TECHNICAL MEMO

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Subject:	Rankin Inlet Design Storm and Precipitation Frequency Quantiles Update Meliadine Gold Mine, Nunavut		

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by Agnico Eagle Mines Limited (Agnico Eagle) to design water management infrastructure, including dams, collection ponds, and channels, for Phase 2 of the Meliadine Gold Mine (the Project) in Nunavut. Design precipitation frequency quantiles needed for design had previously been developed for the 2014 Final Environmental Impact Statement (FEIS), which incorporated precipitation frequency quantiles developed by Golder (2013)[1], using data through 2008. This memo presents an update to the precipitation frequency quantiles and Probable Maximum Precipitation (PMP) estimates using an extended data set which incorporates data through December 2020.

Extended precipitation data sets for the Project were developed by combining Environment Canada (EC) reported data for two stations operated at Rankin Inlet for different periods, plus pre-1981 data for a station at Baker Lake which was transposed to Rankin Inlet using adjustments determined from a comparison of 32 years of coincident data for the two stations. Probable Maximum Precipitation (PMP) estimates were based on the recorded data set.

Extended precipitation data sets were also developed for the Project using adjusted data for Rankin Inlet, obtained from EC's Adjusted and Homogenized Canadian Climate Data (AHCCD). The precipitation analyses and water balance calculations in the 2014 FEIS were based on AHCCD data and, for consistency, updated precipitation frequency analyses and quantiles for this update are based on AHCCD data.

EC adjusted (AHCCD) data for the original Rankin Inlet Climate Station (1981 - 2013) were combined with EC AHCCD data for Baker Lake (1950 - 2013), transposed to Rankin Inlet. EC AHCCD data after 2013 are not available for either station and were instead approximated using relationships determined from analysis of the coincident EC reported and EC adjusted data for Rankin Inlet for 1981 - 2013. These relationships were then applied to recorded data for the successor Rankin Inlet station which has operated since 2013.

The data sets were assessed to yield the results below:

I. Annual Rainfall, Snowfall and Total Precipitation AHCCD amounts for 2 to 1,000-year return period wet years and 2 to 100-year return period dry years.

[1] Golder (2013) references an earlier Golder report, SD 7-1 2009 Aquatics Synthesis Baseline, as the source of the mine site extreme annual precipitation statistics.

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II. Maximum Annual 1-Day, 2-Day, 3-Day, 5-Day and 10-Day AHCCD rain accumulations for 2 to 1,000-year return periods.

III. Maximum Annual Daily and 24-Hour reported rain for 2 to 1,000-year return period wet years and 2 to 100-year return period dry years.

IV. Maximum 24-Hour reported rain for freshet (April - June) and summer (July - October) periods for 2 to 1,000-year return period wet years and 2 to 100-year return period dry years.

V. Annual Probable Maximum Precipitation (PMP) based on recorded data for 1-Day, 2-Day, 3-Day, 5-Day and 10-Day durations and Seasonal 1-Day PMP for Freshet (April - June) and Summer (July - September) periods.

In addition to the above, Climate Change Projections for precipitation in the project region were retrieved from government and university repositories of climate change projections.

This memo details the methodology used to developing precipitation frequency quantiles for the above events and presents the results.

2.0 RECORDED PRECIPITATION (RAIN) DATA

Recorded precipitation data from multiple EC stations were processed to develop an extended continuous record of maximum annual daily rain amounts for Rankin Inlet, combining two Rankin Inlet A which operated over different periods, and supplementing missing years with maximum annual amounts transposed from nearby regional stations. Sections 2.1 through 2.3 deal with recorded maximum annual rain data. Section 2.4 describes the development of an extended record of continuous daily precipitation, including both rain and snow, using adjusted (AHCCD) data.

2.1 Rankin Inlet A Recorded Data

EC has operated three climate stations at Rankin Inlet for the periods as listed in Table 2-1. The two stations at Rankin Inlet A combine to a continuous record for years 1981 to 2020 and are the primary source of data. A third EC station for Rankin Inlet was operated only in 1954 and was not used due to its limited record.

Table 2-1: Rankin Inlet Environment Canada Climate Stations

Station Name	Station ID	Period of Record	Years Recorded
Rankin Inlet*	2303400	1954	1
Rankin Inlet A	2303401	1981 - 2013	32
Rankin Inlet A	2303405	2013 - 2020	8

*Not used due to incomplete and limited data record

2.2 Regional Station Recorded Data

Regional EC climate stations listed in Table 2-2 were used to fill missing annual maximum daily rain values in the Rankin Inlet data, and to extend the data set to years before 1981. The filling and extension of the recorded data was initially done only for maximum annual daily rain amounts, one value per year as required for subsequent precipitation frequency analyses. Filling and extension of ordinary (not limited to maximum annual) data was done later to compute PMP amounts for multi-day sequences.

Table 2-2: Regional Environment Canada Climate Stations

Station Name	Station ID	Distance from Rankin Inlet (km)	Period of Record	Years Recorded
Chester Field Inlet A	2300700	68	1931 - 1980	51
Chester Field Inlet A	2300707	68	1985 - 2014	29
Whale Cove A	2303985	92	1974 - 1984	11
Whale Cove A	2303986	92	1985 - 2014	29
Baker Lake A	2300500	259	1950 - 2013	65

Adjustments to transpose regional maximum annual daily rain data to Rankin Inlet were determined by comparing frequency analyses results of maximum annual daily rain data each station for concurrent periods of record. The EC reported daily rain data for Rankin Inlet from 1981 to 2020 is very complete, with very few missing values to be filled. The transposed data for the pre-1981 period without Rankin Inlet precipitation data was based entirely on Baker Lake which had the most complete and longest period of record of the regional stations.

The transposition of ordinary daily rainfall and snowfall data from Baker Lake to Rankin Inlet, not limited to annual maximum amounts, was done using adjustments determined from a comparison of the 32 years of coincident adjusted (ACCDC) data for the two stations. The adjustments were determined by comparing and matching the mean annual rain and snow total amounts and also one-day annual maximum rainfall quantiles. This methodology provides transposed data that are statistically similar for the 32 year of coincident data and yields a statistically suitable data set for Rankin Inlet for the pre-1981 period when recorded data are not available.

Transposition of adjusted (AHCCD) daily rain data from Baker Lake used a depth-dependent adjustment with most mid-range values being increased by 3 mm. The adjustment for higher amounts was progressively reduced from 3 mm to zero, such that Baker Lake values with return periods greater than about 1 in 10 years were transposed to Rankin Inlet without any adjustment. On the low end, the adjustment was progressively reduced from 3 mm to as low as negative 2 mm, following the differences between the respective frequency curves, before recovering to a zero adjustment to prevent negative results when transposing small values.

2.3 Maximum Annual 24-Hour Recorded Precipitation (Rain) Amounts

Assessment of daily and 24-hour precipitation in the present study is limited to precipitation that occurs as rain. It excludes precipitation which occurs as snow that accumulates over the winter.

EC reported daily data are for a standard observation day typically beginning and ending at midnight. The 24-hour data values are determined from short-interval (typically hourly) data from which a 24-hour total is computed for a moving window of 24 hours. The maximum 24-hour value for an observation day is the largest of the 24-hour totals with an end hour within the observation day period. If a rain event spans two observation days, the 24-amount can be greater than the reported daily amounts.

Hourly precipitation data for Rankin Inlet are not available online and were obtained through a direct request to EC. The data received for the period of short-interval data collection, 1981 – 2013, were found to be incomplete with long periods of missing records. The processed hourly data yielded only 10 years in which coincident hourly data were available to compare with reported annual maximum daily rain amounts. The coincident amounts are listed in Table 2-3 and plotted in Figure 2-1.

