0.00	6.40	51.20
22-May-98	0.48	0.74	15.64	ND	ND	ND	0.00	6.78	54.24
23-May-98	0.48	0.74	15.64	ND	ND	ND	0.00	6.54	52.32
24-May-98	0.48	0.74	15.64	ND	ND	ND	0.00	7.54	60.32
25-May-98	0.48	0.74	15.64	ND	ND	ND	0.00	8.02	64.16
26-May-98	0.48	0.74	15.64	ND	ND	ND	0.00	10.20	81.60
27-May-98	0.48	0.74	15.64	ND	ND	ND	0.00	11.20	89.60
28-May-98	0.48	0.74	15.64	ND	ND	ND	0.00	9.42	75.36
29-May-98	0.48	0.74	15.64	ND	ND	ND	0.00	7.50	60.00
30-May-98	0.48	0.74	15.64	ND	ND	ND	0.00	6.87	54.96
31-May-98	0.48	0.74	15.64	ND	ND	ND	0.00	6.94	55.52
01-Jun-98	0.48	0.74	15.64	ND	ND	ND	0.00	5.46	43.68
02-Jun-98	0.48	0.74	15.64	ND	ND	ND	0.00	4.45	35.60

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
03-Jun-98	0.48	0.74	15.64	ND	ND	ND	0.00	4.27	34.16
04-Jun-98	0.48	0.74	15.64	ND	ND	ND	0.00	4.22	33.76
05-Jun-98	0.48	0.74	15.64	ND	ND	ND	0.00	4.32	34.56
06-Jun-98	0.48	0.74	15.64	ND	ND	ND	0.00	4.58	36.64
07-Jun-98	0.48	0.74	15.64	ND	ND	ND	0.00	4.44	35.52
08-Jun-98	0.48	0.74	15.64	ND	ND	ND	0.00	4.42	35.36
09-Jun-98	0.43	0.48	10.13	ND	ND	ND	0.00	4.51	36.08
10-Jun-98	0.38	0.24	5.06	0.19	0.02	1.54	0.00	3.74	29.92
11-Jun-98	0.37	0.2	4.3	0.19	0.01	1.23	0.00	3.07	24.56
12-Jun-98	0.37	0.19	4.04	0.18	0.01	1.09	0.00	2.54	20.32
13-Jun-98	0.37	0.21	4.33	0.18	0.01	1.01	0.00	2.45	19.60
14-Jun-98	0.38	0.23	4.75	0.18	0.01	1.1	0.00	2.71	21.68
15-Jun-98	0.36	0.18	3.75	0.18	0.01	1.11	0.00	3.25	26.00
16-Jun-98	0.36	0.17	3.66	0.17	0.01	0.85	0.00	2.56	20.48
17-Jun-98	0.36	0.18	3.88	0.18	0.01	0.92	0.00	2.46	19.68
18-Jun-98	0.37	0.2	4.2	0.18	0.01	0.92	0.00	2.60	20.80
19-Jun-98	0.36	0.19	3.91	0.18	0.01	0.92	0.00	2.94	23.52
20-Jun-98	0.36	0.17	3.66	0.18	0.01	1.01	0.00	3.09	24.72
21-Jun-98	0.36	0.16	3.45	0.17	0.01	0.85	0.00	2.99	23.92
22-Jun-98	0.36	0.16	3.45	0.17	0.01	0.78	0.00	2.88	23.04
23-Jun-98	0.26	0.04	0.78	0.17	0.01	0.67	0.00	2.64	21.12
24-Jun-98	ND	ND	ND	0.17	0.01	0.67	0.00	2.33	18.64
25-Jun-98	ND	ND	ND	0.17	0.01	0.67	0.00	2.25	18.00
26-Jun-98	ND	ND	ND	0.17	0.01	0.67	0.00	2.45	19.60
27-Jun-98	ND	ND	ND	0.17	0.01	0.67	0.00	2.58	20.64
28-Jun-98	ND	ND	ND	0.17	0.01	0.77	0.00	2.42	19.36
29-Jun-98	ND	ND	ND	0.17	0.01	0.67	0.00	2.43	19.44
30-Jun-98	ND	ND	ND	0.17	0.01	0.67	0.00	3.42	27.36
01-Jul-98	ND	ND	ND	0.18	0.01	0.95	0.00	4.82	38.56
02-Jul-98	ND	ND	ND	0.21	0.03	2.36	0.00	4.58	36.64
03-Jul-98	ND	ND	ND	0.21	0.02	2.17	0.00	4.51	36.08
04-Jul-98	ND	ND	ND	0.2	0.02	2.06	0.00	3.61	28.88
05-Jul-98	ND	ND	ND	0.19	0.02	1.48	0.00	3.11	24.88
06-Jul-98	ND	ND	ND	0.18	0.01	1.2	0.00	3.00	24.00
07-Jul-98	ND	ND	ND	0.18	0.01	0.92	0.00	2.58	20.64
08-Jul-98	ND	ND	ND	0.17	0.01	0.69	0.00	2.07	16.56
09-Jul-98	ND	ND	ND	0.17	0.01	0.68	0.00	1.90	15.20
