2.0 DESCRIPTION OF EXISTING BIOPHYSICAL ENVIRONMENT

2.1 INTRODUCTION

This section presents a description of the existing environmental conditions in the Nechalacho Mine site and Hydrometallurgical Plant site areas, collectively termed the Thor Lake Project (TLP). Data included in this Developer's Assessment Report (DAR) were drawn from the review of existing literature, past environmental studies and from more recently conducted fieldwork by Stantec, EBA and Knight Piésold. The baseline study reports prepared by these companies have been referenced as appropriate throughout the DAR and are provided in Appendices A, B and C respectively.

2.2 PRESENT LAND USES

The majority of the land use permits for the TLP, particularly at the Nechalacho Mine site are for activities in support of exploration including the establishment of camps.

Present land uses near the two proposed Project sites include mineral exploration, harvesting (fish, wildlife and plants), recreation and tourism. During the winter months recreational activities in the vicinity of the proposed Hydrometallurgical Plant site include snowmobiling, ice skating, ice fishing, snow shoeing, cross country skiing, and dog mushing. Additional details for land use are provided in Section 3.1.

2.3 CLIMATE

The Nechalacho Mine site is situated near the northeast arm of Great Slave Lake, 100 km ESE of Yellowknife. The approximate coordinates (NAD83) for the site are E416500, N6888669 with an elevation of 230 masl. This region experiences a continental polar climate, characterized by long cold winters and short moderate summers and moderate precipitation.

Hourly meteorological data have been recorded on-site for over two years (Stantec 2010a; Appendix A)). The Yellowknife Airport meteorological station (Climate ID: 2204100), operated by the Meteorological Service of Canada (MSC), provides a continuous 65-year climate record for the region and is used in this assessment to describe long-term climate trends for the Project area.

Meteorological stations in the vicinity of the Project site at Inner Whalebacks, Lutsel K'e, Fort Resolution, Fort Reliance and Pine Point provide additional climate data for the region.

As part of the Thor Lake Project, a hydrometallurgical plant is proposed in the Pine Point area located near the south west shore of Great Slave Lake. The approximate coordinates (NAD83) of this site are E642000, N6753200. The site elevation is 210 masl.

No meteorological records at the proposed Hydrometallurgical Plant site exist, therefore the climate of the site is best described by 30-year climate normals (1981-2010) determined from daily data collected by the Meteorological Service of Canada station at Hay River Airport (Climate ID# 2202400), located 75 km to the west of the Project site.

2.3.1 Nechalacho Mine Site Meteorology

A 48-metre wind monitoring tower was installed at the Nechalacho Mine site which records winds at 20 m, 30 m, 40 m and 48 m (Photo 2.3-1).

Photo 2.3-1
Wind Monitoring Tower – Nechalacho Mine Site

A second meteorological station, an AXYS Technologies Watchman 500 is also installed on site and has recorded the parameters of wind speed and direction at 5.33 m, air temperature, relative humidity, barometric pressure and rainfall in hourly intervals since its installation in June 2008 (Photo 2.3-2).

The Nechalacho Mine site meteorological station is installed near the old mine workings southwest of Den Lake (Stantec 2010a). The approximate coordinates (NAD83 Zone 12) for this station are N416464 E6888739. The ground elevation at the station location is 230 m above sea level.

The 840-day period of record for the data presented in this report for this station dates from June 26, 2008 to October 14, 2010. The data characterize the existing meteorological conditions of the Project area and provide a coincidental period of record to regional stations in order to apply trends in long-term records to the site.

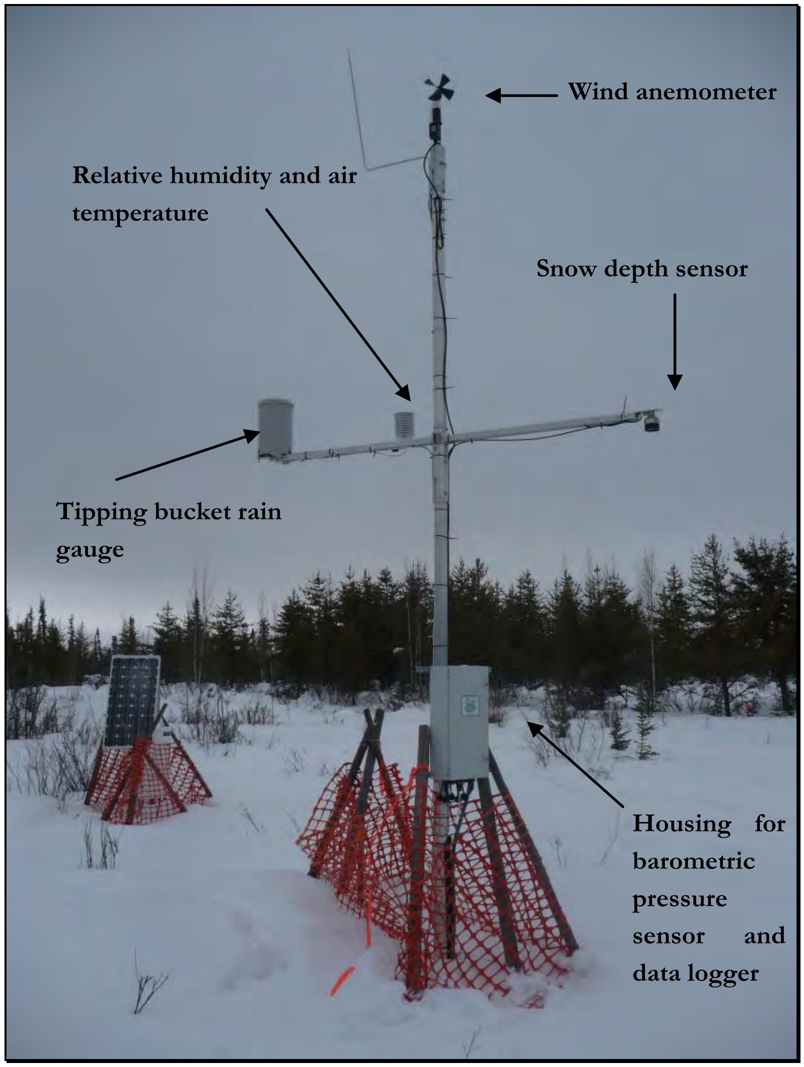


Photo 2.3-2
On-site Meteorological Station – Nechalacho Mine Site

Climate data for the Nechalacho Mine site are summarized by monthly averages or extremes in Table 2.3-1. Detailed analyses of the various meteorological parameters are described in the sections that follow.

TABLE 2.3-1: SUMMARY OF NECHALACHO MINE SITE CLIMATE DATA (JUNE 2008 TO OCTOBER 2010)													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Winds (m/s)													
Extreme Monthly Gust	11.5	10.0	9.8	11.1	10.5	10.5	10.1	11.3	12.0	12.0	12.7	9.7	**12.7**
Mean Monthly Wind Speed	1.2	1.4	1.8	2.0	2.1	2.0	1.7	1.7	1.6	1.8	1.6	0.8	**1.6**
Air Temperature (^{o}C)													
Average Daily Maximum	-20.9	-15.3	-7.8	3.9	7.8	18	20.9	18.9	11.1	2.3	-5.9	-21	**1.0**
Mean Daily	**-24.8**	**-20.2**	**-14.7**	**-2.4**	**1.8**	**12.1**	**15.7**	**13.7**	**7**	**-0.5**	**-8.9**	**-25.2**	**-3.9**
Average Daily Minimum	-29.2	-25.4	-21.0	-7.8	-3.8	6.4	9.8	8.5	2.7	-3.5	-12.4	.29.7	**-8.8**
Extreme Daily Maximum	-0.6	-2.3	11.2	18.3	23.7	26.5	29.8	30.4	22.5	16.9	2.6	-3.4	**30.4**
+Extreme Daily Minimum	-40.1	-40.1	-40.1	-27.3	-18.2	-3.7	-0.5	-3.3	-8	-13.5	-31.7	-40.1	**-40.1**
Rainfall (mm)													
Total Monthly	0.0	0.0	0.0	5.4	12.5	30.1	23.5	32.2	35.6	18	2.4	0.0	**159.7**
Extreme Daily	0.0	0.0	0.0	5.6	9.0	12.4	6.6	12.2	11.4	11.0	3.0	0.0	**12.4**

Source: Thor Lake Meteorological Station (June, 2008 to October 2010)

Note: Air temperature instrumentation is unable to measure air temperatures below -40.1°C

Note: The precipitation gauge only measures rainfall and cannot measure snowfall.

2.3.1.1 Wind Speed and Direction

The wind monitoring tower has wind speed and direction anemometers located at 20, 30, 40 and 48 m above ground. Only wind speed and direction data recorded at the 20 and 48 m heights are presented in this report.

The 371-day period of record for these data is from September 17, 2009 to September 23, 2010. There are 3 data gaps in the record resulting in 74 days of missing data:

1) December 9, 2009 @ 12:00 hr to January 18, 2010 @ 23:00 hrs (40.5 days)

2) June 15, 2010 @ 15:00 hr to June 22, 2010 @ 23:00 hrs (17 days)

3) August 29, 2010 @ 00:00 hr to September 14, 2010 @ 13:00 hrs (16.5 days)

Wind speed data at 48 m over the period of record are presented in Figure 2.3-1.

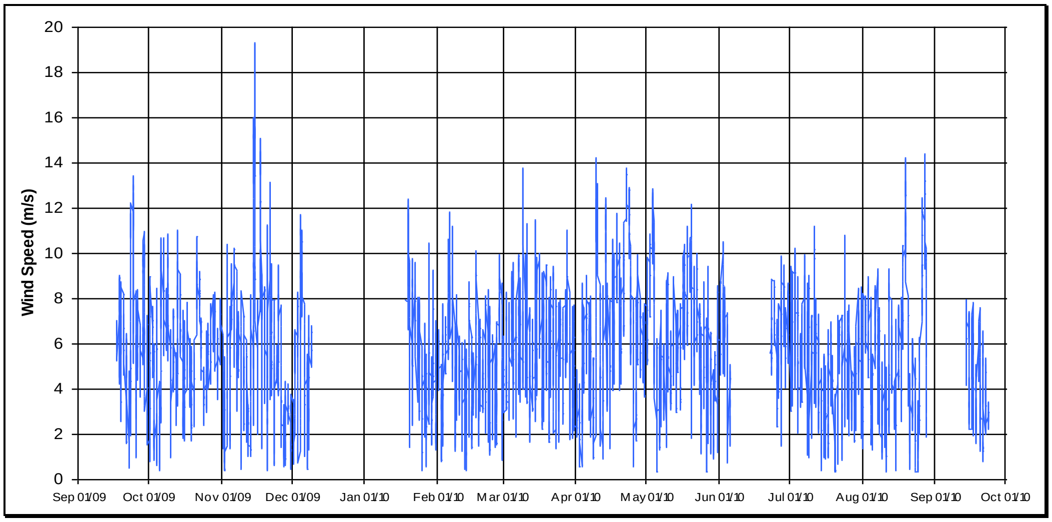


Figure 2.3-1
Hourly Wind Speeds at 48 m above Ground Level – Wind Monitoring Tower – Nechalacho Mine Site

The average hourly wind speed at 48 m above ground level is 5.67 m/s. Wind speeds are generally in the range of 2 to 8 m/s with hourly wind speeds occasionally exceeding 12 m/s. The highest recorded hourly wind speed at 48 m was 19.3 m/s occurring on November 15, 2009 at 11:00 hrs.

Wind speed data at 20 m are presented in Figure 2.3-2.

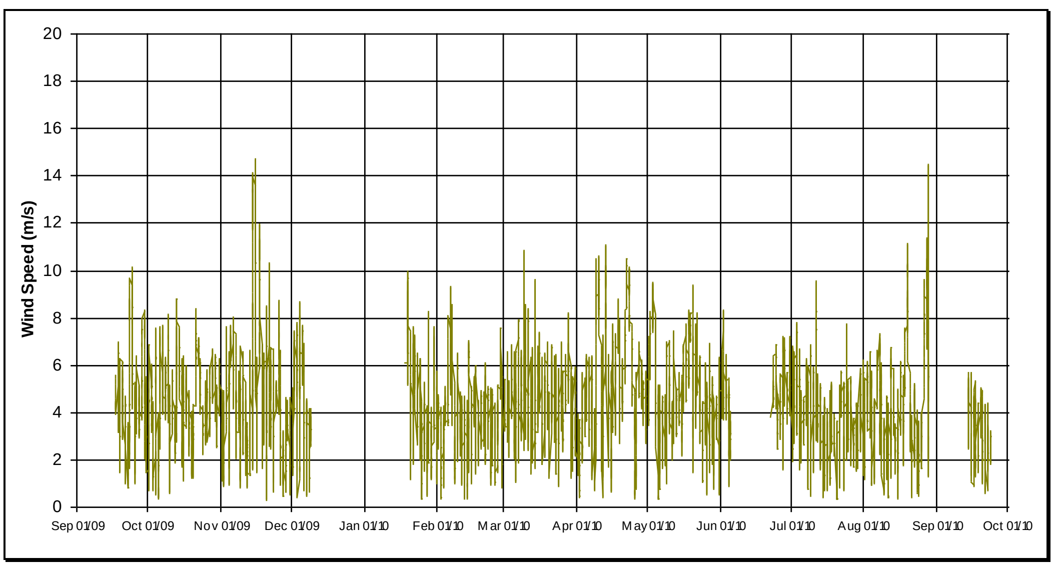
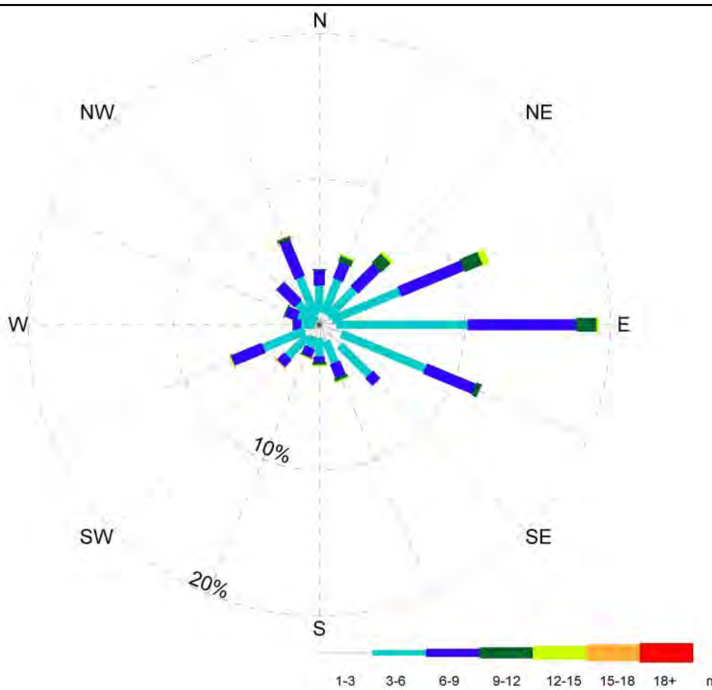


Figure 2.3-2
Hourly Wind Speeds at 20 m above Ground Level – Wind Monitoring Tower – Nechalacho Mine Site

The average hourly wind speed at 20 m above ground level is 4.54 m/s, or an attenuation of approximately 20% from wind speeds measured at 48 m. Wind speeds at 20 m above ground are generally in the range of 2 to 6 m/s, with occasional wind speeds exceeding 10 m/s. The highest recorded hourly wind speed at this anemometer height was 14.7 m/s, also occurring on November 15, 2009 at 11:00 hrs. The attenuation of maximum recorded hourly wind speeds from 48 m to 20 m height is approximately 25%.