Table 2-3: Ranking Inlet Coincident Maximum Annual Daily and 24-hour Rain

Year	Hourly Data Max 24-hr Rain (mm)	Daily Data Max Daily Rain (mm)	Ratio of 24Hr/Daily
1987	16.8	16.8	1.00
1988	10	10.2	0.98
1989	29.2	29.2	1.00
1990	41.4	41.4	0.98
1991	56.9	45.0	1.16
1992	29.2	24.4	1.20
1993	39.8	33.4	1.13
1997	20.5	14.8	1.35
1999	45.8	45.8	0.99
2000	25	13.2	1.89

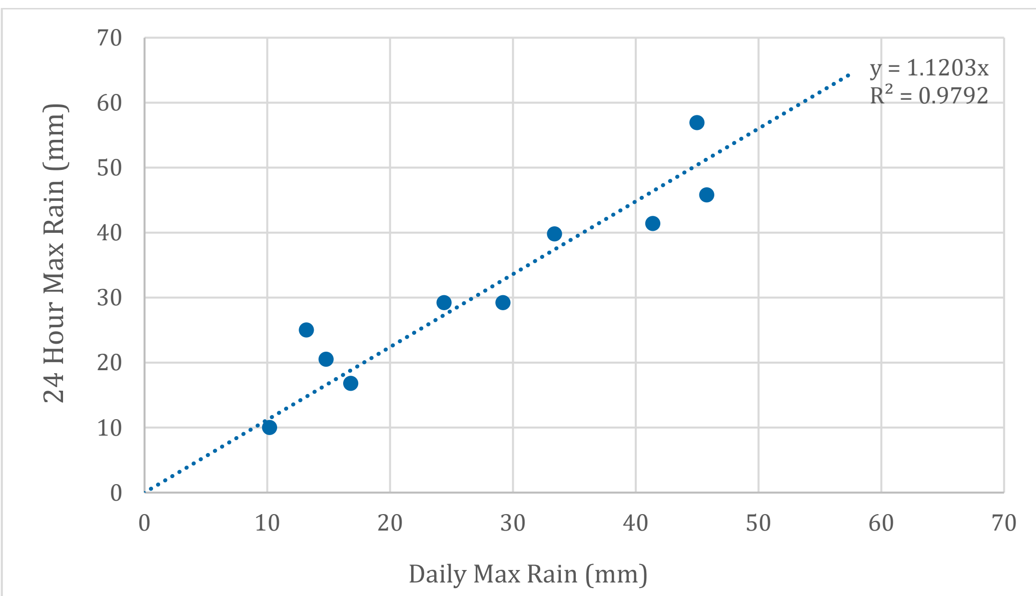

Figure 2-1: Rankin Inlet Maximum Annual Daily versus 24-hour Data Sets

A linear regression line through the maximum daily and 24-hour rain data yielded a slope 1.12 representing a constant multiplier to estimate maximum annual 24-hour values from the corresponding daily values. A multiplier of 1.13 was determined when considering a larger sample of all days for which non-zero 24-hour values were recorded on days with observation day precipitation of at least 5 mm. The 1.13 multiplier is consistent with World Meteorological Organization recommendations for estimation of Probable Maximum Precipitation as discussed in Section 4.0.

A long term data set of maximum annual 24-hour rain amounts was developed using the 1.13 multiplier on the extended maximum annual daily rain data for Rankin Inlet, with the 10 recorded 24-hour maximum values then being inserted into the record.

2.4 Adjusted and Homogenized (AHCCD) Precipitation Data

AHCCD data were used as the basis for precipitation frequency analyses and water balance calculations for the 2014 FEIS and are updated here for consistency with the previous work.

EC Adjusted and Homogenized (AHCCD) daily rain and snow data are available for the original Rankin Inlet A Climate Station 2303401, for 1981 through March 2013, but not the successor Rankin Inlet A Station 2303405. Regional EC AHCCD daily rain and snow data are available for the Baker Lake Climate Station, 2300500, for 1950 through 2012. An extended AHCCD-compatible data set for Rankin Inlet for 1950 to 2020 was developed as described below using recorded data from the successor Rankin Inlet Climate Station and the EC AHCCD data for Baker Lake.

The AHCCD adjustments made by EC to the original Rankin Inlet A station precipitation data (1981 – 2013) were back-calculated by comparison of the recorded and adjusted daily data sets for that station. The identified adjustments were then applied to the recorded data at the successor Rankin Inlet station (2013 - 2020). It is not known whether the adjustments that EC made on the first station are directly applicable to the successor second station with its different instrumentation and operational procedures, but this was done due to the absence of a better alternative.

The EC-derived adjustments applied to the successor Rankin Inlet A second station are as follows:

- Reported trace daily snow amounts were adjusted to 0.147 mm water equivalent.
- Reported measurable daily snow amounts in cm were multiplied by 1.535 to adjust to mm water equivalent.
- Reported trace daily rain amounts were adjusted to 0.3 mm.
- Reported measurable daily rain amounts were adjusted with a non-linear depth-dependent multiplier ranging from 1.35 (at 0.4 mm depth) to 1.023 (at 50 mm depth) and continuing to increase (for smaller depths) or decrease (for greater depths) for rain amounts beyond this central range.

Extension of the adjusted Rankin Inlet data set with data from Baker Lake involved a transposition of the EC adjusted data for Baker Lake. This was done by comparing the EC AHCCD records for the two stations for the coincident period of record from 1981 to 2013. Over the full period of coincident record, rainfall at Rankin Inlet A is 1.17 times that at Baker Lake and snowfall is 1.155 times that at Baker Lake.

Daily adjusted snowfall amounts from Baker Lake were transposed to Rankin Inlet using the long-term 1.155 multiplier adjustment. Further refinement was considered unnecessary for transposition of snow amounts.

Most daily adjusted rainfall amounts from Baker Lake were transposed to Rankin Inlet with the long-term 1.17 multiplier. Daily rain amounts greater than a maximum annual daily 2-year return period amount were transposed with a multiplier that gradually decreased to 1.0 for amounts equal to or greater than a 50-year return period.

Where daily values were missing in the EC adjusted records for both Rankin Inlet or and Baker Lake, gaps were filled with Rankin Inlet monthly mean values. Single missing days sandwiched between days with zero precipitation were estimated as zero rain or snow as applicable.

3.0 DATA SERIES COMPLETION AND TIME SERIES ASSESSMENT

The foregoing analysis yielded annual time series of maximum reported daily and 24-hour precipitation (rain) amounts, ready for frequency analysis, for 71 years from 1950 to 2020. The extended adjusted (AHCCD) daily data received additional processing to develop water year annual time series of total rain, snow and precipitation and annual maximum 1-, 2-, 3-, 5- and 10-day rain accumulations ready for frequency analysis, for 69 water years from 1952 to 2020.

A water year begins on October 1 of the prior calendar year and ends on September 30 of the water (and calendar) year so that snow is accumulated over the winter months which span two calendar years. The water year adjusted (AHCCD) data begin with year 1952 because of substantial periods of missing winter precipitation records in 1951.

Tables of all annual data series which were developed for subsequent analysis are provided in Appendix A.

Figure 3-1 plots the adjusted (AHCCD) annual rain, snow, and precipitation (rain plus snow) data points together with lines designating the 10-year moving mean values for each series. Figure 3-2 plots the adjusted (AHCCD) maximum 1-day rain amounts for freshet (April to June) and annual periods, plus annual maximum 2-day, 3-day, 5-day, and 10-day accumulations, also with lines showing the 10-year mean values for each series.