10-Jul-98	ND	ND	ND	0.17	0.01	0.67	0.00	2.07	16.56
11-Jul-98	ND	ND	ND	0.17	0.01	0.82	0.00	2.02	16.16
12-Jul-98	ND	ND	ND	0.16	0.01	0.67	0.00	1.72	13.76

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
13-Jul-98	0.27	0.04	0.86	0.17	0.01	0.69	0.00	1.48	11.84
14-Jul-98	0.28	0.04	0.94	0.16	0.01	0.67	0.00	1.18	9.44
15-Jul-98	0.28	0.05	0.98	0.16	0.01	0.59	0.00	1.87	14.96
16-Jul-98	0.31	0.08	1.72	0.17	0.01	0.87	0.00	1.97	15.76
17-Jul-98	0.29	0.06	1.21	0.17	0.01	0.89	0.00	3.85	30.80
18-Jul-98	0.28	0.05	1.08	0.19	0.02	1.52	0.00	3.01	24.08
19-Jul-98	0.28	0.05	1.01	0.19	0.01	1.23	0.00	2.60	20.80
20-Jul-98	0.27	0.04	0.91	0.18	0.01	1.15	0.00	2.30	18.40
21-Jul-98	0.27	0.04	0.86	0.17	0.01	0.86	0.00	1.94	15.52
22-Jul-98	0.27	0.04	0.87	0.17	0.01	0.74	0.00	1.77	14.16
23-Jul-98	0.27	0.04	0.84	0.17	0.01	0.67	0.00	1.93	15.44
24-Jul-98	0.27	0.04	0.81	0.16	0.01	0.67	0.00	1.75	14.00
25-Jul-98	0.27	0.04	0.79	0.16	0.01	0.67	0.00	1.58	12.64
26-Jul-98	0.26	0.04	0.76	0.16	0.01	0.59	0.00	1.61	12.88
27-Jul-98	0.26	0.03	0.72	0.16	0.01	0.57	0.00	1.67	13.36
28-Jul-98	0.26	0.03	0.71	0.16	0.01	0.59	0.00	1.64	13.12
29-Jul-98	0.26	0.03	0.7	0.16	0.01	0.58	0.00	1.63	13.04
30-Jul-98	0.26	0.03	0.66	0.16	0.01	0.57	0.00	1.45	11.60
31-Jul-98	0.26	0.03	0.65	0.16	0.01	0.49	0.00	1.25	10.00
01-Aug-98	0.25	0.03	0.62	0.15	0	0.45	0.00	1.11	8.88
02-Aug-98	0.25	0.03	0.62	0.15	0	0.39	0.00	0.96	7.66
03-Aug-98	0.25	0.03	0.6	0.15	0	0.4	0.00	0.94	7.55
04-Aug-98	0.26	0.03	0.64	0.15	0	0.45	0.00	1.00	7.99
05-Aug-98	0.27	0.04	0.82	0.15	0.01	0.46	0.00	1.14	9.12
06-Aug-98	0.26	0.03	0.7	0.16	0.01	0.65	0.00	1.65	13.20
07-Aug-98	0.26	0.03	0.69	0.17	0.01	0.72	0.00	1.09	8.72
08-Aug-98	0.26	0.03	0.71	0.16	0.01	0.57	0.00	0.97	7.75
09-Aug-98	0.26	0.03	0.69	0.16	0.01	0.5	0.00	1.27	10.16
10-Aug-98	0.25	0.03	0.64	0.16	0.01	0.63	0.00	1.90	15.20
11-Aug-98	0.27	0.04	0.84	0.15	0.01	0.47	0.00	1.45	11.60
12-Aug-98	0.26	0.03	0.71	0.15	0.01	0.49	0.00	2.28	18.24
13-Aug-98	0.26	0.04	0.77	0.16	0.01	0.62	0.00	1.86	14.88
14-Aug-98	0.27	0.04	0.8	0.16	0.01	0.49	0.00	1.98	15.84
15-Aug-98	0.26	0.03	0.71	0.16	0.01	0.62	0.00	2.09	16.72
16-Aug-98	0.26	0.03	0.71	0.17	0.01	0.68	0.00	1.48	11.84
17-Aug-98	0.26	0.03	0.7	0.16	0.01	0.57	0.00	1.09	8.72
18-Aug-98	0.31	0.1	2.13	0.16	0.01	0.48	0.00	1.07	8.56
19-Aug-98	0.35	0.15	3.23	0.15	0.01	0.48	0.00	1.10	8.80
20-Aug-98	0.35	0.16	3.29	0.15	0	0.42	0.00	0.84	6.72
21-Aug-98	0.35	0.15	3.17	0.15	0	0.41	0.00	0.92	7.33

Attachment C: AGRA Data Analysis
Tenas Hydrometeorological Baseline Report

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
22-Aug-98	0.35	0.15	3.17	0.15	0	0.37	0.00	0.81	6.50