The period of record wind roses for winds recorded at 48 m and 20 m are shown in Figures 2.3-3 and 2.3-4. The wind roses display graphically the total duration of wind occurring within a specified speed range and compass direction from which the wind is blowing as a percentage of the total period of record. These data are summarized in the wind speed and direction frequency distribution table, which is located in the lower right of the figure.

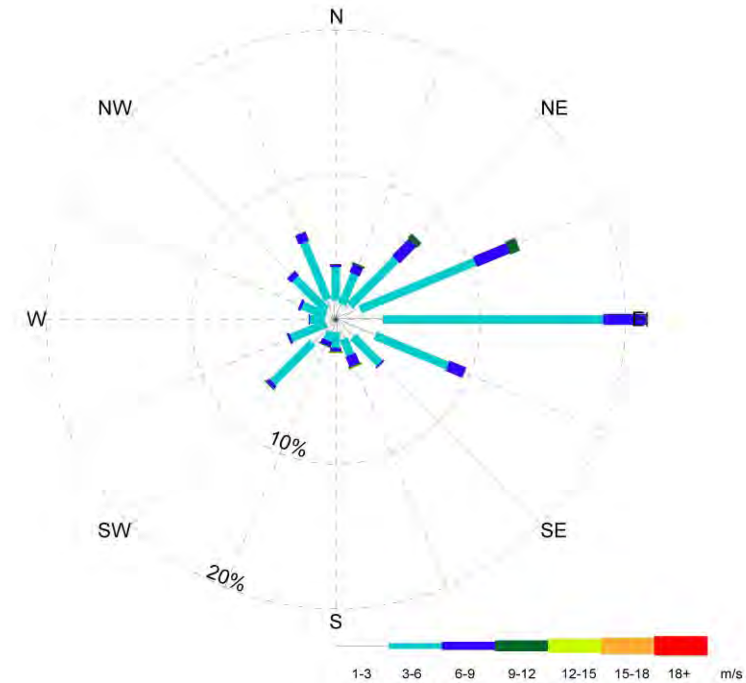


Station Name: Wind Tower
NAD 83 location:
N62° 7' 17.1" W112° 36' 5.0"
Ground Elevation above SL: 235 m
Anamometer Height: 48 m
Record Length: 371 days
Start Date: Sep. 17, 2009
End Date: Sep. 23, 2010

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.93	5.05	4.65	1.33	0.46	-	-	12.42
NE	-	0.83	2.59	2.14	0.88	0.20	-	-	6.64
NNE	-	0.84	2.51	1.18	0.43	0.10	-	-	5.06
N	-	0.84	1.88	1.02	0.08	-	-	-	3.83
NNW	-	0.69	2.82	2.68	0.24	-	-	-	6.42
NW	-	0.32	1.75	1.71	0.01	-	-	-	3.80
WNW	-	0.28	1.32	0.80	0.08	-	-	-	2.48
W	-	0.36	0.91	0.50	0.06	-	-	-	1.84
WSW	-	1.09	3.06	2.26	0.06	0.04	-	-	6.50
SW	-	1.12	1.93	0.67	0.01	0.01	0.06	-	3.81
SSW	-	0.90	0.79	0.60	0.07	0.04	-	-	2.40
S	-	0.90	1.27	0.39	0.20	0.08	-	-	2.85
SSE	-	1.22	1.60	1.01	0.21	0.07	-	-	4.11
SE	-	2.00	2.85	0.70	-	-	-	-	5.55
ESE	-	1.64	6.24	3.64	0.35	-	-	-	11.87
E	-	1.18	9.01	7.44	1.40	0.15	-	-	19.19
Calm	1.25	-	-	-	-	-	-	-	1.25
Total (%)	1.25	15.14	45.56	31.41	5.42	1.16	0.06	-	100.00

Figure 2.3-3
48 m Wind Rose – Wind Monitoring Tower – Nechalacho Mine Site



Station Name: Wind Tower
NAD 83 location:
N62° 7' 17.1" W112° 36' 5.0"
Ground Elevation above SL: 235 m
Anamometer Height: 20 m
Record Length: 371 days
Start Date: Sep. 17, 2009
End Date: Sep. 23, 2010

Wind Speed & Direction Frequency Distribution Table

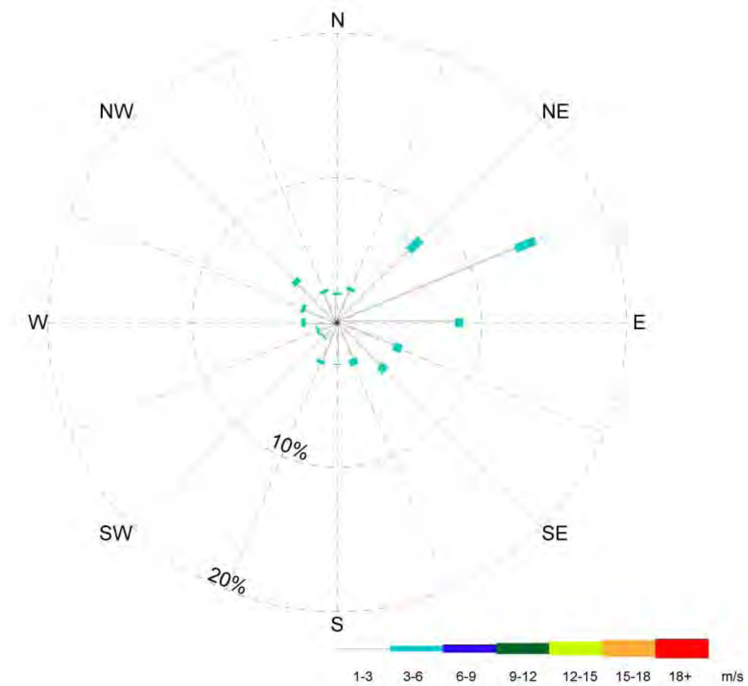
	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.84	8.58	2.47	0.69	-	-	-	13.57
NE	-	1.39	4.50	1.61	0.41	-	-	-	7.91
NNE	-	1.12	2.27	0.60	0.11	-	-	-	4.11
N	-	1.33	2.29	0.20	-	-	-	-	3.81
NNW	-	1.50	4.26	0.64	-	-	-	-	6.41
NW	-	0.94	3.04	0.39	-	-	-	-	4.37
WNW	-	0.76	1.75	0.17	-	-	-	-	2.68
W	-	0.77	1.02	0.07	-	-	-	-	1.86
WSW	-	0.74	2.61	0.14	0.01	-	-	-	3.50
SW	-	2.26	3.91	0.25	0.06	-	-	-	6.47
SSW	-	0.93	0.63	0.32	0.07	-	-	-	1.95
S	-	0.88	1.09	0.24	0.06	0.06	-	-	2.33
SSE	-	1.46	1.21	0.74	0.10	0.06	-	-	3.56
SE	-	1.71	2.57	0.11	-	-	-	-	4.39
ESE	-	2.96	5.41	1.23	-	-	-	-	9.60
E	-	3.25	15.23	2.94	0.13	-	-	-	21.56
Calm	1.93	-	-	-	-	-	-	-	1.93
Total (%)	1.93	23.83	60.36	12.14	1.63	0.11	-	-	100.00

Figure 2.3-4
20 m Wind Rose – Wind Monitoring Tower – Nechalacho Mine Site

Figures 2.3-3 and 2.3-4 as expected, are quite similar in nature with respect to wind direction and indicate that winds at Thor Lake come predominantly from the east (ENE, E, ESE - 43% frequency of occurrence) Winds are least common from the west (1.8%). Calm winds (less than 1 m/s) occurred 1.5% of the time with little difference between 48 m and 20 m anemometer heights.

The attenuation of wind speed with decreasing ground height is illustrated with the data in the frequency distribution tables contained within Figures 2.3-3 and 2.3-4. The frequency of occurrence of 48 m high winds between 15–18 m/s was 0.06%, while the 20 m anemometer recorded no winds in this range. Between the 12-15 m/s range, the occurrence for 48 m high winds was 1.2%, compared to 0.1% for the 20 m high anemometer. At wind speeds of between 9-12 m/s, the 48 m high wind frequency of occurrence was 5.4%, while at 20 m height the wind occurrence was 1.6%. Finally at wind speeds of between 6-9 m/s, the 48 m anemometer indicated the frequency of occurrence was 31.4%, while the 20 m high anemometer indicated 12.1%.

The wind rose for the Nechalacho Mine site over the period of record from June 27, 2008 to October 14, 2010 is shown in Figure 2.3-5.



Station Name: Thor
NAD 83 location:
N62° 7' 17.1" W112° 36' 5.0"
Elevation above SL: 230 m
Tower Height: 5.33 m
Record Length: 840 days
Start Date: Jun. 27, 2008
End Date: Oct. 14, 2010

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	13.34	1.48	-	-	-	-	-	14.82
NE	-	7.02	1.13	-	-	-	-	-	8.15
NNE	-	2.37	0.22	-	-	-	-	-	2.58
N	-	1.92	0.14	-	-	-	-	-	2.06
NNW	-	2.23	0.18	-	-	-	-	-	2.41
NW	-	3.81	0.36	-	-	-	-	-	4.18
WNW	-	2.39	0.24	-	-	-	-	-	2.64
W	-	2.19	0.26	-	-	-	-	-	2.45
WSW	-	1.36	0.14	-	-	-	-	-	1.50
SW	-	1.30	0.08	-	-	-	-	-	1.38
SSW	-	2.82	0.22	-	-	-	-	-	3.05
S	-	2.85	0.05	-	-	-	-	-	2.90
SSE	-	2.71	0.46	-	-	-	-	-	3.16
SE	-	4.18	0.55	-	-	-	-	-	4.73
ESE	-	4.25	0.54	-	-	-	-	-	4.79
E	-	8.16	0.54	-	-	-	-	-	8.70
Calm	30.50	-	-	-	-	-	-	-	30.50
Total (%)	30.50	62.90	6.61	-	-	-	-	-	100.00

Figure 2.3-5
Wind Rose – Period of Record – Nechalacho Mine Site

Typical daily wind speeds at the Nechalacho Mine site are on the order of 2 m/s, with daily maximum gusts near 6 m/s (Figure 2.3-6). Wind gusts in excess of 10 m/s are not uncommon. The maximum daily wind gust for the period of record was 12.7 m/s, which occurred on November 15, 2009, the same date and time as the maximum wind recorded on the 48 m wind tower.

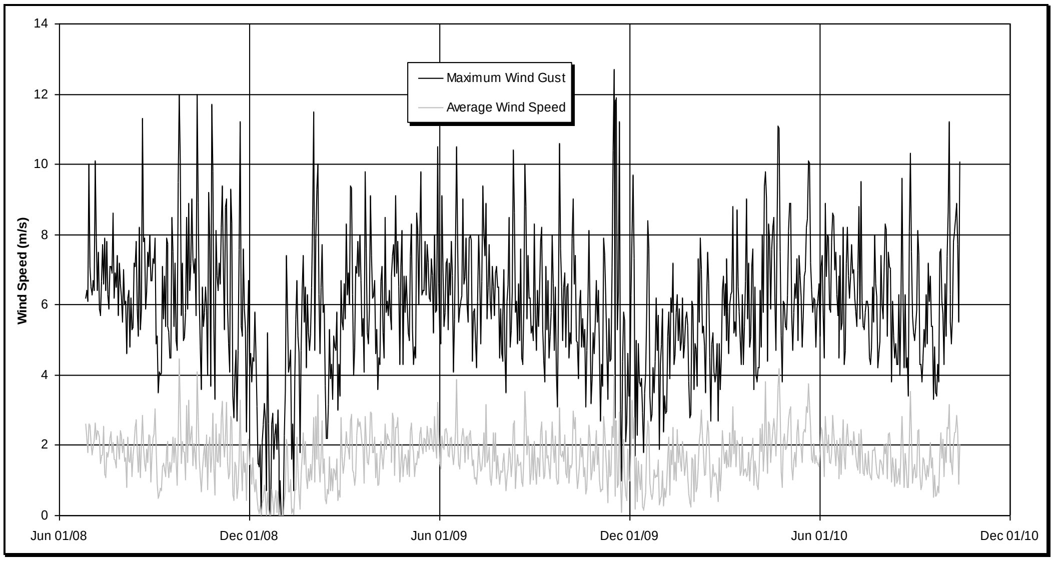


Figure 2.3-6
Daily Maximum Recorded Wind Speeds – Nechalacho Mine Site

2.3.1.2 Air Temperature

Figure 2.3-7 illustrates air temperature data recorded at the Nechalacho Mine site over the period of record. The mean air temperature is shown as a thick red line bounded by thin black lines, representing the maximum and minimum temperatures for the day.