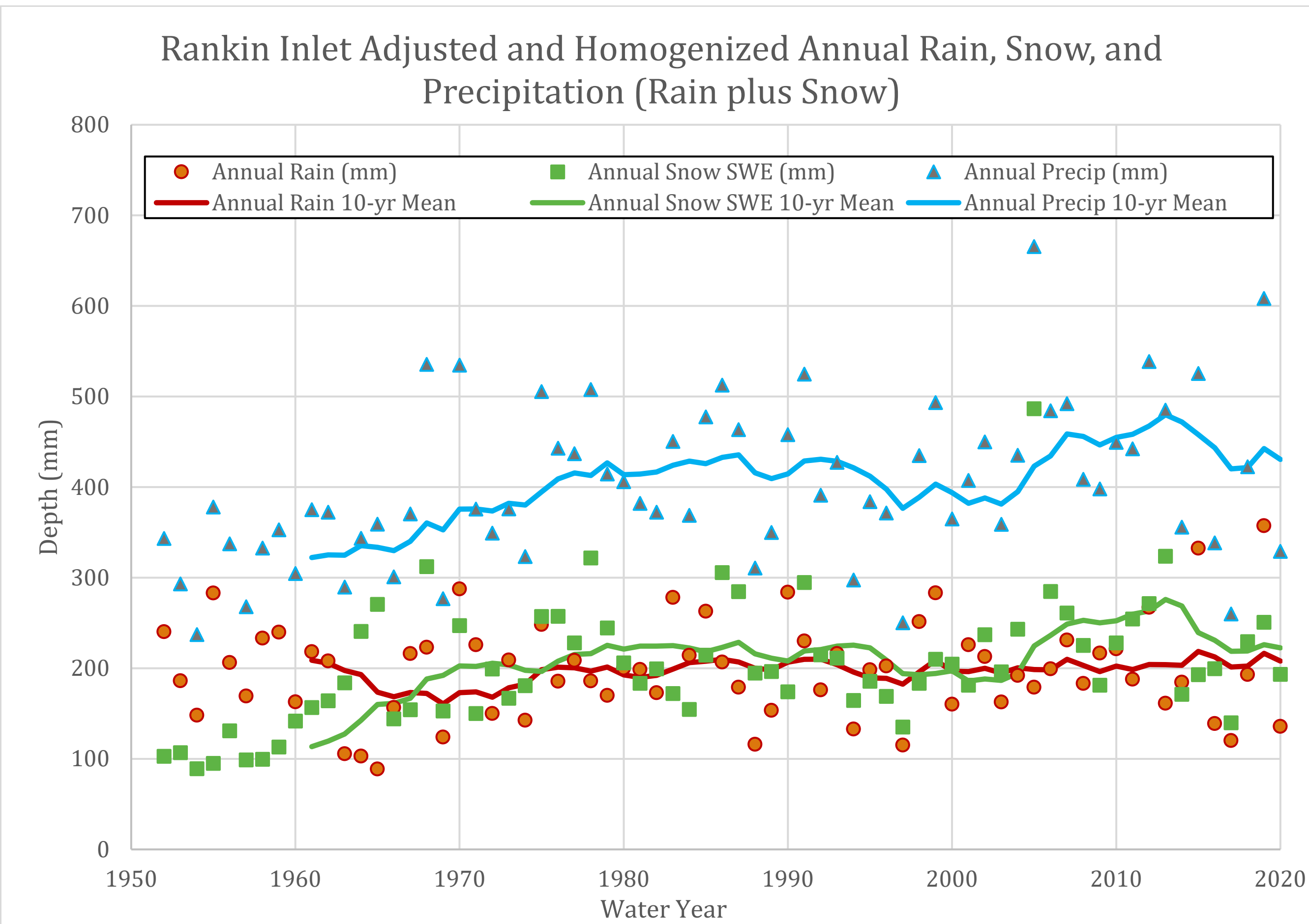

Figure 3-1: Annual Adjusted Rain, Snow, and Precipitation, 1952 - 2020

The annual data plots are interpreted to show the following:

- Annual precipitation appears to be trending upward, but this is almost entirely due to the snow component which is anomalously low for years 1952 to 1959. An apparent discontinuity in the snow data before and after 1960 may be due to a change in snow measurement equipment or methods. Separately, an extraordinarily large snowfall occurred in 2005, raising the 10-year moving mean to record highs for the following decade.
- There is no obvious trend in the 10-year moving mean of the annual rain. The apparent trend in the annual precipitation would largely disappear if the years prior to 1960, with suspect snow data, are ignored. The more reliable 10-year mean precipitation data would then start at year 1968.
- The two years with the highest annual rain both occurred in the past decade, in 2015 and 2019. A single year with exceptionally high record snowfall occurred in 2005, with 50% more snow than the next highest snowfall years, 1978 and 2013.
- The higher rain amounts that occurred in 2015 and 2019 are consistent with higher amounts predicted by climate change models. Quantitatively, the record rain amount of 357 mm in 2019 is about 25% greater than in prior record wet years with from 283 to 289 mm rain which occurred in 1955, 1970, 1990, and 1999. However, the two recent years of record high rain occur between years of low rain and are insufficient to identify a trend or to validate climate change predictions.