23-Aug-98	0.35	0.15	3.17	0.15	0	0.34	0.00	0.79	6.31
24-Aug-98	0.36	0.17	3.62	0.15	0	0.36	0.00	0.73	5.80
25-Aug-98	0.36	0.18	3.73	0.15	0	0.39	0.00	0.93	7.43
26-Aug-98	0.35	0.15	3.17	0.17	0.01	0.72	0.00	0.98	7.82
27-Aug-98	0.35	0.16	3.37	0.16	0.01	0.67	0.00	0.80	6.42
28-Aug-98	0.36	0.17	3.54	0.16	0.01	0.48	0.00	0.77	6.14
29-Aug-98	0.35	0.16	3.33	0.16	0.01	0.48	0.00	0.87	6.96
30-Aug-98	0.35	0.15	3.23	0.15	0	0.44	0.00	0.86	6.86
31-Aug-98	0.35	0.16	3.35	0.15	0	0.41	0.00	0.76	6.11
01-Sep-98	0.36	0.17	3.47	0.15	0.01	0.48	0.00	0.82	6.56
02-Sep-98	0.35	0.15	3.17	0.15	0.01	0.48	0.00	0.99	7.90
03-Sep-98	0.35	0.15	3.17	0.15	0.01	0.48	0.00	0.75	6.02
04-Sep-98	0.35	0.15	3.17	0.15	0	0.37	0.00	0.63	5.02
05-Sep-98	0.36	0.16	3.47	0.15	0	0.38	0.00	0.60	4.82
06-Sep-98	0.36	0.18	3.69	0.15	0	0.42	0.00	0.74	5.90
07-Sep-98	0.36	0.16	3.43	0.16	0.01	0.57	0.00	1.33	10.64
08-Sep-98	0.35	0.15	3.19	0.15	0	0.42	0.00	0.97	7.73
09-Sep-98	0.36	0.17	3.66	0.15	0	0.43	0.00	0.86	6.84
10-Sep-98	0.36	0.18	3.72	0.15	0.01	0.48	0.00	0.90	7.17
11-Sep-98	0.36	0.17	3.66	0.15	0	0.45	0.00	1.23	9.84
12-Sep-98	0.36	0.17	3.6	0.15	0	0.38	0.00	1.09	8.72
13-Sep-98	0.35	0.15	3.23	0.15	0	0.4	0.00	1.00	8.00
14-Sep-98	0.35	0.15	3.17	0.15	0	0.36	0.00	0.89	7.12
15-Sep-98	0.35	0.15	3.17	0.15	0	0.34	0.00	0.78	6.26
16-Sep-98	0.35	0.15	3.17	0.15	0	0.34	0.00	0.73	5.86
17-Sep-98	0.35	0.15	3.17	0.15	0	0.34	0.00	0.72	5.72
18-Sep-98	0.35	0.15	3.17	0.15	0	0.34	0.00	0.69	5.50
19-Sep-98	0.35	0.15	3.17	0.15	0	0.34	0.00	0.68	5.46
20-Sep-98	0.35	0.15	3.17	0.15	0	0.34	0.00	0.66	5.30
21-Sep-98	0.35	0.15	3.17	0.15	0	0.34	0.00	0.62	4.97
22-Sep-98	0.35	0.15	3.17	0.15	0	0.34	0.00	0.60	4.79
23-Sep-98	0.35	0.15	3.17	0.14	0	0.34	0.00	0.58	4.61
24-Sep-98	0.35	0.14	2.96	0.15	0	0.34	0.00	0.57	4.56
25-Sep-98	0.34	0.13	2.74	0.15	0	0.34	0.00	0.58	4.62
26-Sep-98	0.34	0.14	2.85	0.15	0	0.34	0.00	0.58	4.63
27-Sep-98	0.34	0.13	2.74	0.15	0	0.34	0.00	0.65	5.21
28-Sep-98	0.34	0.13	2.74	0.15	0	0.34	0.00	0.68	5.40
29-Sep-98	0.34	0.13	2.74	0.15	0	0.34	0.00	0.66	5.27
30-Sep-98	0.34	0.14	2.87	0.15	0	0.34	0.00	0.65	5.21

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
01-Oct-98	0.34	0.13	2.74	0.15	0	0.34	0.00	0.64	5.08
02-Oct-98	0.34	0.13	2.74	0.15	0	0.34	0.00	0.63	5.06
03-Oct-98	0.34	0.13	2.74	0.15	0	0.34	0.00	0.63	5.02
04-Oct-98	0.36	0.17	3.48	0.15	0	0.34	0.00	0.59	4.75
05-Oct-98	0.39	0.25	5.2	0.15	0	0.36	0.00	0.76	6.09
06-Oct-98	0.39	0.26	5.38	0.16	0.01	0.58	0.00	2.36	18.88
07-Oct-98	0.38	0.23	4.92	0.16	0.01	0.63	0.00	2.54	20.32
08-Oct-98	0.38	0.22	4.65	0.16	0.01	0.52	0.00	2.00	16.00
09-Oct-98	0.37	0.2	4.2	0.18	0.01	1	0.00	1.79	14.32