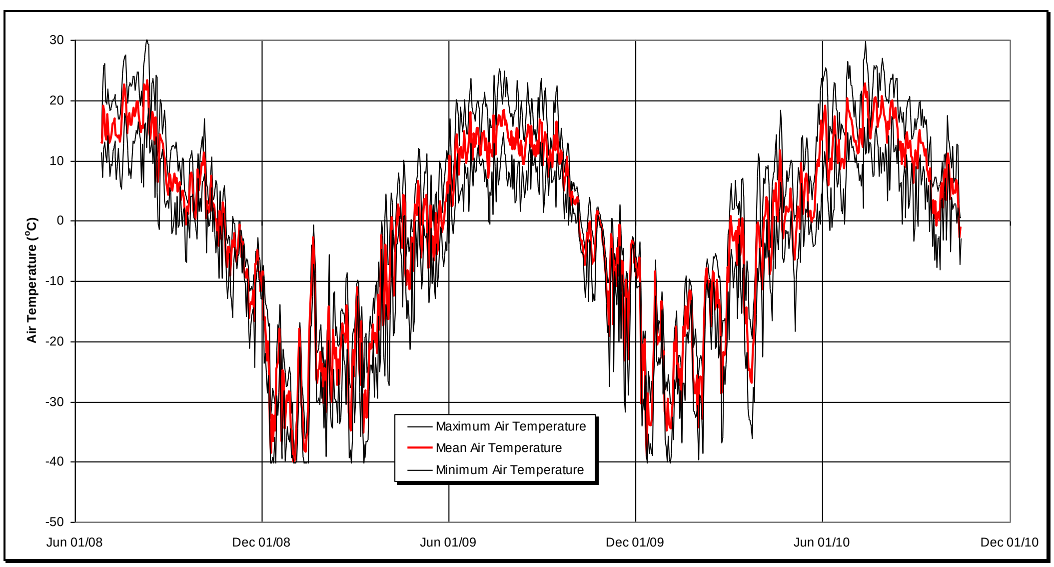


Figure 2.3-7
Daily Air Temperatures – Nechalacho Mine Site

A strong yearly air temperature pattern is evident. The summer period occurs between late May and August with a temperature range between 0ºC and 30ºC. The mean summer temperature is near 15°C. Typically, overnight lows are between 5ºC and 10ºC. Between August and November, temperatures begin to drop to winter normals. The coldest period for the site occurs from December to February. During the winter, the mean daily temperature is -25ºC, however there is a larger day-to-day variation from the mean than during the summer. The current onsite temperature probe does not record temperatures colder than -40.1°C, so it is likely that the extreme minimum temperature has not been recorded. Temperatures begin to increase between March and May to normal summer temperatures.

2.3.1.3 Relative Humidity

Figure 2.3-8 shows the daily relative humidity plotted over the entire period of record. The thick blue line in the figure represents the daily mean % RH. Daily maximums and minimums are indicated by thin black lines.

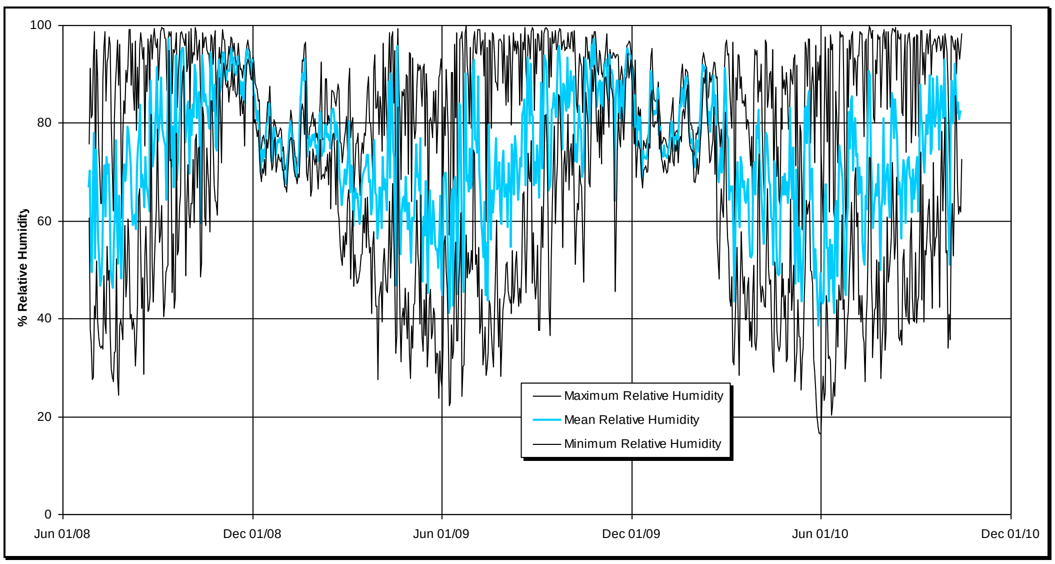


Figure 2.3-8
Daily Maximum, Mean, and Minimum Relative Humidity – Nechalacho Mine Site

There is a seasonal variation in relative humidity at the site. During the winter months, mean % RH is between 70% and 90%. A gradual decrease in mean % RH begins to occur in late February, with levels of 40% to 70% commonly occurring during the summer months of June and July. Mean relative humidity begins to increase again in early August to the winter period normals.

The variance of relative humidity is indicated by the envelope between maximum and minimum relative humidity. Over the winter period, the variance is typically ±10% from the mean. During the summer period variations are much larger, typically on the order of ±30% or larger.

2.3.1.4 Barometric Pressure

Figure 2.3-9 shows the daily barometric pressure (corrected to sea level-equivalent pressure) plotted over the period of record. The figure shows the daily maximum and minimum barometric pressure, shown as black lines about the mean, plotted in green.

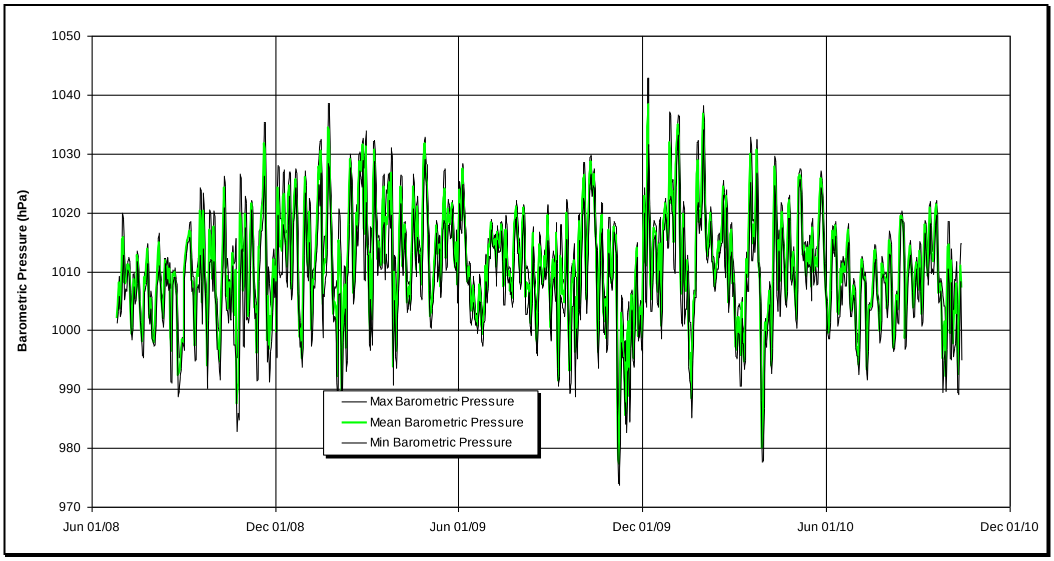


Figure 2.3-9
Daily Sea Level Equivalent Barometric Pressures – Nechalacho Mine Site

All barometric pressures recorded by the onsite meteorological station have been corrected to sea level equivalent pressures. Barometric pressure at the site typically varies between 1,000 hPa and 1,020 hPa throughout the year. The lowest barometric pressure over the period of record was 975 hPa. recorded on November 7, 2009 and the highest was 1,044 hPa on December 6, 2009. There is little seasonal variation, however barometric pressure can change by more than 30 hPa from one day to the next.

Daily variation is less pronounced during the summer period than during the winter months. During the summer, daily variations are less than ±5 hPa. During the winter, day-to-day fluctuations can be as large as ±30 hPa.

2.3.1.5 Rainfall

Total precipitation is not recorded on site as the station only records rainfall and not water equivalent snowfall. Precipitation falling as snow must be inferred from snow course data collected in late March of 2009.

Average monthly rainfall at the Nechalacho Mine site, based on the 28-month period of record, is plotted in Figure 2.3-10.

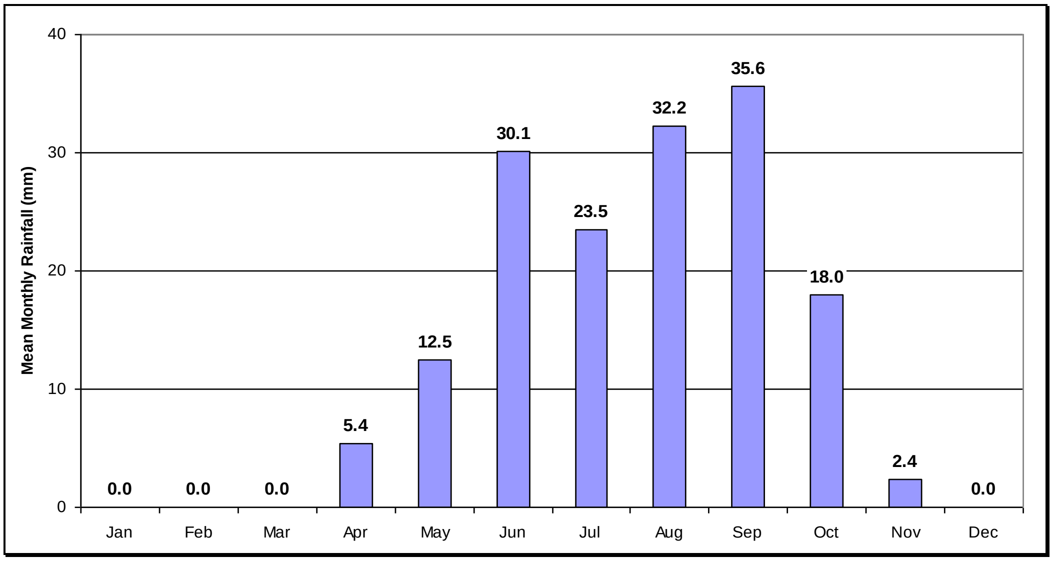


Figure 2.3-10
Average Monthly Rainfall – Nechalacho Mine Site

Monthly average rainfall is highest during September (35.6 mm). Based on a sum of monthly averages, the site would be expected to receive an average of 160 mm of rainfall per year.

The most extreme rainfall event recorded for one day was 12.4 mm (Table 2.3-1). Light precipitation events on the order of 1 or 2 mm are common, however events in excess of 10 mm have occurred on eight occasions over the two-year period of record. The maximum recorded one-hour rainfall event was 4.8 mm (Stantec 2010a)

2.3.1.6 On-Site Snow Surveys

Snowpack surveys at site were conducted for six courses throughout the Nechalacho Mine site area in late March 2009 to coincide with regional snowpack surveys conducted by Environment Canada (Stantec 2010a). Snow survey data from the six courses are summarized in Table 2.3-2.

TABLE 2.3-2: NECHALACHO MINE SITE SNOW COURSE DATA SUMMARY (MARCH 2009)

Snow Course	SC1	SC2	SC3	SC4	SC5	SC6	Site Mean
Snow Depth (cm)	31.3	64.8	58.5	66.6	61.4	59.5	57.0
Snow Density (kg/m^3)	245.1	168.6	177.5	173.0	155.3	189	184.8
Water Equivalent (mm)	78.7	109.1	103.0	115.1	85.2	72.5	93.9

Based on the 2009 mean SWE snow course data and mean monthly rainfall, approximately 254 mm of precipitation would be expected annually at the Nechalacho Mine site, 37% (or 94 mm) of which falling as snow.

2.3.2 Climate Trends in the Vicinity of the Nechalacho Mine Site

Long-term regional climate records from the Yellowknife Airport station provide a 65-year trend which can be applied to the region of the Nechalacho Mine site, with the establishment of a correlation between regional climate and site-specific climate over a coincidental period of record.

2.3.2.1 Air Temperature

Figure 2.3-11 shows a very good correlation for mean air temperatures recorded at the Yellowknife Airport and the Nechalacho Mine site for the two years of coincidental data. Mean air temperature data recorded at Fort Reliance and Hay River also exhibit good correlation, showing minimal regional variance with respect to air temperatures.

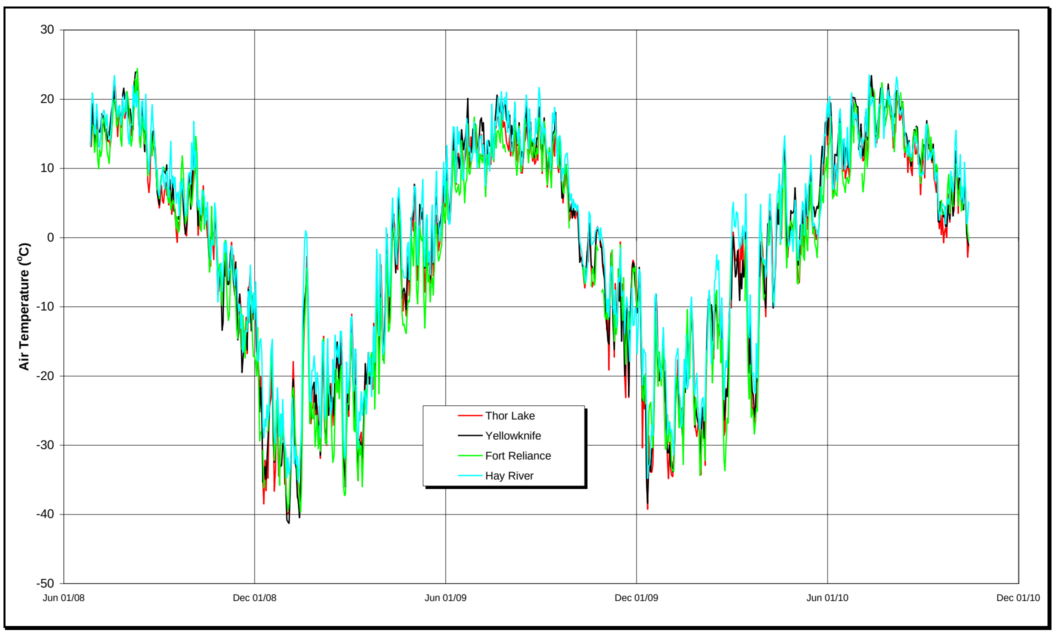


Figure 2.3-11
Recorded Air Temperatures – Nechalacho Mine Site, Yellowknife Airport, Fort Reliance, and Hay River Meteorological Stations

Figure 2.3-12 illustrates the overall mean annual temperature trend for Yellowknife Airport from 1942 to 2009. The average maximum temperature for the warmest month and the average minimum temperature for the coldest month for each year have also been plotted along with the respective trend line.