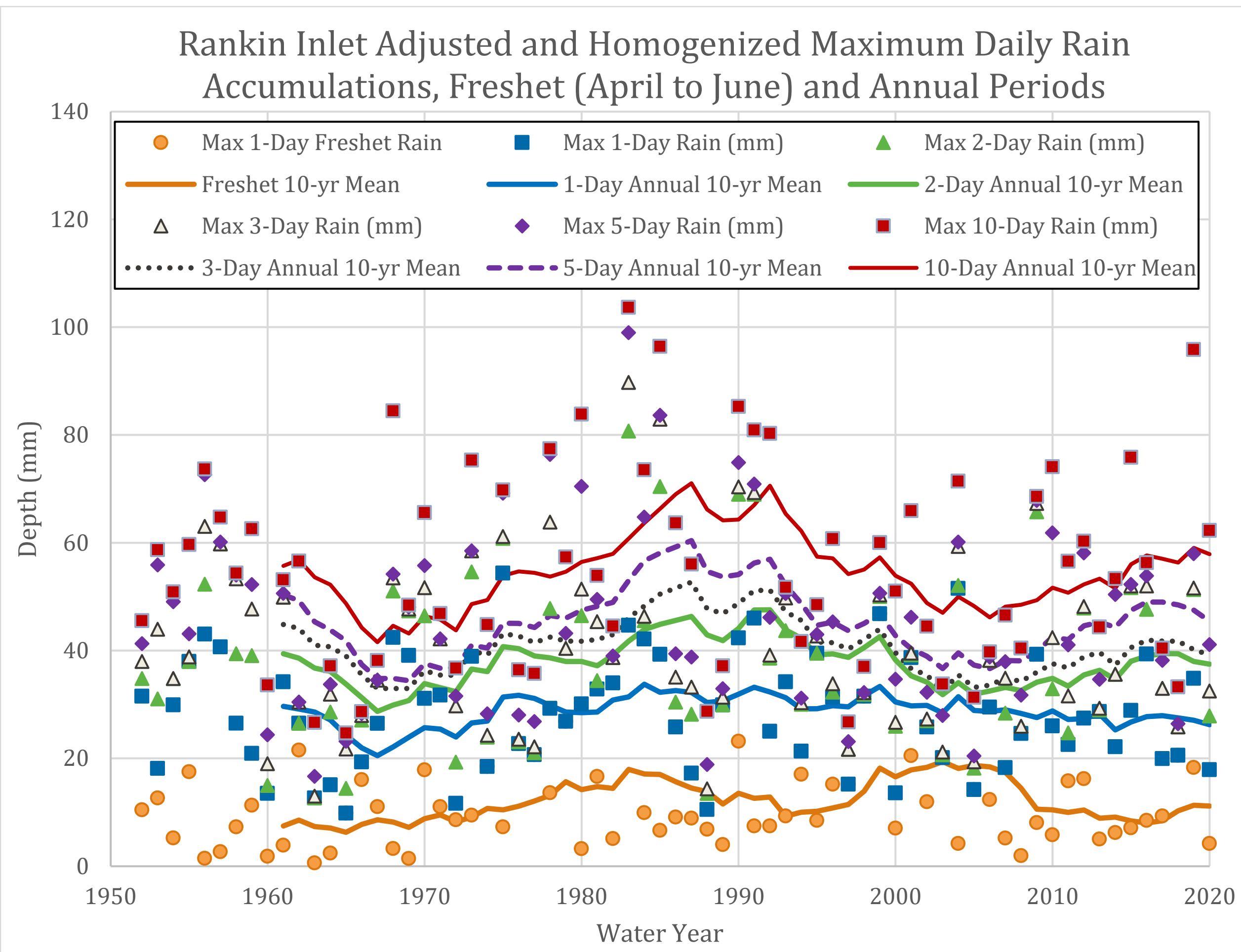

Figure 3-2: Adjusted Maximum Freshet and Annual Daily Rain Accumulations, 1952 - 2020

The plots of annual accumulations are interpreted to show the following:

- All accumulations over the past decade, for the duration and periods selected for analysis, have been within the range of prior historical events.
- The moving 10-year mean data for 3-day through 10-day accumulations show a cyclical pattern with 10-year mean low amounts in the mid-1960s, a high period for the years ending about 1986 to 1993, and another low period in the mid-2000s. This pattern does not appear in the 1-day data for freshet and annual periods.
- The 10-day accumulations for 2015 and 2019, which had record high annual rainfalls, are both high but within the range of prior variability. This suggest that the record high annual rain amounts in 2015 and 2019, were probably associated with prolonged wet periods rather than discrete wet events.
- None of the data sets show any obvious trends which would lead to future departures from the range of historic variability.

4.0 PRECIPITATION FREQUENCY ANALYSES AND RESULTS

Frequency analyses of the completed data sets were conducted using HYFRAN frequency analysis software to fit multiple standard statistical distributions to the precipitation data sets. A subjective “best fit” assessment was made by visual inspection of plotted frequency curves from Log Pearson Type 3, Generalized Extreme Value (GEV), 3-Parameter Lognormal and Gumbel distributions, and the 3-Parameter Lognormal distribution was selected for the quantiles presented in this assessment.

A representative plot of the selected 3-Parameter Lognormal distribution is shown in Figure 4-1 for annual maximum 1-day reported rain amounts. The fit within the range of reported data is very good and the extrapolation to large extreme values appears reasonable. The extrapolation to small extreme events yields negative depths which are not plausible but are not relevant to the design of water management infrastructure and are ignored.

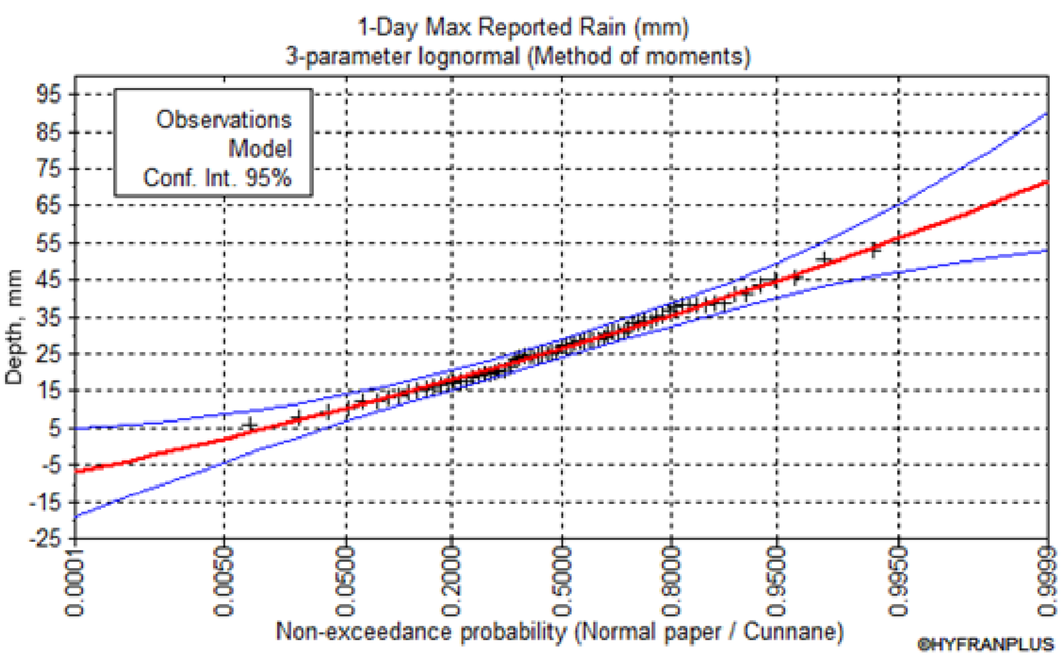

Figure 4-1: 3-Parameter Lognormal Distribution for 1-Day Reported Rain

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Tables 4-1 to 4-3 provide the precipitation frequency analysis quantiles for the time series introduced above.

Table 4-1: Rankin Inlet Maximum Daily and 24-hour Reported Rain Data (Annual)

Type of Year	Return Period (years)	Max Day Rain (mm)	Max 24-hour Rain (mm)
Wet	1000	62.9	71.1
	500	60.1	67.9
	200	56.2	63.5
	100	53	59.9
	50	49.7	56
	20	44.8	50.5
	10	40.5	45.7
	5	35.5	40.1
	3	31	35
Median	2	26.5	29.9
Dry	3	21.1	24
	5	18	20.5
	10	13.8	15.9
	20	10.4	12.2
	50	6.72	8.11
	100	4.34	5.5

Table 4-2: Rankin Inlet Seasonal and Annual Precipitation – AHCCD Data

Type of Year	Return Period (years)	Annual Rainfall (mm)	Annual Snowfall (mm)	Annual Total Precip (mm)
Wet	1000	398	531	738
	500	381	494	708
	200	358	447	668
	100	339	411	636
	50	320	376	602
	20	292	328	555
	10	268	291	515
	5	241	252	471
	3	218	221	432
Median	2	194	192	394
Dry	3	168	163	351
	5	153	148	327
	10	133	129	296
	20	117	115	272
	50	101	102	247
	100	90	94.3	231

Table 4-3: Rankin Inlet Rain Daily Accumulations – AHCCD Data (Annual)

Type of Year	Return Period (years)	1-Day Rain (mm)	2-Day Rain (mm)	3-Day Rain (mm)	5-Day Rain (mm)	10-Day Rain (mm)
Wet	1000	65.1	98.8	108	115	126
	500	62.2	93.1	102	109	120
	200	58.3	85.4	93	99.8	112
	100	55.1	79.4	86.3	92.9	105
	50	51.7	73.1	79.3	85.8	97.8
	20	46.7	64.5	69.7	75.9	87.8
	10	42.4	57.4	61.9	67.8	79.5
	5	37.4	49.5	53.3	58.8	70.1
	3	32.8	42.7	46.1	51.2	61.8
Median	2	28.2	36.3	39.2	43.9	53.7
Dry	3	22.9	29.2	31.7	35.9	44.6
	5	19.7	25.3	27.6	31.4	39.5
	10	15.5	20.2	22.4	25.8	32.8
	20	12.1	16.4	18.5	21.5	27.6
	50	8.46	12.5	14.5	17.1	22.1
	100	6.07	10	12	14.3	18.6

5.0 PROBABLE MAXIMUM PRECIPITATION

PMP estimates based on recorded data were made for 24-hour durations for Freshet, Summer, and Annual periods. PMP estimates based on adjusted AHCCD data were made for annual 1-Day, 2-Day, 3 Day, 5-Day and 10-Day durations.