10-Oct-98	0.37	0.2	4.18	0.16	0.01	0.67	0.00	1.43	11.44
11-Oct-98	0.37	0.19	3.97	0.16	0.01	0.67	0.00	1.28	10.24
12-Oct-98	0.37	0.19	3.93	0.16	0.01	0.67	0.00	1.22	9.76
13-Oct-98	0.37	0.2	4.2	0.16	0.01	0.67	0.00	1.23	9.84
14-Oct-98	0.36	0.18	3.86	0.16	0.01	0.67	0.00	1.33	10.64
15-Oct-98	0.36	0.17	3.66	0.16	0.01	0.67	0.00	1.23	9.84
16-Oct-98	0.37	0.2	4.2	0.16	0.01	0.67	0.00	1.18	9.44
17-Oct-98	0.36	0.18	3.84	0.16	0.01	0.67	0.00	1.17	9.36
18-Oct-98	0.37	0.2	4.13	0.16	0.01	0.67	0.00	1.15	9.20
19-Oct-98	0.37	0.2	4.2	0.16	0.01	0.57	0.00	1.13	9.04
20-Oct-98	0.37	0.2	4.2	0.16	0.01	0.65	0.00	1.13	9.04
21-Oct-98	0.37	0.2	4.2	0.16	0.01	0.67	0.00	1.17	9.36
22-Oct-98	0.37	0.2	4.2	0.16	0.01	0.64	0.00	1.18	9.44
23-Oct-98	0.37	0.2	4.2	0.16	0.01	0.5	0.00	1.20	9.60
24-Oct-98	0.37	0.2	4.2	0.16	0.01	0.48	0.00	1.19	9.52
25-Oct-98	0.37	0.21	4.35	0.16	0.01	0.48	0.00	1.17	9.36
26-Oct-98	0.38	0.23	4.87	0.16	0.01	0.48	0.00	1.30	10.40
27-Oct-98	0.38	0.23	4.89	0.16	0.01	0.65	0.00	1.44	11.52
28-Oct-98	0.37	0.2	4.22	0.18	0.01	1.03	0.00	1.49	11.92
29-Oct-98	0.37	0.2	4.2	0.17	0.01	0.79	0.00	1.23	9.84
30-Oct-98	0.37	0.2	4.2	0.16	0.01	0.67	0.00	1.08	8.64
31-Oct-98	0.37	0.2	4.2	0.17	0.01	0.82	0.00	1.17	9.36
01-Nov-98	0.37	0.2	4.2	0.18	0.01	0.92	0.00	1.14	9.12
02-Nov-98	0.37	0.2	4.2	0.18	0.01	0.92	0.00	1.04	8.32
03-Nov-98	0.37	0.19	4.09	0.18	0.01	0.92	0.00	0.98	7.82
04-Nov-98	0.36	0.17	3.66	0.18	0.01	0.92	0.00	0.94	7.50
05-Nov-98	0.36	0.17	3.66	0.17	0.01	0.72	0.00	0.92	7.38
06-Nov-98	0.36	0.17	3.66	0.16	0.01	0.67	0.00	0.88	7.03
07-Nov-98	0.36	0.17	3.66	0.16	0.01	0.67	0.00	0.83	6.62
08-Nov-98	0.36	0.16	3.45	0.16	0.01	0.67	0.00	0.79	6.29
09-Nov-98	0.35	0.18	3.79	0.16	0.01	0.67	0.00	0.71	5.66

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
10-Nov-98	ND	ND	ND	0.16	0.01	0.52	0.00	0.57	4.52
11-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.55	4.36
12-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.52	4.19
13-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.50	4.02
14-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.48	3.86
15-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.46	3.71
16-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.44	3.55
17-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.43	3.42
18-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.41	3.29
19-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.46	3.70
20-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.52	4.18
21-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.48	3.81
22-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.43	3.46
23-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.42	3.32
24-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.41	3.24
25-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.40	3.17
26-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.39	3.10
27-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.37	2.96
28-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.35	2.80
29-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.33	2.66
30-Nov-98	ND	ND	ND	ND	ND	ND	0.00	0.32	2.52
01-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.31	2.50
02-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.31	2.47
03-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.31	2.45
04-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.30	2.42
05-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.30	2.40
06-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.30	2.38
07-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.29	2.34
08-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.29	2.30
09-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.28	2.27
10-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.30	2.42
11-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.32	2.58
12-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.34	2.75
13-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.32	2.58
14-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.30	2.42
15-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.27	2.18
16-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.26	2.06
17-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.30	2.43
18-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.29	2.34
19-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.27	2.12

Date	Tenas Creek			Four Creek			Goathorn Creek		
	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]	Water Level [m]	Discharge [m3/s]	Discharge [L/s/km2]
20-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.24	1.92
21-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.23	1.84
22-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.22	1.77
23-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.21	1.70
24-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.21	1.66
25-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.20	1.62
26-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.20	1.58
27-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.19	1.54
28-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.19	1.51
29-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.18	1.47
30-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.18	1.44
31-Dec-98	ND	ND	ND	ND	ND	ND	0.00	0.18	1.41