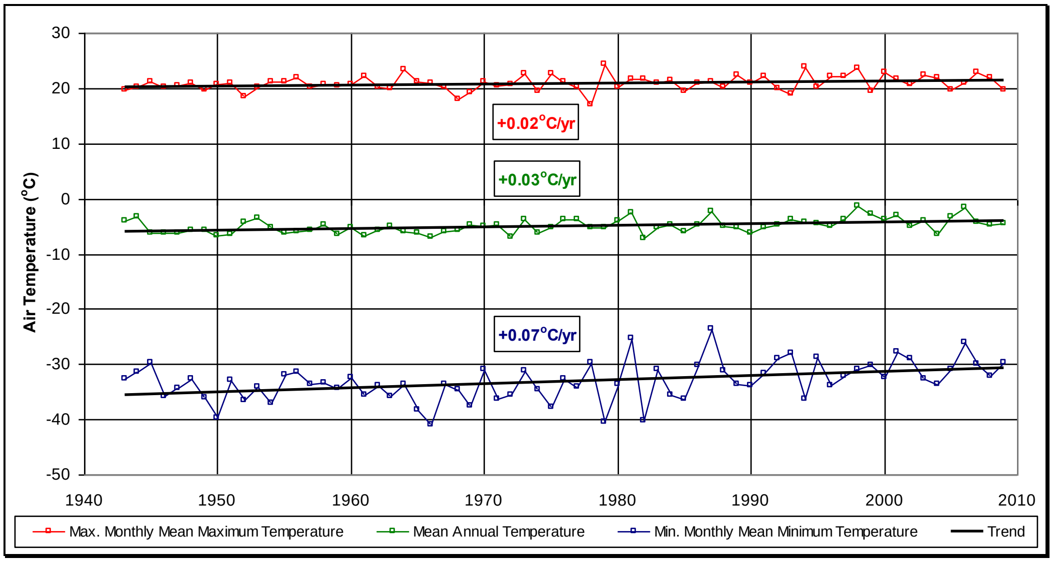


Figure 2.3-12
Historical Mean Annual Air Temperature – Yellowknife Airport (1943 – 2009)

The data indicate that in general, the mean annual temperature over the past 65 years has been gradually increasing in the region, at an average rate of 0.03°C per year. Over a 65-year span, this amounts to an average temperature increase of 2°C. Monthly minimum temperatures during the winter have also been increasing on average at a slightly faster rate, 0.07°C, or 4.5°C over 65 years.

Figures 2.3-13 to 2.3-15 illustrate the mean temperature trend over the same time period for the months of January, April and July respectively.

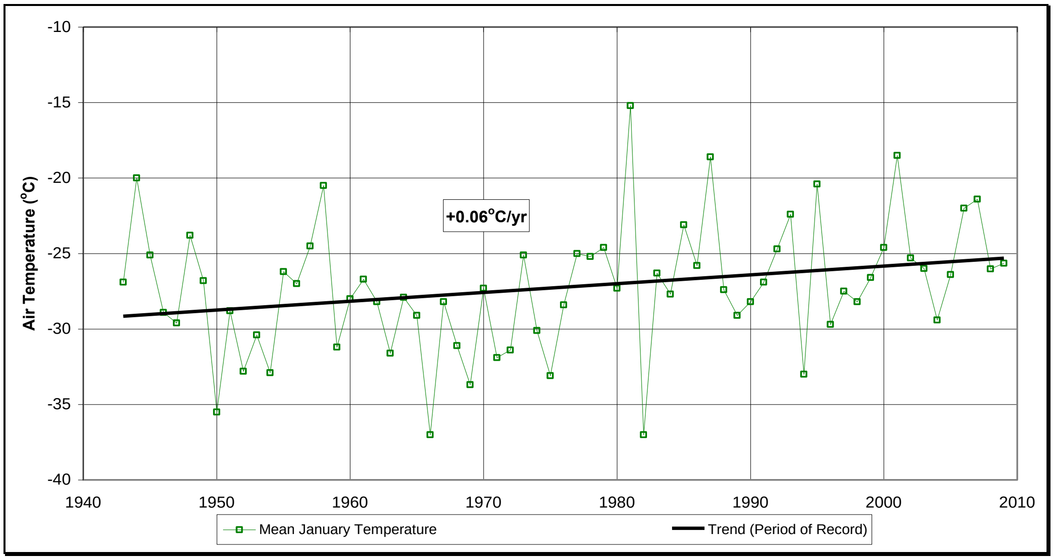


Figure 2.3-13
Historical January Air Temperatures – Yellowknife Airport (1943 – 2009)

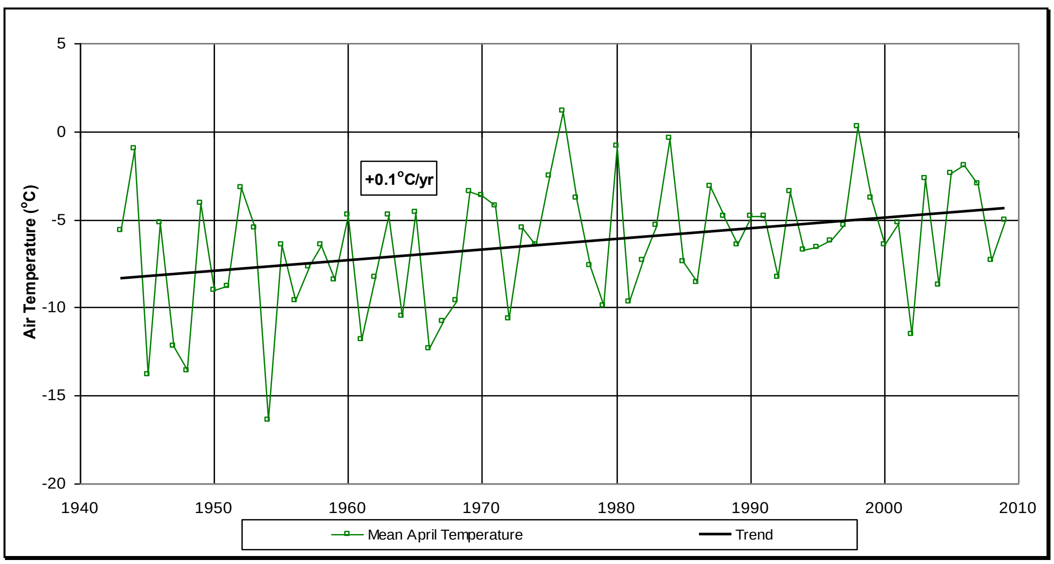


Figure 2.3-14
Historical April Air Temperatures – Yellowknife Airport (1943 – 2009)

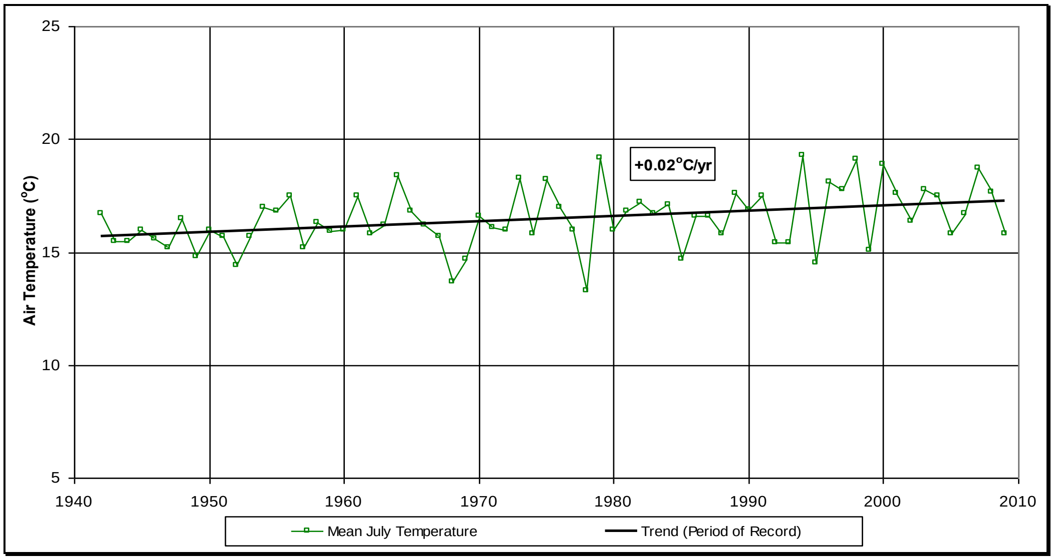


Figure 2.3-15
Historical July Air Temperatures – Yellowknife Airport (1942 – 2009)

Since 1942, mean January temperatures in the region have been increasing by an average of 0.06°C per year. Eight of the ten warmest Januarys on record have occurred in the last 18 years. Mean April temperatures, when the snowpack begins to melt, have been increasing on average 0.1°C per year over the last 65 years. Mean July temperatures have been increasing as well, but at a slower rate, averaging 0.02°C per year.

2.3.2.2 Precipitation

Average monthly rainfall recorded at Thor Lake and Yellowknife between July 2008 and December 2009 has been plotted in Figure 2.3-16 and illustrates the relationship of local precipitation to regional records.

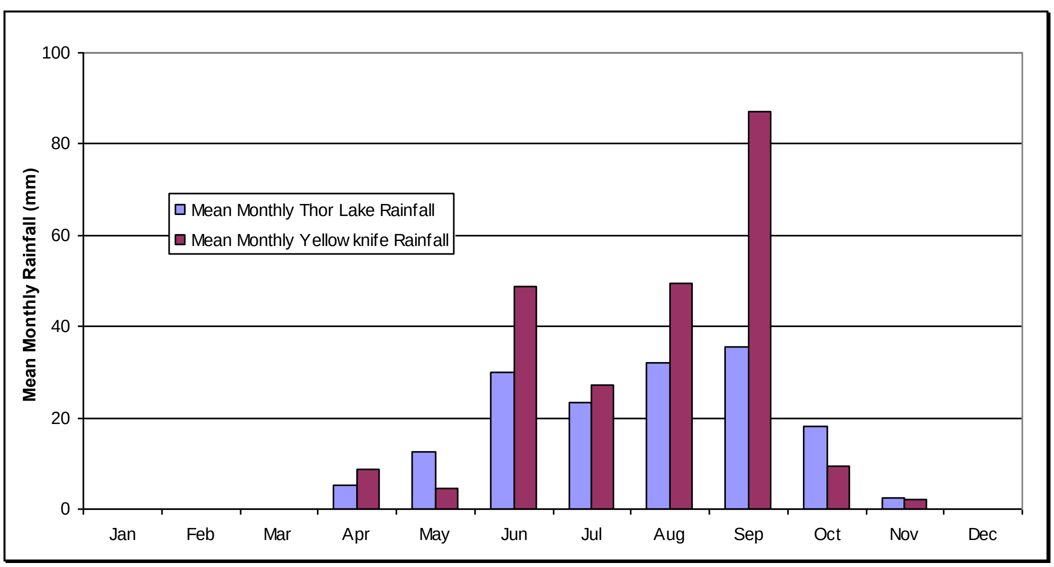


Figure 2.3-16
Average Monthly Rainfall Comparison (Nechalacho Mine Site to Yellowknife)

Based on the 18-month coincidental period of record, rainfall is considerably less on average at the Nechalacho Mine site than at Yellowknife during the summer and fall months. Total annual precipitation, taken as the sum of monthly averages, yields a coefficient of 0.67 between rainfall at the Nechalacho Mine site and rainfall at Yellowknife (237.5 mm at Yellowknife vs. 159.7 mm at the Nechalacho Mine site).

To describe the trend in annual precipitation for the region, total annual rainfall recorded at Yellowknife Airport since 1943 has been plotted in Figure 2.3-17.

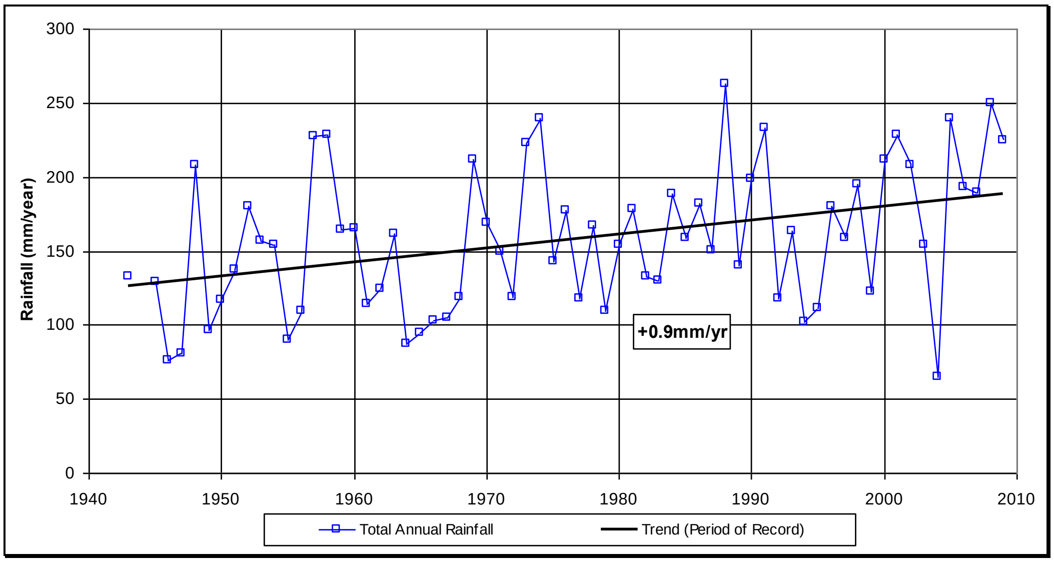


Figure 2.3-17
Historical Annual Rainfall – Yellowknife Airport (1943 – 2009)

On average, annual rainfall has been increasing at Yellowknife Airport by 0.9 mm/year over the last 65 years, for a total of 58 mm. Total annual water-equivalent precipitation at Yellowknife is plotted in Figure 2.3-18 along with its respective trend line and shows a similar increase (1.1 mm/year).