PMP amounts were estimated using a statistical method developed by D.M. Hershfield (Hershfield, 1965) as presented in the World Meteorological Organization's (WMO) 2009 Manual on Estimation of Probable Maximum Precipitation. The method estimates the PMP from the mean and standard deviation of the precipitation data set together with a K_m value which is a function of rainfall duration (ranging from five minutes to 24 hours) and the mean of the annual series. The WMO Manual includes six figures for determining the K_m value and various adjustments to the data set mean and standard deviation for the length of record, and to the initial PMP amount for the number of observational units for fixed-interval observation amounts, and depth-area reduction.

The basic equation for PMP estimation is:

$$PMP = X_n + (K_m \times S_n)$$

Where:

X_n = Average (mean) of the annual maximum precipitation values (included in Appendix A)

K_m = Coefficient as a function of rainfall duration and mean of annual series from WMO (2009) Figure 4.1; coefficient of 18.5 was determined for a 24-hour duration at Rankin Inlet

S_n = Standard deviation of the annual data values (included in Appendix A)

to which additional adjustment factors are applied per WMO (2009) figures:

- Figure 4.2 based on ratio of X_n to X_{n-m} (mean that excludes the maximum year);
- Figure 4.3 based on ratio of S_n to S_{n-m} (standard deviation that excludes the maximum year);
- Figure 4.4 based on period (length) of record;
- Figure 4.5 based on the number of observational units; and
- Figure 4.7 based on drainage basin area.

WMO (2009) Figure 4.1 does not include curves for durations longer than 24 hours, but the available curves indicate that longer durations might have slightly higher K_m values, not to exceed an upper limit of 20. For simplicity, the 18.5 coefficient was used for all durations without further adjustment, due to absence of direct guidance and considering that the PMP amount for design purposes is more dependent on event duration than a small adjustment to the K_m coefficient.

The Figure 4.5 adjustment for number of observational units for fixed-interval observation amounts addresses the resolution of source data values. For example, if a 24-hour PMP is determined from observation day values instead of hourly values, the result from the basic equation based on daily data would be multiplied by 1.13 to yield a 24-hour result. The Figure 4.7 adjustment is an area reduction factor that is applied when a PMP estimate is required over an area greater than 20 km^2. Area reduction factors were not applied to the PMP results presented in this report. Readers are referred to WMO (2009) for additional information on the PMP estimation procedure.

5.1 PMP Results

Tables 5-1 and 5-2 present the PMP estimates for Rankin Inlet A.

Table 5-1: 24-hour Seasonal and Annual PMP Estimates based on Recorded Data

Season	24-hour PMP (mm)
Freshet (April - June)	206
Summer (July - October)**	269
Annual	258

** the annual PMP value is recommended for the summer period.

The annual 24-PMP amount is recommended for the summer period as it is not reasonable for the summer (partial period) value to be greater than the annual (full period) value. Also, the Hershfield Method was developed based on annual data and its applicability to seasonal data is unknown.

Table 5-2: 24-hour and Multi-Day Annual PMP Estimates based on AHCCD Data

Rain Duration	Annual PMP (mm)
24-Hour (1-Day)	264
48-Hour (2-Days)	342
72-Hour (3-Days)	363
120-Hour (5-Days)	380
240-Hour (10-Days)	419

6.0 CLIMATE CHANGE

It is generally accepted that human carbon emissions and other impacts on the carbon cycle are causing and/or accelerating climate change at a global scale, often characterized as global warming. Climate change has been the subject of considerable scientific/academic research including the development of complex Global Circulation Models (GCMs) to predict future climate conditions that could result from different carbon emission scenarios. The various climate change studies now underway worldwide often have some affiliation with the United Nations International Panel on Climate Change (IPCC) which provides participants, including Canadian agencies and institutions, with access to an international assemblage of GCMs. The current assessment relies on three sources of Canadian climate change predictions which utilize the GCMs believed to be most applicable to Canada,

The Pacific Climate Impacts Consortium (PCIC), based at the University of Victoria, identified 24 GCM's judged to be suitable for assessing the impacts of climate change and climate variability in Canada, with emphasis on the Pacific and Yukon region. The PCIC developed and provides internet-accessible "bias-corrected" outputs for these models together with rankings of the suitability of each model for the regions shown in Figure 6-1. Rankin Inlet is in the Greenland (GRL) region.

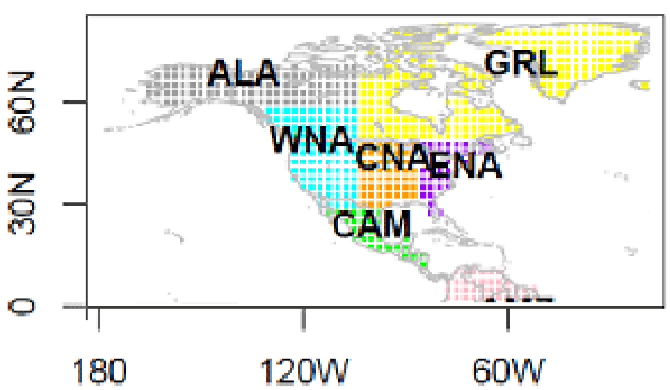

Figure 6-1: PCIC Statistically Downscaled Climate Regions

The PCIC bias-corrected GCM outputs are used as inputs for further statistical processing by the Climate Atlas of Canada developed by the University of Winnipeg Prairie Climate Centre, and by the IDF Climate Change (IDF_CC) Tool developed by the Western University (formerly University of Western Ontario) Department of Civil and Environmental Engineering and Institute for Catastrophic Loss Reduction.

Climate change projections for Rankin Inlet (and the Meliadine Project site) are based on outputs from the IDF_CC and Canadian Climate Atlas tools, both available online. Projections were downloaded for climate change scenarios designated as Representative Concentration Pathways (RCPs) 4.5 (medium carbon) and 8.5 (high carbon), which are available from both tools. The Climate Atlas of Canada tool does not provide projections for the RCP 2.6 (low-carbon) scenario which is unlikely to be achieved.

6.1 Climate Change Effects on Maximum 24-Hour Annual Precipitation

Climate change effects on short duration rainfall events were assessed using the Western University IDF_CC Online Tool v4.0 (Simonovic, Schardong, Gaur, & Sandink, 2018). The tool provides rainfall intensity-duration-frequency (IDF) data for historic observations and for climate change adjusted scenarios from the PCIC bias-corrected Global Circulation Models (GCMs) and other non-PCIC models. The tool allows retrieval of IDF tables for individual GCMs as well as ensemble results. Data were retrieved for Rankin Inlet for which both historical data and PCIC bias-corrected climate change model predictions are available.

The IDF_CC tool provides access to predicted future 2-year through 100-year return period precipitation amounts for durations from 5-minutes to 24-hours, of which only the 24-hour duration was assessed for the present study. Results were retrieved for the full available projection period from year 2006 to 2100.