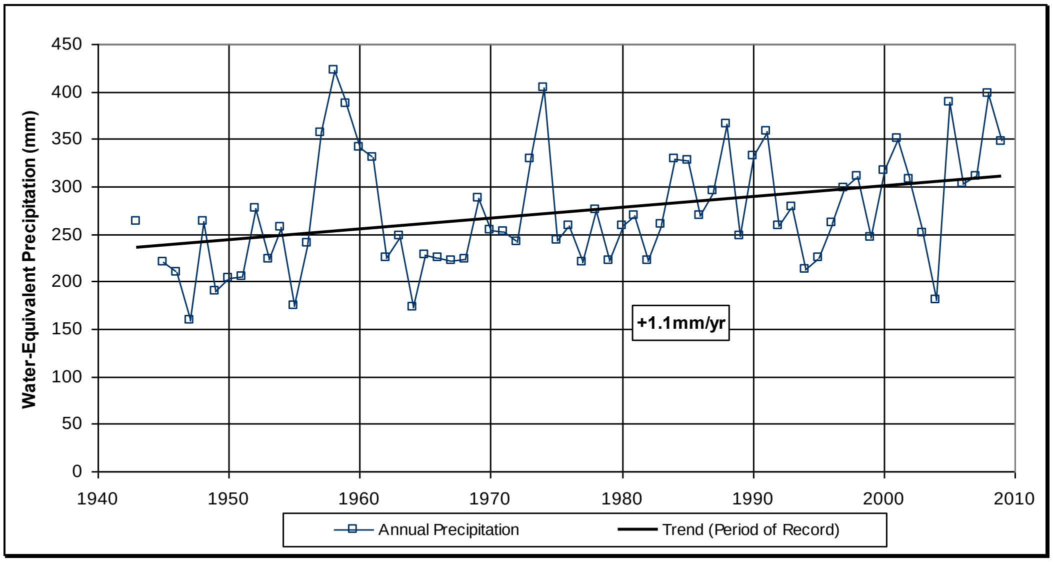


Figure 2.3-18
Historical Annual Precipitation – Yellowknife Airport (1943 – 2009)

2.3.2.3 Snow Pack

In order to correlate regional snowpack SWE recorded at Tibbitt Lake to the site, end-of-March recorded SWE is compared to that measured at Thor Lake for 2009. Table 2.3-2 shows a mean 2009 end-of-March snow pack of 93.9 mm SWE measured at site. The recorded snow pack at the same time at Tibbitt Lake was 99 mm, yielding a ratio of 0.95 between the sites.

The historical end-of-March water-equivalent snowpack, representing the near-maximum for the year, has been plotted for Tibbitt Lake in Figure 2.3-19.

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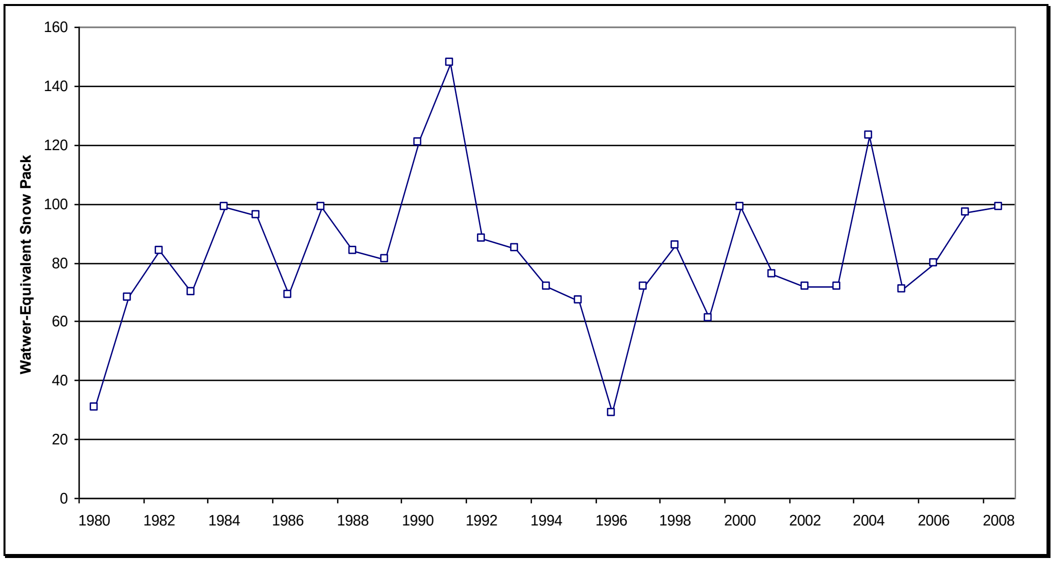


Figure 2.3-19
Historical Water-Equivalent Snow Pack – Tibbitt Lake (1981 – 2009)

Historically, yearly maximum SWE has varied between 31 and 148 mm, increasing on average between 1981 and 1992, followed by a sharp decrease in winter snowfall. SWE has been increasing on average since 1997. The 30-year record would suggest some sort of cyclical behaviour to total snow pack in the region; however a longer period of record is required to confidently determine the trend.

Annual snowfall recorded at Yellowknife Airport provides a longer historical record of snowfall for the region. Figure 2.3-20 shows annual snowfall over the past 65 years at Yellowknife.

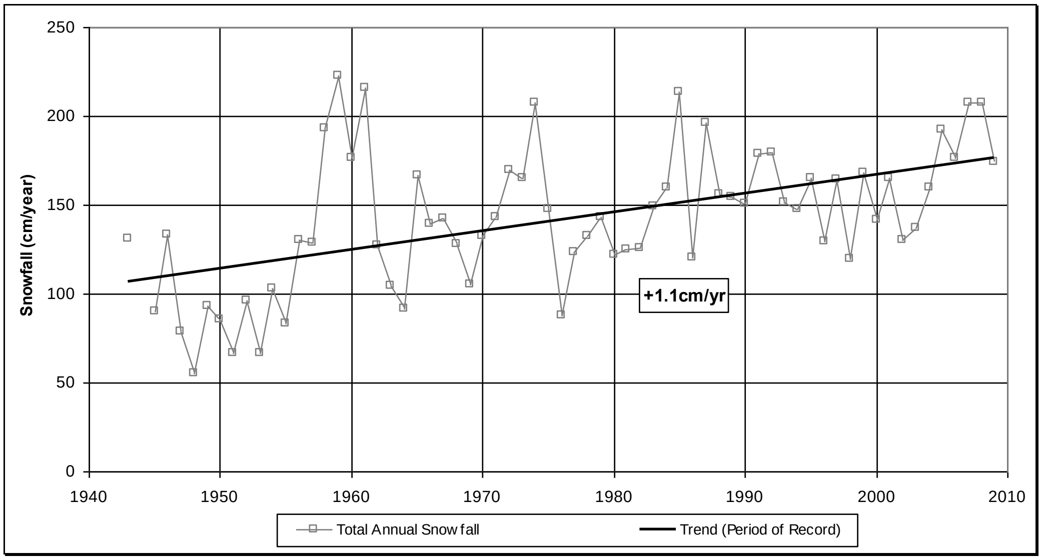


Figure 2.3-20
Historical Annual Snowfall – Yellowknife Airport (1943 – 2009)

Over the period of record, annual snowfall has been increasing by an average of 1.1 cm per year. Two of the largest recorded snowfall years occurred in 2007 and 2008. Winter snowfall amounts exhibit some cyclical behavior on the scale of approximately 10 years.

The first date of the year on which the snow pack has completely melted is plotted in Figure 2.3-21. The figure illustrates that this has been occurring increasingly earlier in the year since snow depth data were recorded at Yellowknife Airport in 1955. As a comparison, the first date of the year which the winter snowpack has begun to accumulate is plotted in Figure 2.3-22. The figure shows that with little change to the start of the snow season, winters are becoming shorter on average year by year.

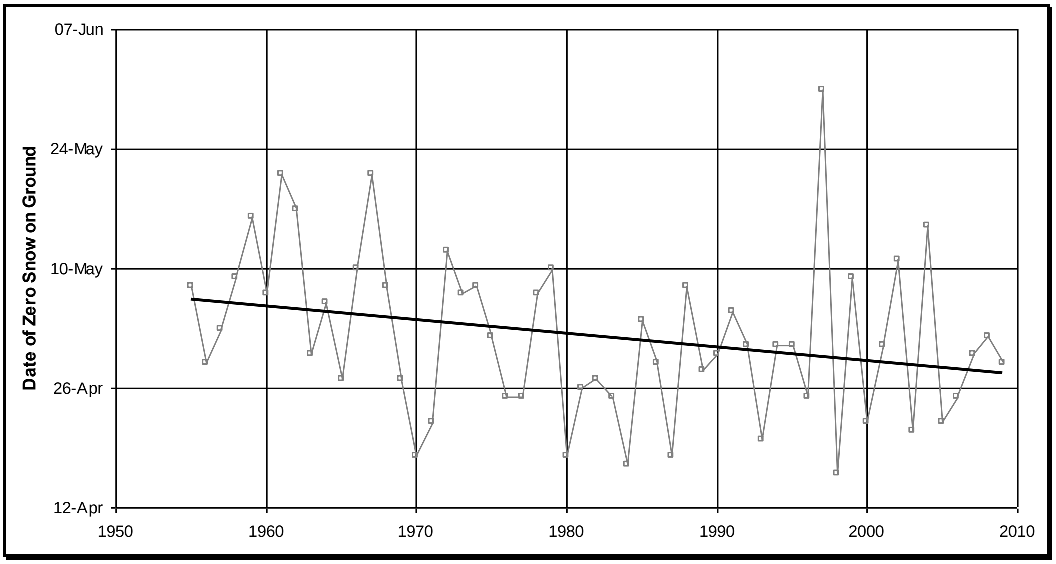


Figure 2.3-21
Historical Date of Zero Snow on Ground – Yellowknife Airport (1955 – 2009)

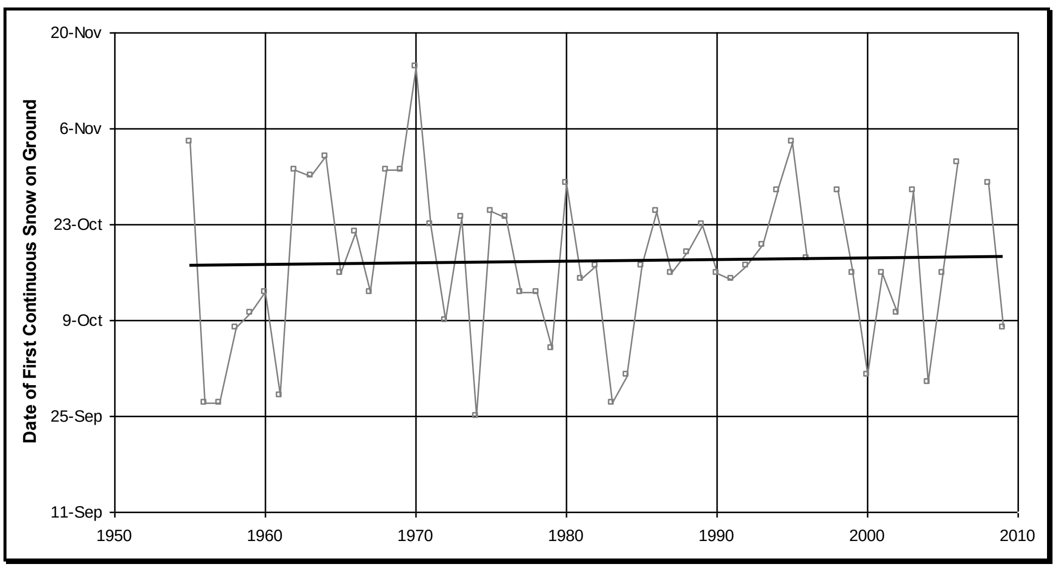


Figure 2.3-22
Historical Date of First Snow on Ground – Yellowknife Airport (1955 – 2009)

2.3.3 Hydrometallurgical Plant Site Climate

To describe the climate for the proposed Hydrometallurgical Plant site at Pine Point, 30-year climate normals for temperature and precipitation were calculated for the period between June 1980 and May 2010 from daily data at Hay River Airport published by Environment Canada. Temperature and precipitation extremes consider the entire period of record at the station (1943 to present). Mean and maximum wind speed and predominant wind direction for the site were determined using hourly data over a five-year period between June 2006 and May 2010. Climate normals and wind observations are summarized in Table 2.3-3.

2.3.3.1 Air Temperature

Based on the 30-year period of daily temperature observations, the mean annual temperature at Hay River is -2.6ºC. July is the warmest month on average (16.1ºC) while January is the coldest (-21.7ºC). Temperatures are typically below zero from November to March and above zero between May and September. The coldest temperature ever recorded at Hay River Airport was -48.3ºC (February 1, 1947). The warmest was 36.7ºC (August 9, 1981).

2.3.3.2 Precipitation

Mean annual precipitation at Hay River is 335 mm, of which, 65% (217 mm annually, on average) falls as rain and 35% as snow (137 cm annually, on average). The highest daily precipitation total ever recorded was 59.9 mm (September 13, 1991), which fell entirely as rain. The largest daily snowfall ever recorded was 47.6 cm (November 5, 2006). Precipitation is typically higher during the summer, with 53% of the annual total occurring between June and September. Based on the 30-year period, rainfall has occurred in every month, however snow has not occurred in July and August over the last 30 years.

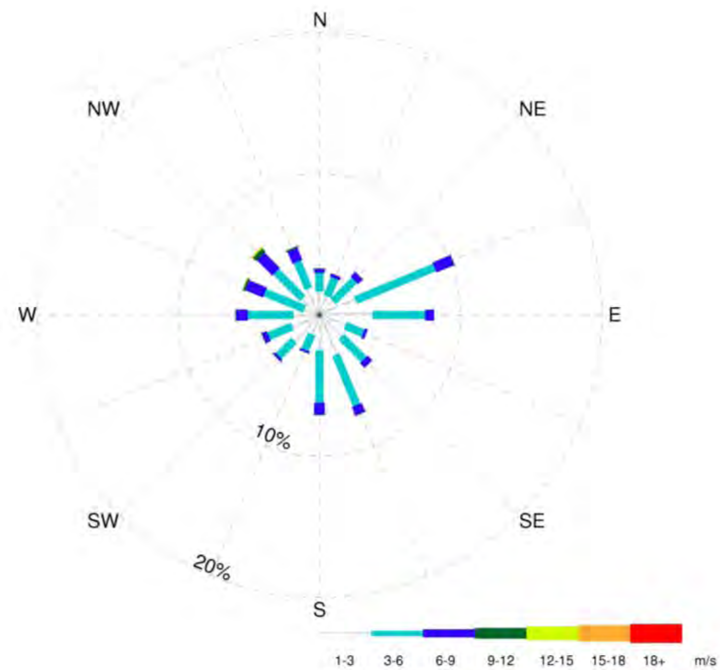
2.3.3.3 Wind Speed and Direction

Mean annual and monthly wind speeds and predominant wind direction were determined from hourly wind observations over the five-year period between June 2006 and May 2010. The wind rose for the entire period of record is illustrated in Figure 2.3-23.

TABLE 2.3-3: CLIMATE DATA, HAY RIVER A STATION, NWT (JUNE 1980 – MAY 2010)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature:													
Daily Maximum (°C)	-17.3	-14.2	-7.8	2.9	10.7	18.0	21.2	19.6	13.2	4.1	-7.7	-14.6	2.3
Daily Average (°C)	**-21.7**	**-19.6**	**-13.8**	**-2.7**	**5.4**	**12.5**	**16.1**	**14.6**	**8.6**	**0.5**	**-11.6**	**-18.9**	**-2.6**
Daily Minimum (°C)	-26.2	-24.9	-19.8	-8.2	0.0	6.9	10.9	9.5	4.1	-3.2	-15.4	-23.3	-7.5
†Extreme Maximum (°C)	10.7	13.2	15.6	26.0	33.3	34.0	35.0	**36.7**	30.0	29.2	15.0	12.2	36.7
†Extreme Minimum (°C)	-47.8	**-48.3**	-44.4	-38.9	-20.5	-5.6	0.7	-1.1	-11.7	-24.3	-40.8	-47.2	-48.3
Precipitation:													
Mean Total Precipitation (mm)	**16.4**	**14.0**	**14.3**	**13.1**	**23.3**	**30.9**	**45.4**	**57.3**	**45.2**	**34.5**	**25.1**	**16.1**	**335.5**
Mean Snowfall (cm)	19.2	16.5	16.4	9.5	5.2	0.1	0.0	0.0	1.8	19.1	30.3	19.4	137.3
Mean Rainfall (mm)	0.1	0.2	0.2	4.1	18.0	30.9	45.4	57.3	43.3	16.3	0.9	0.3	217.0
†Extreme Daily Precipitation (mm)	15.0	31.5	16.2	28.4	31.4	48.0	47.2	58.6	**59.9**	36.8	35.1	22.6	59.9
†Extreme Daily Snowfall (cm)	19.6	31.5	18.4	28.4	18.0	3.0	0.0	0.0	12.2	36.8	**47.6**	22.6	47.6
†Extreme Daily Rainfall (mm)	1.6	2.0	3.3	12.2	29.5	48.0	47.2	58.6	**59.9**	25.8	8.4	5.1	59.9
Average Snow Depth (cm)	35	43	45	23	1	0	0	0	0	3	16	28	16
Snow Depth at Month End (cm)	39	46	38	6	0	0	0	0	0	8	23	31	16
‡Wind:													
Mean Wind Speed (km/hr)	**10.0**	**9.7**	**11.9**	**12.5**	**12.4**	**11.3**	**10.1**	**11.2**	**11.5**	**12.7**	**11.9**	**11.1**	**11.4**
Peak Hourly Wind Speed (km/hr)	48	46	41	48	48	41	41	44	**61**	59	46	43	**61**
Predominant Wind Direction(s)	WNW	WNW ENE SSE	ENE WNW SSE	ENE SSE	ENE	ENE	ENE	*N/A	*N/A	SSE	WSW E SSE	SSE WNW	ENE SSE WNW

Source: Environment Canada (2010) – Hay River A Station: 60°50'23" N, 115°46'58" W; Elevation: 164.9 m; Climate Station ID: 2202400
†Temperature extremes over entire period of record (1943 – 2010)
‡Wind Speeds determined from hourly data between June 2005 and May 2010
*No strong predominance to wind direction



Station Name: Hay River A
NAD 27 location:
N60° 50' 23.0" W115° 46' 58.0"
Elevation above SL: 300 m
Tower Height: 10 m
Record Length: 1826 days
Start Date: June 1, 2005
End Date: May 31, 2010

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	2.78	6.05	1.34	0.03	-	-	-	10.20
NE	-	1.38	2.11	0.44	0.02	-	-	-	3.96
NNE	-	1.45	1.38	0.22	-	-	-	-	3.05
N	-	1.67	1.33	0.27	0.02	-	-	-	3.29
NNW	-	2.03	2.07	0.90	0.12	-	-	-	5.13
NW	-	1.69	2.67	1.52	0.34	0.08	0.01	-	6.31
WNW	-	1.15	3.04	1.35	0.16	0.02	-	-	5.72
W	-	1.85	3.23	0.82	0.06	-	-	-	5.96
WSW	-	2.11	1.78	0.35	0.05	-	-	-	4.30
SW	-	2.55	1.55	0.16	0.02	-	-	-	4.28
SSW	-	1.46	1.21	0.14	-	-	-	-	2.83
S	-	2.48	3.73	0.83	0.04	-	-	-	7.08
SSE	-	3.05	3.86	0.64	0.02	-	-	-	7.57
SE	-	2.18	2.26	0.45	-	-	-	-	4.90
ESE	-	1.98	1.38	0.19	-	-	-	-	3.56
E	-	3.75	3.75	0.61	-	-	-	-	8.12
Calm	13.74	-	-	-	-	-	-	-	13.74
Total (%)	13.74	33.56	41.41	10.25	0.92	0.11	0.02	-	100.00

Figure 2.3-23
Wind Rose - Period of Record – Hay River

Winds at Hay River tend to come with the highest frequency from three directions: ENE, SSE and WNW. Wind direction exhibits some seasonality, with east winds occurring predominantly during the summer months and southeast and northwest winds occurring more typically during the winter. Winds were calm (less than 1 m/s) 13.7% of the time.

Mean annual wind speed at Hay River is 11.4 km/hr (Table 2.3-3). Higher wind speeds tend to occur between March and May and between September and November, agreeing with local observations that severe wind typically occurs in the fall and spring. September and October also have significantly higher one-hour average wind speeds than the rest of the year (61 km/hr and 59 km/h, respectively).

2.3.3.4 Evaporation

Evaporation data are not available for the site, however annual lake evaporation for Hay River is estimated at 430 mm, with monthly totals ranging from 19 mm in April to a maximum of 120 mm in July (Knight Piésold 2010b).

2.3.4 Climate Trends in the Vicinity of the Hydrometallurgical Plant Site

General circulation models (GCM) in combination with various population and economic growth scenarios provide simulations of climate change over the period of 2010 to 2039 for the Mackenzie Valley referenced to 1961 to 1990 climate normals (Burn 2003).

In addition to GCM projections, 64-year mean annual temperature and precipitation trends (1945-2009) for Hay River, which is considered to be representative of the Pine Point area, are presented as a comparison to the future scenarios and a preliminary validation of the projections.

Seven highly regarded GCMs in combination with various atmospheric change scenarios provided 29 projections of temperature and precipitation change over the next 30 years (Burn 2003). Upper and lower estimates (selected as the 86th percentiles) and the median projection scenarios are summarized in Table 2.3-4 for mean annual temperature, mean winter temperature and annual precipitation for the Upper Mackenzie Valley. The 64-year trend at Hay River is also shown.

TABLE 2.3.4: CLIMATE CHANGE SCENARIOS FOR SOUTHERN MACKENZIE VALLEY

	[1]1961-1990 Climate Normals (Baseline)	1981 – 2010 Climate Normals (Hay River)	1945 – 2009 Trend (Hay River)	2010-2039 Climate Change Projections		
				[2]Low	Mid	[2]High
Mean Annual Temperature (ºC)	-3.4ºC	-2.6ºC	+0.03ºC/yr	+1.0ºC	+1.3ºC	+2.1ºC
[2]Mean Winter Temperature (ºC)	-22.2ºC	-20.1ºC	+0.08ºC/yr	+0.6ºC	+1.6ºC	+2.5ºC
Annual Precipitation (mm)	342 mm	336 mm	-0.07 mm/yr	+0.9%	+6.2%	+9.6%

Source: Burn (2003)

[1] Source: Environment Canada: HAY RIVER A Climate Normals

[2] Low and high represent the 12th and 86th percentile of 29 climate change projections

[3] Mean winter temperature defined in climate scenarios as DJF and as the mean of December, January and February monthly means in climate normals

2.3.4.1 Air Temperature

Mean annual temperature over the period of 2010 to 2039 is projected by GCMs to increase in the Upper Mackenzie Valley by between 1.0ºC and 2.1ºC over the 1961 – 1990 baseline mean temperature for the region (-3.4ºC at Hay River). The rate of increase is similar to what has been observed over the past 64 years, plotted in green in Figure 2.3-24.

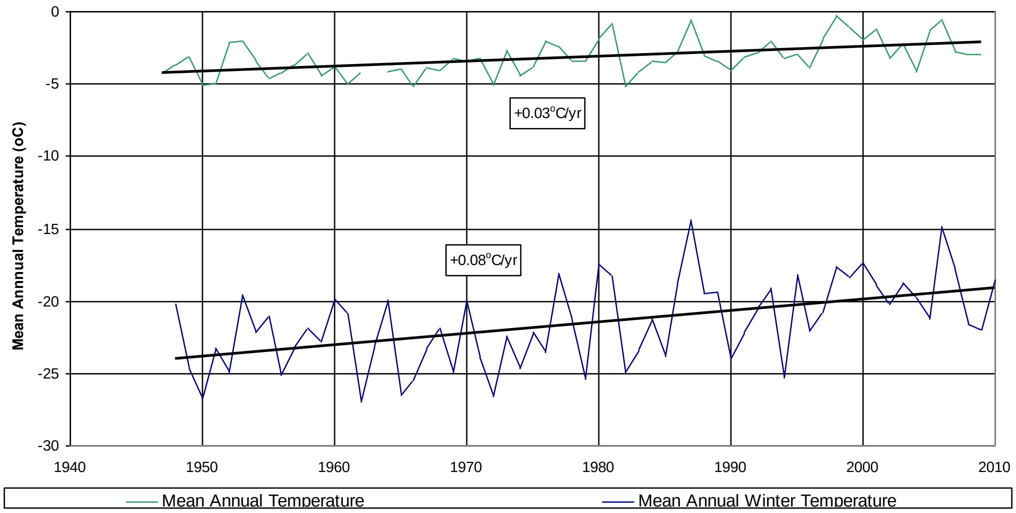


Figure 2.3-24
Historical Mean Annual Temperature and Mean Annual Winter Temperature – Hay River

Mean winter temperatures are projected to increase at a slightly faster, but more variable rate in the region (between 0.6ºC and 2.5ºC). The 64-year plot of mean winter (December, January, February) temperature, plotted for Hay River in blue in Figure 2.3-24, also illustrates a faster rate of warming for the winter months.

The trends in mean annual temperature and mean winter temperature are similar to those observed at Yellowknife (Section 2.3.2, Figure 2.3-12). Increasing temperatures, in particular during the winter, would tend to shorten the length of the snow season in the region. The plot of historical last day of snow on ground at Yellowknife in Figure 2.3-21 illustrated a trend towards an earlier snow melt. Since temperatures at Yellowknife and Hay River exhibit a close correlation (Section 2.3.2, Figure 2.3-11) the trend can also be assumed for Hay River.

Although warming trends are evident in the region, the magnitude of natural year-to-year variations in annual temperature is 5 to 10 times the projected increase over the next 30 years. Over the next 30 years, air temperatures are projected to increase on average in the Upper Mackenzie Valley, however natural year-to-year climate variability will be more noticeable to a casual observer.

2.3.4.2 Precipitation

Although GCMs tend to predict that an increase in precipitation at high latitudes is likely, the effects of climate change on regional precipitation patterns are uncertain as they will be significantly influenced by changes in global circulation patterns (Hengeveld 1997). Furthermore, when reproducing the magnitude and spatial variability of observed climate, GCMs, while accurately simulating temperature, have tended to over-predict precipitation (Burn 2003).

For the Upper Mackenzie Valley, the projected increase in precipitation over the next 30 years is between 0.9% and 9.6% over the 1961-1990 baseline (342 mm at Hay River).

The 64-year plot (1945 - 2009) of annual precipitation at Hay River in Figure 2.3-25 however, shows a near-neutral trend (decreasing on average 0.07 mm per year).