To possibly improve accuracy, IDF results were retrieved for each of 12 bias-adjusted GCMs identified by the PCIC as being most appropriate to the GRL region, and then further reviewed by sorting the results in the priority sequence recommended by the PCIC. IDF results presented in Tables 6-1 and 6-2 represent the average of results from the PCIC's top six recommended GCMs[2].

Table 6-1: 24-Hour Rain with RCP 4.5 Climate Change Scenario

	Maximum 24-Hour Rain Depth (mm)						
Return Period	**2-Years**	**5-Years**	**10-Years**	**20-Years**	**25-Years**	**50-Years**	**100-Years**
Historic Baseline	30.24	43.18	50.59	56.95	58.83	64.21	69.02
Top six PCIC Bias Corrected GCM's	33.53	49.59	59.75	69.26	72.24	81.33	90.26
Ratio to Baseline	1.11	1.15	1.18	1.22	1.23	1.27	1.31

Table 6-2: 24-Hour Rain with RCP 8.5 Climate Change Scenario

	Maximum 24-Hour Rain Depth (mm)						
Return Period	**2-Years**	**5-Years**	**10-Years**	**20-Years**	**25-Years**	**50-Years**	**100-Years**
Historic Baseline	30.24	43.18	50.59	56.95	58.83	64.21	69.02
Top six PCIC Bias Corrected GCM's	35.79	52.31	62.57	72.10	75.08	84.16	93.09
Ratio to Baseline	1.18	1.21	1.24	1.27	1.28	1.31	1.35

[2] PCIC top six GCMs for GRL region: MPI-ESM-MR, CanESM2, CNRM-CM5, CSIRO-Mk3-6-0, HadGEM2-ES, and MIROC5

6.2 Climate Atlas of Canada Climate Change Precipitation Projections

The Climate Atlas of Canada tool, developed and maintained by the University of Winnipeg Prairie Climate Centre, provides historic average and climate change predictions for RCP 4.5 and RCP 8.5 scenarios for three 30-year time periods: 1976 - 2005, 2021 - 2050 and 2051 - 2080. Climate change predictions for precipitation are provided for seasonal totals over spring, summer, fall, winter and annual periods, and for maximum annual precipitation amounts over 1-day, 3-day, and 5-day durations. The tool reflects the ensemble results of the PCIC's 24 bias-corrected GCMs.

Tables 6.3 and 6-4 present the Climate Atlas of Canada precipitation predictions for Rankin Inlet for the RCP 4.5 and RCP 8.5 scenarios.

Table 6-3: Climate Atlas Precipitation Predictions with RCP 4.5 Climate Change Scenario

		1976-2005 (baseline)	2021-2050		2051-2080	
Variable	**Period**	**Mean (mm)**	**Mean (mm)**	**Ratio to baseline**	**Mean (mm)**	**Ratio to baseline**
Precipitation	Annual	291	314	1.08	332	1.14
Precipitation	Spring	47	51	1.09	54	1.15
Precipitation	Summer	109	111	1.02	116	1.06
Precipitation	Fall	98	109	1.11	114	1.16
Precipitation	Winter	37	43	1.16	48	1.30
Max 1-Day Precipitation		21	23	1.10	24	1.14
Max 3-Day Precipitation		27	30	1.11	31	1.15
Max 5-Day Precipitation		32	35	1.09	37	1.16

Table 6-4: Climate Atlas Precipitation Predictions with RCP 8.5 Climate Change Scenario

		1976-2005 (baseline)	2021-2050		2051-2080	
Variable	**Period**	**Mean (mm)**	**Mean (mm)**	**Ratio to baseline**	**Mean (mm)**	**Ratio to baseline**
Precipitation	Annual	291	319	1.10	354	1.22
Precipitation	Spring	47	52	1.11	56	1.19
Precipitation	Summer	109	113	1.04	120	1.10
Precipitation	Fall	98	110	1.12	125	1.28
Precipitation	Winter	37	44	1.19	53	1.43
Max 1-Day Precipitation		21	23	1.10	26	1.24
Max 3-Day Precipitation		27	30	1.11	33	1.22
Max 5-Day Precipitation		32	36	1.13	39	1.22

7.0 SUMMARY

This report provides an update to precipitation frequency quantiles initially developed in 2009, included in the project 2014 FEIS, and used for the design of water management infrastructure. The update uses data through December 2020. The quantiles developed for the FEIS were based on Environment Canada (EC) Adjusted and Homogenized Climate Change Data (AHCCD) rather than EC recorded data.

The current update considered both EC Recorded and EC AHCCD data. For Rankin Inlet, the main differences between the two data sets is that the AHCCD daily rain amounts are higher than the recorded amounts by non-linear multipliers which vary, for illustration, from about 1.023 for large daily rain amounts (50 mm) to about 1.35 for small daily rain amounts (0.4 mm). The AHCCD snow water equivalents of daily snow amounts are higher than the recorded amounts by a constant multiplier of 1.535. Reported trace amounts of daily rain and snow water equivalents are quantified in the AHCCD data as 0.3 mm and 0.147 mm respectively.

Extended daily data sets were developed for Rankin Inlet and then processed to identify annuals series with values of interest for subsequent frequency analysis. The values of interest included annual totals of rainfall, snowfall and precipitation, annual maximum 1-day through 10-day rainfall accumulations, plus amounts that are specific to annual freshet (April to June) and summer (July to October) periods. The precipitation frequency quantiles determined for these values of interest are presented in body of this report.

The data sets developed as inputs for frequency analysis were plotted as time series charts to look for trends in the source point data and lines showing 10-year average values. The two years of highest rainfall since 1950 (when EC records begin) occurred very recently, in 2015 and 2019. However, these two years did not include record highs for any of the many other precipitation metrics that were examined. The data suggest that the record high annual rain amounts in 2015 and 2019 were probably associated with prolonged wet periods rather than discrete (up to 10-day duration) wet events. The two recent years of record high annual rain occur are insufficient to identify a trend in annual or other duration rain amounts or to validate the occurrence of climate change predictions relative to precipitation.

Climate change Global Circulation Model (GCM) predictions for precipitation were obtained online from the University of Winnipeg Prairie Climate Centre and from the Western University (formerly University of Western Ontario) Department of Civil and Environmental Engineering and Institute for Catastrophic Loss Reduction. Both sources relied on inputs from bias-corrected GCM results developed by the University of Victoria Pacific Climate Impacts Consortium (PCIC) which, in turn relied, on inputs from 24 internationally-sourced GCMs. Ensemble results from the bias-corrected GCMs, reflecting the average of multiple specific GCMs, suggest that precipitation amounts near Rankin Inlet might increase by 8% up to 35% by year 2100 depending on the climate change assumptions (RCP scenario) and precipitation metric (annual, seasonal, daily amounts, and return period). Details are provided in the report above.

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Attachments:
Appendix A: Time Series of Annual Precipitation
Appendix B: Tetra Tech's Limitations on the Use of this Document

REFERENCES

Agnico Eagle (Agnico Eagle Mines Limited), 2018. Meliadine Gold Project Water Management Plan. Version 3. 6513-MPS-11. March 2018.

Climate Atlas Canada: https://climateatlas.ca/map/canada/plus30_2030_85#

Golder 2012. SD7-1 Aquatics Baseline Synthesis Report. 1994-2009 – Meliadine Gold Project, Nunavut. Final Report submitted to Agnico Eagle Mines Limited., Report No. Doc 327-1013730076. October 16, 2012.

Golder 2013, SD 2-6 Surface Water Management Plan – Meliadine Gold Project, Nunavut. Final Report submitted to Agnico Eagle Mines Limited, Project No. Doc 232-1013730076 Ver. 0. January 2013.