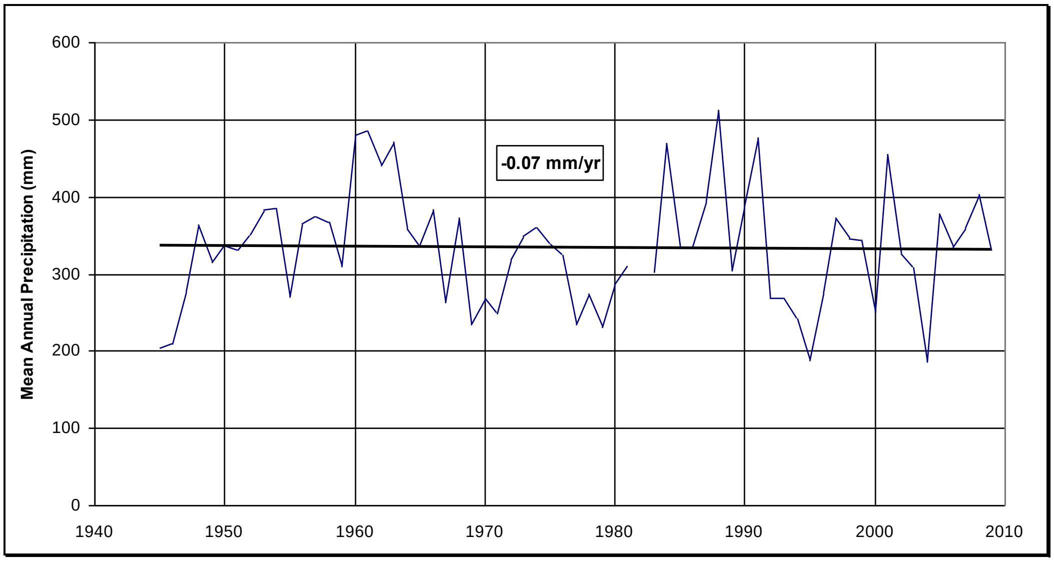


Figure 2.3-25
Historical Mean Annual Precipitation – Hay River

Further illustrating regional variability is the trend at Yellowknife which shows an average increase of 1.1 mm annually (Section 2.3.2, Fig. 2.3-18). Although most long-term climate records in arctic regions indicate increasing trends, some stations show decreases in precipitation (Hinzman et. al. 2005).

The 64-year plot of annual rainfall at Hay River in Figure 2.3-26 shows an average increase annually of 0.7 mm per year. Over the same period, annual snowfall, plotted in Figure 2.3-27, has been decreasing at an average rate of 0.3 cm per year.

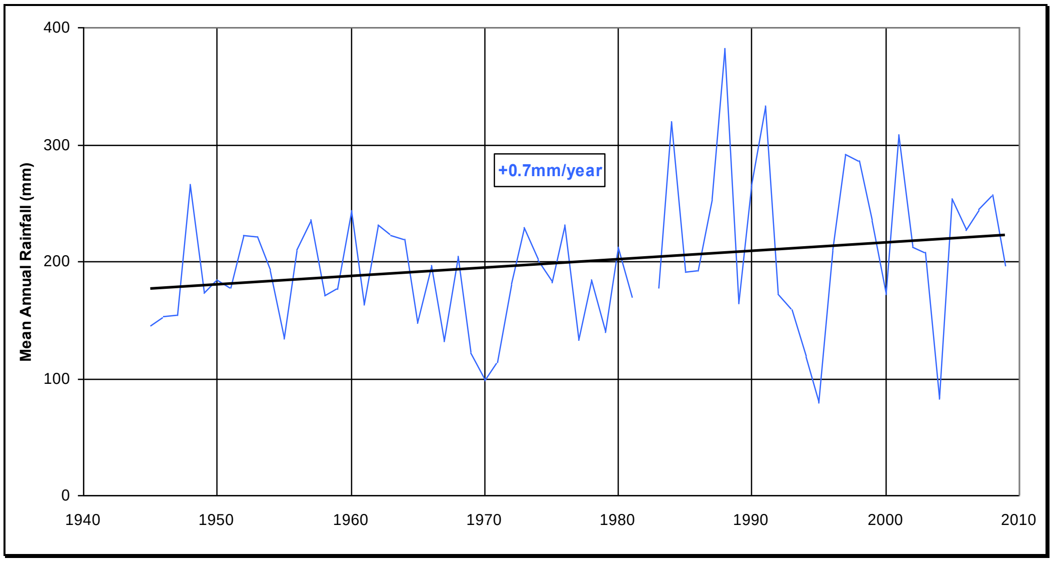


Figure 2.3-26
Historical Mean Annual Rainfall – Hay River

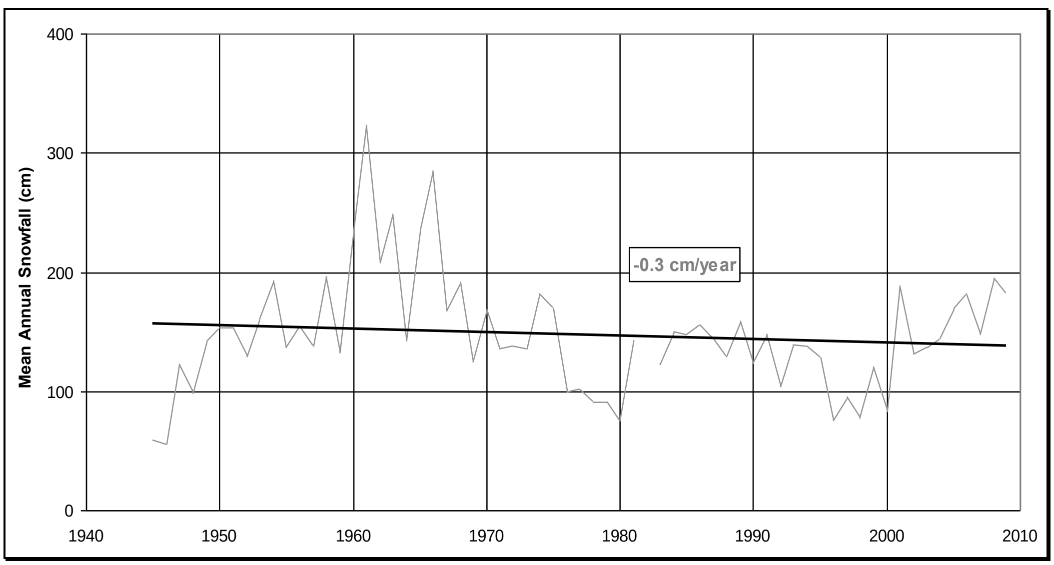


Figure 2.3-27
Historical Mean Annual Snowfall – Hay River

These trends indicate not only that a larger portion of annual precipitation is falling as rain at Hay River but also that snow is of increasingly higher water content, evidenced by the discrepancy between the trends in mean annual precipitation (-0.07 mm/year), rainfall (+0.7 mm/yr) and snowfall (-0.3 cm/year).

2.4 AIR QUALITY AND NOISE

2.4.1 Air Quality

Ambient air quality is monitored in the Deh Cho Region at the Northwest Territories Department of Environment and Natural Resources station at Fort Liard and for the North Slave Region at Yellowknife. With a 2006 population of 3,648 compared to 18,700 at Yellowknife and 583 at Fort Liard, the results provide a good estimate for a range of potential ambient conditions in the Thor Lake Project area including both the Nechalacho Mine and Flotation Plant site and the Hydrometallurgical Plant site.

Results from the 2008 and 2009 NWT Air Quality Report are presented in Table 2.4-1 along with current NWT air quality standards. National (NAQQO) or Provincial (Alberta) standards that have been adopted in the NWT are shown with an asterisk.

TABLE 2.4-1: FORT LIARD AND YELLOWKNIFE BASELINE AIR QUALITY (2008 AND 2009)

Species	NWT Standard (*NAQQO , **Alberta)		Fort Liard		Yellowknife	
	Maximum	Avg. Period	2008 Maximum	2009 Maximum	2008 Maximum	2009 Maximum
SO_2	450 μg/m³	1 hr	5 μg/m³	8 μg/m³	13 μg/m³	11 μg/m³
	150 μg/m³	24-hrs	-	-	-	-
	30 μg/m³	annual	2 μg/m³	-	<4 μg/m³	<4 μg/m³
NO_2	*400 μg/m³	1-hr	n/a	n/a	80 μg/m³	44 μg/m³
	*200 μg/m³	24-hrs	n/a	n/a	-	27 μg/m³
	*60 μg/m³	annual	n/a	n/a	4 μg/m³	4 μg/m³
CO	*15 mg/ m³	1-hr	n/a	n/a	2.7 mg/m³	2.2 mg/m³
	*6 mg/ m³	8-hr	n/a	n/a	1.1 mg/m³	-
$PM_{2.5}$	30 μg/m³	24-hr	28 μg/m³	27 μg/m³	62 μg/m³	18 μg/m³
PM_{10}	50 μg/m³	24-hr	54 μg/m³	52 μg/m³	105 μg/m³	100 μg/m³
Ground -level O_3	*160 μg/m3	1-hr	127 μg/m³	112 μg/m³	111 μg/m³	98 μg/m³
	127 μg/m³	8-hr	120 μg/m³	108 μg/m³	102 μg/m³	96 μg/m³

*Northwest Territories Air Quality Report, Northwest Territories Environment and Natural Resources (2008, 2009)

SO_2 concentrations are very low at both Yellowknife and Fort Liard and are indicative of baseline. SO_2 is produced greatly as a function of industrial processes and baseline levels at the Thor Lake Project sites are likely closer to or lower than what is observed at Fort Liard, or essentially negligible.

Regional NO_2 concentrations are typically higher in the winter months, likely due to increased fuel consumption in combination with winter inversions, characterized by very low wind speeds and a stable atmosphere, which result in a diminished ability for dispersion of pollutants. Baseline NO_2 would likely be much lower in more remote areas due to fewer sources of combustion (automobiles, butane stoves/heaters, industry).

Baseline levels of fine particulate matter ($PM_{2.5}$) are typically higher on average during winter months due to inversion conditions. However short-period peaks, which exceed air quality standards, occur during summer months due to forest fire smoke. Typical 24-hour average $PM_{2.5}$ baseline concentrations in the region are in the range of 5 to 10 $\mu g/m^3$, however forest fires can cause exceedances of air quality standards.

Coarse particulate matter (PM_{10}) concentrations are higher in snow-free months due to road dust and are particularly elevated in April and May due to 'spring-time dust events' from residual winter gravel (GNWT ENR 2010f). Peak 24-hour average concentrations in Yellowknife are double those observed in Fort Liard due to increased vehicle traffic and the number of roads. Baseline concentrations in remote areas would likely be similar to that observed during the winter at Yellowknife and Fort Liard (typically less than 10 $\mu g/m^3$).

Without the influence of vehicle traffic, ground level ozone (O_3) typically exhibits a spring maximum. At Fort Liard and Yellowknife, one- and eight-hour average concentrations during spring peaks are on the order of 100 $\mu g/m^3$. Baseline concentrations during the rest of the year are typically around 60 $\mu g/m^3$. These levels would be typical of remote areas over the entire region.

In small northern communities, the major contributor to CO production is individual-dwelling wood burning, so peak values tend to occur during the winter months and be worsened by inversions. However, due to the sparse pockets of small populations that characterize the region, CO levels are not expected to pose a concern to air quality, especially in remote areas.

2.4.2 Ambient Noise

The Nechalacho Mine site in particular, is located in a remote area where natural background ambient noise levels are expected to be low, generally in the range of 35 dBA. The acoustic environment is dominated by the sounds of nature, e.g. wind rustling through the foliage, birds singing, waves lapping on the shores of Thor Lake, etc.

Anthropogenic sounds that can be heard in the Nechalacho Mine site from time to time are those associated with the limited and intermittent ongoing exploration drilling program, the existing mining camp at Thor Lake, the camp power generator, local exploration-related vehicle traffic, and the limited fixed-wing aircraft flights that use the airstrip.

At the Hydrometallurgical Plant site, the natural ambient noise levels are also expected to be low and generally in the range of 35 dBA. However, because of the existing network of roads related to the former Pine Point Mine operation, anthropogenic sounds that can be heard in this area from time to time are those associated with limited and intermittent vehicular traffic that uses these roads, local off-road ATV and snowmobile traffic, and associated hunting that occurs seasonally throughout the Pine Point region.

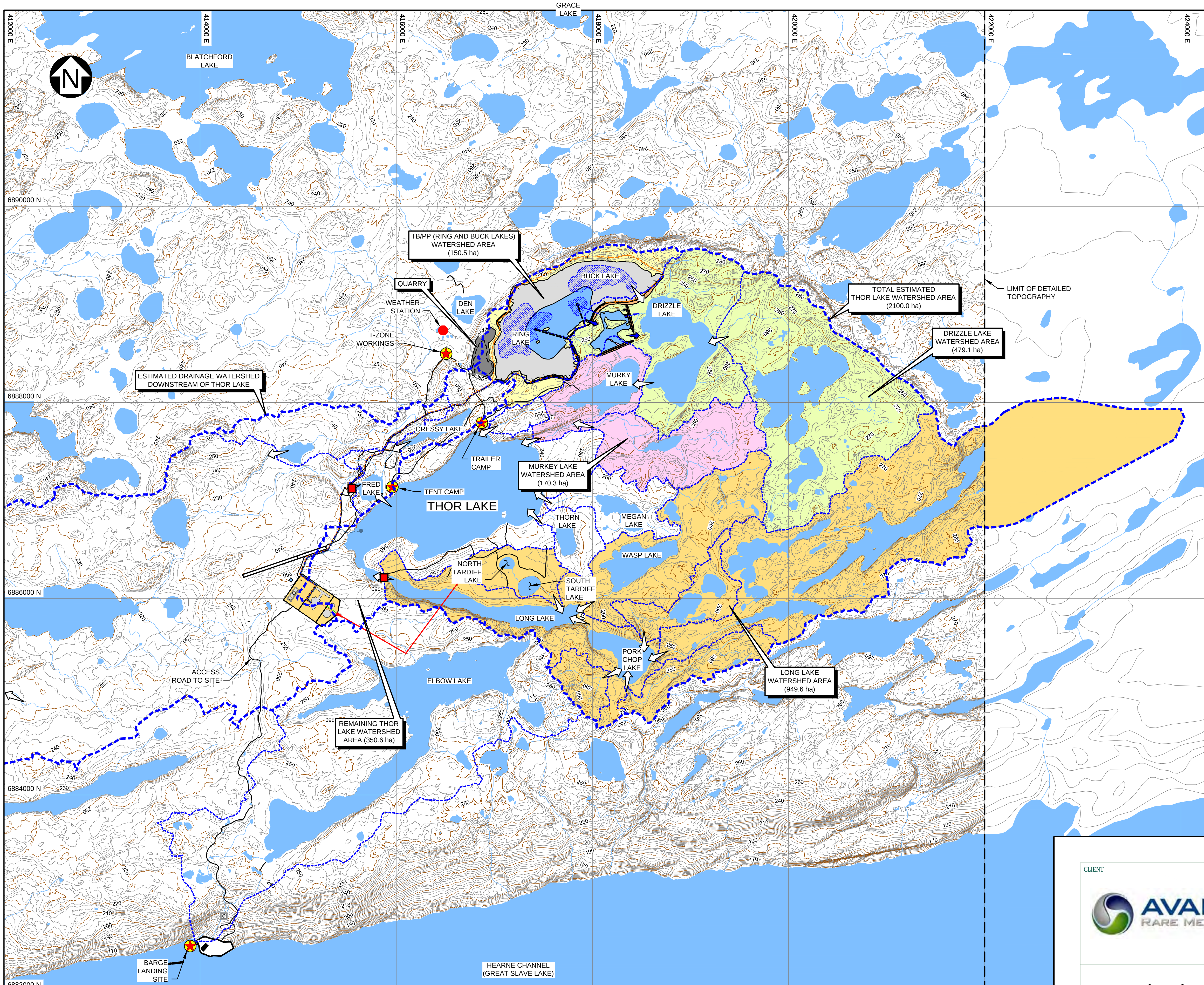
2.5 HYDROLOGY

2.5.1 Background

Existing hydrological information for the Nechalacho Mine site area is described in Melville et al. (1989), Stantec (2010a) and Knight Piésold (2011b, 2010e, 2010f) Melville et al. (1989) described flow patterns and presented selected data on streamflows, focussing on the Cressy, Den, and Thor Lake systems, and not at all on Thor headwater lakes (e.g. Ring, Buck, Drizzle and Murky Lakes), which will be the aquatic area most affected by the Project.