[1]Hershfield, D.M., 1965: Method for Estimating Probable Maximum Precipitation, Journal of the American Waterworks Association, 57: 965–972.

IDF_CC Tool: https://www.idf-cc-uwo.ca/home

PCIC Bias Corrected Description:https://www.pacificclimate.org/data/statistically-downscaled-climate-scenarios

Schardong, A., S. P. Simonovic, A. Gaur, and D. Sandink (2020) Web-based Tool for the Development of Intensity Duration Frequency Curves under Changing Climate at Gauged and Ungauged Locations, Water, Special Issue Extreme Value Analysis of Short-Duration Rainfall, and Intensity–Duration–Frequency Models, 12, 1243; doi:10.3390/w12051243, open access, https://www.mdpi.com/2073-4441/12/5/1243/pdf .

World Meteorological Organization. "Chapter 4. Statistical Estimates." Manual on Estimation of Probable Maximum Precipitation (PMP). WMO-No. 1045 ed., 2009, pp. 65-75, library.wmo.int/doc_num.php?explnum_id=7706.

APPENDIX A

ANNUAL SERIES PRECIPITATION DATA

Table A1: Annual and Seasonal Recorded Maximum Daily and 24-Hour Rain

Calendar Year	Annual Max Daily Rain (mm)	Annual Max 24-hr Rain (mm)	Freshet (Apr-June) Max 24-hr Rain (mm)	Summer (July-Oct) Max 24-hr Rain (mm)
1950	12.2	13.9	1.1	13.9
1951	15.0	17.0	14.1	16.7
1952	28.7	32.4	7.6	32.4
1953	15.9	18.0	10.7	17.5
1954	27.4	31.0	4.1	31.0
1955	34.0	38.4	17.0	38.4
1956	38.8	43.8	1.1	43.8
1957	36.8	41.6	2.3	41.6
1958	24.6	27.8	5.7	27.6
1959	18.7	21.2	8.9	21.2
1960	30.9	34.9	1.5	11.5
1961	17.8	20.1	3.2	20.1
1962	24.6	27.8	21.8	27.6
1963	9.4	10.7	0.3	10.7
1964	12.2	13.9	2.0	13.9
1965	6.1	6.9	7.4	6.6
1966	17.0	19.2	15.2	19.1
1967	24.6	27.8	8.2	27.6
1968	38.3	43.3	2.8	43.3
1969	35.5	40.1	1.1	40.1
1970	28.4	32.1	17.3	32.1
1971	28.9	32.7	8.2	32.7
1972	7.9	9.3	6.6	9.3
1973	34.8	39.3	7.0	39.3
1974	16.2	18.3	18.3	17.0
1975	52.9	59.8	5.7	59.6
1976	20.5	23.2	23.3	16.0
1977	19.0	21.5	21.5	14.3
1978	27.4	31.0	12.4	31.0
1979	25.4	28.7	28.7	7.8
1980	28.1	31.8	2.9	31.8
1981	32.1	36.3	18.3	36.3
1982	33.2	37.5	5.5	37.5
1983	43.7	49.4	49.4	30.3
1984	41.2	46.6	10.8	46.6
1985	38.4	43.4	7.2	43.4
1986	25.2	28.5	9.9	28.5
1987	16.8	16.8 (recorded)	9.7	16.8

Table A1: Annual and Seasonal Recorded Maximum Daily and 24-Hour Rain

Calendar Year	Annual Max Daily Rain (mm)	Annual Max 24-hr Rain (mm)	Freshet (Apr-June) Max 24-hr Rain (mm)	Summer (July-Oct) Max 24-hr Rain (mm)
1988	10.2	10.2 (recorded)	7.5	10.2
1989	29.2	29.2 (recorded)	4.3	29.2
1990	41.4	41.4 (recorded)	25.5	41.4
1991	45.0	56.9 (recorded)	8.1	56.9
1992	24.4	29.2 (recorded)	8.1	29.2
1993	33.4	39.8 (recorded)	10.2	39.8
1994	20.8	23.5	18.8	23.5
1995	38.6	43.6	9.3	43.6
1996	30.6	34.6 (recorded)	16.7	34.6
1997	14.8	20.5 (recorded)	16.7	8.8
1998	30.8	34.8	34.8	21.7
1999	45.8	45.8 (recorded)	45.8	45.8
2000	13.2	25.0 (recorded)	1.4	14.9
2001	37.8	42.7	22.6	42.7
2002	25.2	28.5	13.1	28.5
2003	19.6	22.1	22.1	14.9
2004	50.4	57.0	4.5	57.0
2005	13.8	15.6	15.6	12.7
2006	28.8	32.5	13.6	32.5
2007	17.8	20.1	5.7	20.1
2008	24.0	27.1	2.0	27.1
2009	38.4	43.4	8.8	43.4
2010	25.4	28.7	6.3	28.7
2011	26.8	30.3	17.4	24.9
2012	23.7	26.8	17.9	26.8
2013	31.0	35.0	2.3	35.0
2014	21.6	24.4	6.8	24.4
2015	28.2	31.9	7.7	31.9
2016	38.4	43.4	9.3	43.4
2017	19.4	21.9	10.2	21.9
2018	20.0	22.6	22.6	18.1
2019	34.0	38.4	20.1	38.4
2020	17.4	19.7	4.5	19.7
Mean:	**26.9**	**30.4**	**11.9**	**28.7**
Maximum:	**52.9**	**59.8**	**51.8**	**59.6**
Minimum:	**6.1**	**6.9**	**0.3**	**6.6**
Standard Deviation:	**10.4**	**11.7**	**10.0**	**12.7**

Table A2: Annual Adjusted (AHCCD) Rain, Snowfall Water Equivalent and Precipitation

Water Year	Annual Rain (mm)	Annual Snowfall Water Equivalent (mm)	Annual Precipitation (mm)
1952	240.4	102.9	343.3
1953	186.2	106.8	293.0
1954	148.1	89.1	237.2
1955	283.0	95.0	378.0
1956	206.4	131.0	337.3
1957	169.2	98.8	268.0
1958	233.2	99.6	332.8
1959	239.9	113.1	352.9
1960	162.8	141.7	304.5
1961	218.3	156.7	375.1
1962	208.1	164.2	372.2
1963	105.6	183.9	289.6
1964	102.9	240.6	343.5
1965	88.7	270.5	359.1
1966	156.7	144.2	300.9
1967	216.1	154.3	370.4
1968	223.1	312.3	535.4
1969	123.9	152.8	276.7
1970	287.5	247.1	534.6
1971	225.9	150.0	375.8
1972	150.0	199.1	349.1
1973	209.1	166.9	376.0
1974	142.6	180.8	323.4
1975	248.2	257.2	505.5
1976	185.6	257.4	443.0
1977	208.8	228.0	436.8
1978	186.1	321.7	507.8
1979	169.9	244.5	414.4
1980	200.0	205.9	405.9
1981	198.7	183.4	382.1
1982	173.0	199.3	372.3
1983	278.2	172.2	450.4
1984	214.3	154.6	368.8
1985	263.0	214.5	477.5
1986	206.9	305.7	512.6
1987	179.0	284.5	463.5
1988	116.0	194.6	310.6

Table A2: Annual Adjusted (AHCCD) Rain, Snowfall Water Equivalent and Precipitation

Water Year	Annual Rain (mm)	Annual Snowfall Water Equivalent (mm)	Annual Precipitation (mm)
1989	153.5	196.3	349.8
1990	283.9	174.1	458.0
1991	230.0	294.7	524.7
1992	176.2	214.8	391.0
1993	216.3	211.1	427.4
1994	132.9	164.5	297.4
1995	198.4	185.6	384.0
1996	202.4	169.0	371.4
1997	115.2	135.0	250.2
1998	251.4	183.4	434.8
1999	283.3	210.0	493.2
2000	160.3	204.5	364.8
2001	226.0	181.3	407.3
2002	212.8	237.1	449.9
2003	162.8	196.1	358.9
2004	192.0	243.2	435.1
2005	179.1	486.5	665.6
2006	199.4	284.8	484.2
2007	231.1	260.9	492.0
2008	183.3	225.3	408.6
2009	216.6	181.3	398.0
2010	221.4	227.9	449.3
2011	187.9	254.4	442.2
2012	267.3	271.4	538.7
2013	161.3	323.7	485.0
2014	184.5	171.2	355.8
2015	332.6	192.9	525.4
2016	138.9	199.5	338.4
2017	120.2	139.7	259.9
2018	193.1	229.4	422.5
2019	357.4	250.8	608.2
2020	135.7	193.3	329.0
Mean:	**198.0**	**203.2**	**401.2**
Maximum:	**357.4**	**486.5**	**665.6**
Minimum:	**88.7**	**89.1**	**237.2**
Standard Deviation:	**53.0**	**66.6**	**86.0**

Table A3: Freshet (April - June) Max 1-Day and Annual Max 1-Day through 10-Day Adjusted (AHCCD) Rain

Water Year	Freshet 1-Day Rain (mm)	Annual 1-Day Rain (mm)	Annual 2-Day Rain (mm)	Annual 3-Day Rain (mm)	Annual 5-Day Rain (mm)	Annual 10-Day Rain (mm)
1952	10.5	31.5	34.8	38.0	41.3	45.6
1953	12.7	18.1	31.1	44.0	55.9	58.7
1954	5.2	29.9	34.8	34.8	49.1	50.9
1955	17.5	38.0	38.0	38.8	43.1	59.7
1956	1.5	43.1	52.3	63.0	72.6	73.7
1957	2.7	40.7	59.8	59.8	60.1	64.8
1958	7.3	26.5	39.4	53.3	54.0	54.4
1959	11.3	20.9	39.1	47.7	52.3	62.6
1960	1.8	13.5	15.0	19.0	24.4	33.6
1961	3.9	34.2	49.9	49.9	50.6	53.2
1962	21.6	26.5	26.5	30.4	30.4	56.6
1963	0.6	12.7	12.7	13.0	16.7	26.7
1964	2.4	15.1	28.6	31.9	33.8	37.2
1965	9.8	9.8	14.4	21.7	23.2	24.7
1966	16.1	19.3	27.1	28.0	28.3	28.7
1967	11.1	26.5	34.5	34.5	34.5	38.2
1968	3.3	42.4	51.1	53.5	54.2	84.5
1969	1.5	39.1	47.4	47.7	48.1	48.4
1970	17.9	31.1	46.4	51.7	55.8	65.6
1971	11.1	31.7	42.2	42.2	42.2	46.9
1972	8.6	11.7	19.3	29.8	31.6	36.7
1973	9.5	38.9	54.6	58.5	58.5	75.3
1974	18.5	18.5	23.9	24.3	28.3	44.8
1975	7.3	54.4	60.8	61.2	69.2	69.8
1976	22.7	22.7	23.1	23.6	28.1	36.4
1977	20.7	20.7	21.0	22.2	26.9	35.8
1978	13.6	29.3	47.8	63.8	76.4	77.5
1979	26.9	26.9	40.4	40.4	43.2	57.4
1980	3.3	30.1	46.5	51.4	70.5	83.9
1981	16.7	32.9	34.4	45.4	49.5	53.9
1982	5.1	34.0	38.7	38.7	39.0	44.6
1983	44.7	44.7	80.7	89.8	99.0	103.7
1984	9.9	42.2	45.6	46.4	64.8	73.6
1985	6.7	39.3	70.4	82.9	83.7	96.4
1986	9.1	25.8	30.5	35.1	39.4	63.7
1987	8.9	17.3	28.2	33.2	38.8	56.0
1988	6.9	10.5	13.5	14.4	18.9	28.7
1989	4.0	29.9	29.9	31.4	32.9	37.2

Table A3: Freshet (April - June) Max 1-Day and Annual Max 1-Day through 10-Day Adjusted (AHCCD) Rain

Water Year	Freshet 1-Day Rain (mm)	Annual 1-Day Rain (mm)	Annual 2-Day Rain (mm)	Annual 3-Day Rain (mm)	Annual 5-Day Rain (mm)	Annual 10-Day Rain (mm)
1990	23.2	42.4	69.0	70.4	74.9	85.3
1991	7.5	46.0	69.0	69.3	70.9	80.9
1992	7.5	25.0	38.6	39.2	46.2	80.3
1993	9.3	34.2	43.7	49.8	50.6	51.7
1994	17.1	21.3	30.1	30.4	31.2	41.7
1995	8.5	39.5	39.5	42.7	43.0	48.5
1996	15.2	31.3	32.3	33.9	45.3	60.8
1997	15.2	15.2	21.7	21.7	23.1	26.8
1998	31.5	31.5	31.9	32.2	32.2	37.1
1999	46.8	46.8	50.0	50.3	50.6	60.0
2000	7.1	13.6	26.0	26.7	34.7	51.0
2001	20.5	38.7	39.2	39.5	46.2	66.0
2002	12.0	25.8	27.0	27.3	32.3	44.5
2003	20.1	20.1	20.7	21.2	28.0	33.8
2004	4.2	51.5	52.1	59.3	60.2	71.4
2005	14.2	14.2	18.2	19.4	20.5	31.3
2006	12.4	29.5	38.2	38.2	38.8	39.7
2007	5.2	18.3	28.4	34.9	38.0	46.6
2008	2.0	24.6	26.0	26.0	31.7	40.5
2009	8.1	39.3	65.8	67.3	67.9	68.6
2010	5.8	26.0	32.9	42.4	61.9	74.1
2011	15.8	22.6	24.7	31.6	41.1	56.6
2012	16.2	27.5	47.9	48.2	58.1	60.3
2013	5.0	28.7	29.0	29.3	34.7	44.4
2014	6.3	22.2	35.6	35.6	50.4	53.3
2015	7.1	28.9	51.7	52.0	52.3	75.9
2016	8.5	39.4	47.7	52.0	53.9	56.3
2017	9.3	20.0	33.0	33.0	38.2	40.5
2018	20.6	20.6	25.9	25.9	26.4	33.3
2019	18.3	34.9	51.3	51.6	58.0	95.9
2020	4.2	17.9	27.9	32.5	62.3	62.3
Mean:	**11.9**	**28.7**	**37.8**	**41.0**	**45.7**	**55.2**
Maximum:	**46.8**	**54.4**	**80.7**	**89.8**	**99.0**	**103.7**
Minimum:	**0.6**	**9.8**	**12.7**	**13.0**	**16.7**	**24.7**
Standard Deviation:	**8.9**	**10.4**	**14.7**	**15.7**	**16.6**	**18.3**

APPENDIX B

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT (HYDROTECHNICAL)

LIMITATIONS ON USE OF THIS DOCUMENT

HYDROTECHNICAL

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1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH’s “Instruments of Professional Service”), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of TETRA TECH’s Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH’s Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless expressly agreed to in the Services Agreement, TETRA TECH was not retained to explore, address or consider, and has not explored, addressed or considered any environmental or regulatory issues associated with the project.

1.8 LEVEL OF RISK

It is incumbent upon the Client and any Authorized Party, to be knowledgeable of the level of risk that has been incorporated into the project design, in consideration of the level of the hydrotechnical information that was reasonably acquired to facilitate completion of the design.