The Stantec (2010a) hydrologic study consisted of the measurement of lake level and streamflow at nine gauged waterbodies, in combination with the monitoring of climatic conditions recorded at the climate station installed in the area in 2008. A snow survey in the proposed site area was also carried out in 2009 to coincide with a regional snow study being conducted by Environment Canada.

The Nechalacho Mine and associated infrastructure is located in the Thor Lake watershed area (estimated 2,100 ha), which drains into a larger watershed area (estimated 6,700 ha) downstream before flowing into Great Slave Lake as shown in Figure 2.5-1. Sub-catchment areas within the Thor Lake watershed have been identified based on available imagery and mapping.



LEGEND:

- WATER
- ROAD
- WATERSHED BOUNDARY
- SUB WATERSHED DIVIDE
- DRAINAGE DIRECTION
- BASELINE MONITORING LOCATION
- WEATHER STATION

NOTES:

1. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 12N AND IS IN METRES.
2. CONTOURS ARE IN METRES. CONTOUR INTERVAL WITHIN DETAILED TOPOGRAPHY IS 2 METRES. SURROUNDING CONTOUR INTERVAL IS 10 METRES.
3. LAKE AREAS ARE INCLUDED IN CATCHMENT AREA TOTAL.
4. FIGURE SOURCE IS KNIGHT PIÉSOLD CONSULTING REF. NB11-00132 FIGURE 2 DATED MARCH 11, 2011.

SCALE 1:40,000

0.4 0 0.4 1.0 1.6km

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THOR LAKE PROJECT

Estimated Project Site Watershed Areas

EBA Engineering Consultants Ltd.

PROJECT NO.	DWN	CKD	REV
V15101007.006.014	JAB	RH	1
OFFICE	DATE		
VANC	April 28, 2011		

Figure 2.5-1

Q:\Vancouver\Drafting\Engineering\V151\V15101007\006\014\V15101007.006.014_FIG 2.5-1_R1.dwg [FIGURE 2.5-1] April 28, 2011 - 4:43:24 pm (BY: BOKIC, JON)

2.5.2 Surface Flow Observations

The observed or presumed direction of surface flow within the Nechalacho Mine site area is shown in Figure 2.5-2. The shorelines of several of the lakes in the area were found to consist of continuous peatland (Melville et al. 1989), with no apparent connecting channels to other lakes. For example, it was suggested by Melville et al. (1989) that: water from Elbow Lake seeps into Great Slave Lake over a distance of 1.1 km; water from Fred Lake eventually reaches Great Slave Lake after flowing through peatland, several lakes, and small streams; and, water from Cressy Lake seeps into Fred Lake through peatland. These observations were confirmed during field reconnaissance carried out in May and June of 2009 (Stantec 2010a).

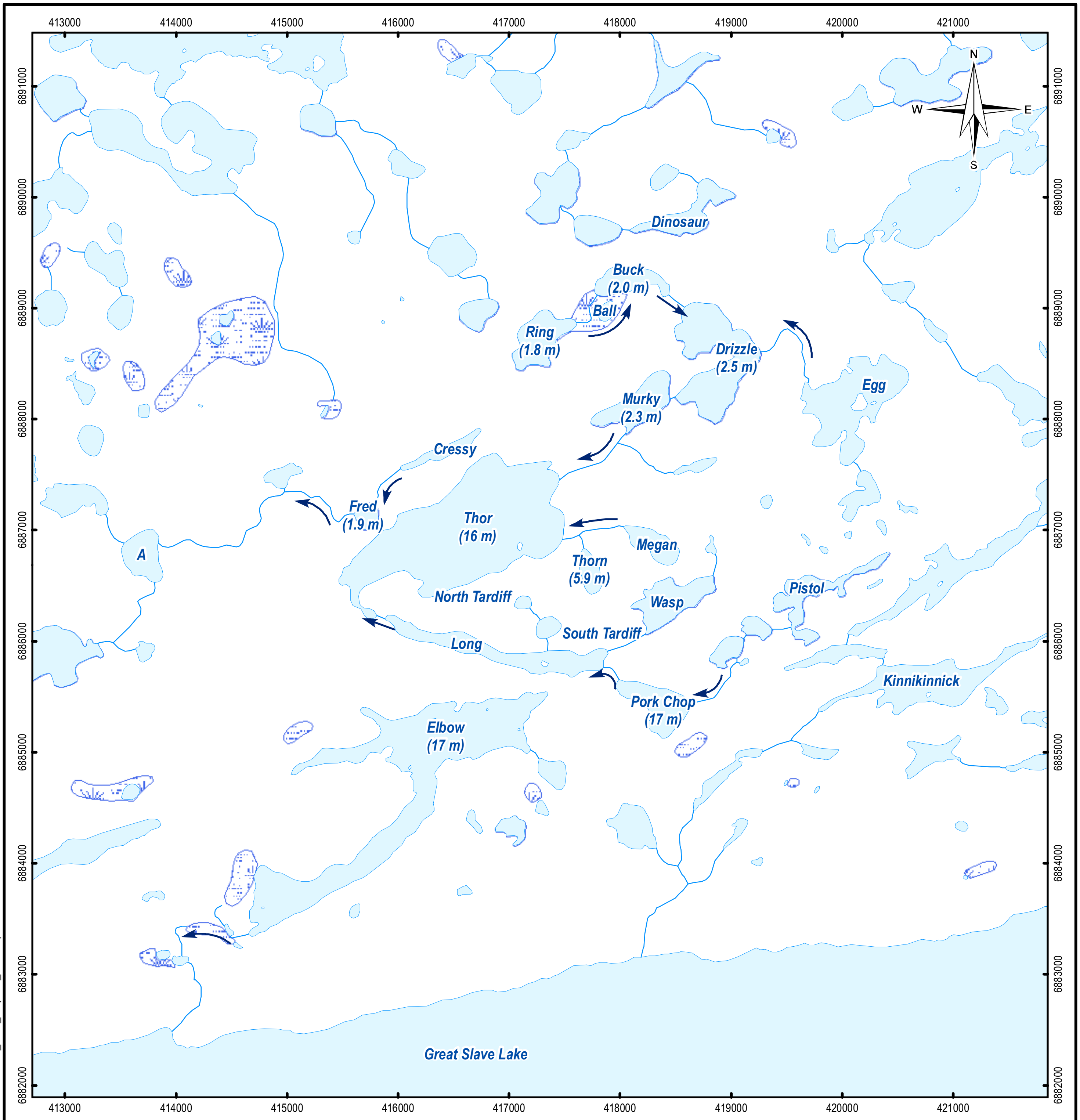
Water velocity measurements carried out by Stantec (2010a) revealed that flow periodically reverses between Thor and Long lakes in the small channel connecting them, perhaps due to changes in wind intensity and direction, or transient changes at the Thor Lake outflow to Fred Lake. Although water flows predominantly from Long to Thor Lake, this periodic flow reversal allows water exchange between the two basins, effectively allowing them to operate as a single lake.

Water flows from Thor Lake to Fred Lake through a defined channel that has a 1.5 m waterfall near its outlet. As discussed in Section 2.8.1, this waterfall precludes upstream fish passage from Fred to Thor Lake.

The upper Thor Lake watershed consists of Ring, Buck, Drizzle, Egg, and Murky lakes. Ring Lake is the highest lake in the basin and is connected to Buck Lake via a marsh, which may have seasonal drainage channels into Buck Lake. Egg Lake is situated upstream of Drizzle Lake, but lies outside the influence of mining development and has no surface connectivity to Drizzle Lake. During site investigations, water levels in this marsh area were 0.1 to 0.3 m deep with no observable flow direction. Buck Lake is bounded at its downstream end by bedrock outcrops and does not have a discernible channel at its outlet. A thin soil veneer overlies the bedrock at this location. The elevation difference between Buck and Drizzle lakes is approximately five metres. Only shallow overland flow (<0.05 m) was observed between these lakes in October , 2009, likely due to seasonally high water levels causing Buck Lake to overflow toward Drizzle Lake. No previous hydrologic data have been collected for this upper watershed, however, efforts are currently underway to gather data and provide input for future monitoring.

Drizzle Lake flows into Murky Lake through a small marsh. The Murky Lake outlet leading to Thor Lake consists of a defined channel lined with a thin veneer of alluvium or confined by bedrock. Flows in this channel are very low during dry summer periods.

The presence or absence of defined channels connecting lakes likely governs the biological characteristics of those lakes. Small, shallow lakes are unlikely to support fish populations if channels are unavailable through which fish can descend to deeper downstream waters for overwintering.



LEGEND

(2.0) Maximum Water Depth

Flow Direction

Watercourse

Waterbody

Wetland

NOTES

Base data source: NTS 1:50,000 (Sheets 85I01 & 85I02).

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THOR LAKE PROJECT

Nechalacho Mine Site
Lake Area Depths and Flow Directions

PROJECTION	DATUM
UTM Zone 12	NAD83

Scale: 1:50,000

1 0.5 0 1

Kilometers

FILE NO.
V15101007_DAR_Map004_LakeDepth.mxd

PROJECT NO.	DWN	CKD	REV
V15101007.006	SL	RH	0

OFFICE	DATE
EBA-VANC	March 7, 2011

Figure 2.5-2

Q:\Vancouver\GIS\ENGINEERING\V151\V15101007_ThorLake\Maps\006_DAR\V15101007_DAR_Map004_LakeDepth.mxd

The Thor Lake watershed consists of an area of 2,100 ha. The Ring Group (Ring, Buck, Drizzle, and Murky lakes) constitutes 800 ha or 38% of that watershed, and about 19% of the annual Thor Lake discharge (2.06 million m^3/yr). Water discharge from Ring and Buck lakes alone, which are proposed as the tailings management facility area, make up about 7% of the annual Thor Lake discharge.

2.5.3 Lake Level Data

Water level measurements were made during the open water season from August, 2008 to October, 2010 (Stantec 2010a). Water level monitoring stations, consisting of a staff gauge and HOBO pressure transducer, were established in Thor, Long, Elbow, and Cressy lakes (Figure 2.5-3). The pressure transducers were removed prior to freeze-up and re-established the following spring.

Results of lake level measurements are shown in Figures 2.5-4 to 2.5-6, for 2008 to 2010, respectively, and are described in Stantec (2010a). Water levels rise rapidly during snowmelt and then decrease once the melt water drains off through outlet channels. It is not uncommon during the freshet period for water levels to fall for a short period of time due to re-freezing of the snowpack.

During summer, water levels rise briefly following significant rainfall events. An examination of lake level changes (Figures 2.5-4 to 2.5-6) and corresponding rainfall amounts indicates that in general, lake levels rise less than five centimetres following major storm events and return to previous levels within a few days. The seasonal changes in lake levels apparent in the data reflect the hydrological characteristics of this region. These characteristics have been studied extensively and are described and explained in Woo (1993):

> *Meltwater fills the many depressions on the land surface and then flows over frozen ground in sheets or rills. Because the shallow, seasonally thawed suprapermafrost layer cannot retain much meltwater or rainwater, the water table rises rapidly so that water is delivered quickly to lower slopes and stream channels. Fairly rapidly, the active layer increases in depth due to increased solar radiation, causing the water table to drop below the surface and a corresponding decline in surface flows.*
>
> *Surface runoff follows pronounced diurnal cycles, reflecting daily variation of snowmelt contribution. The abundance of water at the surface, combined with large amounts of energy available, enables high evaporation in the spring. As summer advances, surface flow declines, because thawing of the active layer provides a thicker zone where suprapermafrost groundwater can be stored, and the water table drops below the surface. Also, most of the snow has been depleted and summer rainfall is the only major source of water-supply. Finally, evaporation and lateral flow continue to withdraw water from the active layer, leaving far less water to sustain surface flow than in the spring. Evaporation also decreases in the Arctic during summer as the surface dries out, while in the subarctic, transpiration of vascular plants speeds evaporation.*
>
> *The outlets of many small lakes are blocked by thick snowdrifts accumulated in winter. As lake storage increases, water levels rise until the snow dam is breached. This usually yields the peak annual outflow, accompanied by rapid depletion of lake storage accumulated during melt. Afterward, ice decay enlarges open water areas on the lake where evaporation is effective. Then the slopes gradually become free of snow, exposed ground thaws, and surface runoff diminishes as meltwater supply declines and evaporation increases.*

Q:\Vancouver\GIS\ENGINEERING\V151\V15101007_ThorLake\Maps\006_DAR\V15101007_DAR_Map041_HydroMonitoring.mxd

LEGEND

- Lake/Stream Level Locations
- Meteorological Station

NOTES
Figure Source: Figure 3-1. Stantec 2010a.

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Nechalacho Mine Site
Hydrology Monitoring Locations

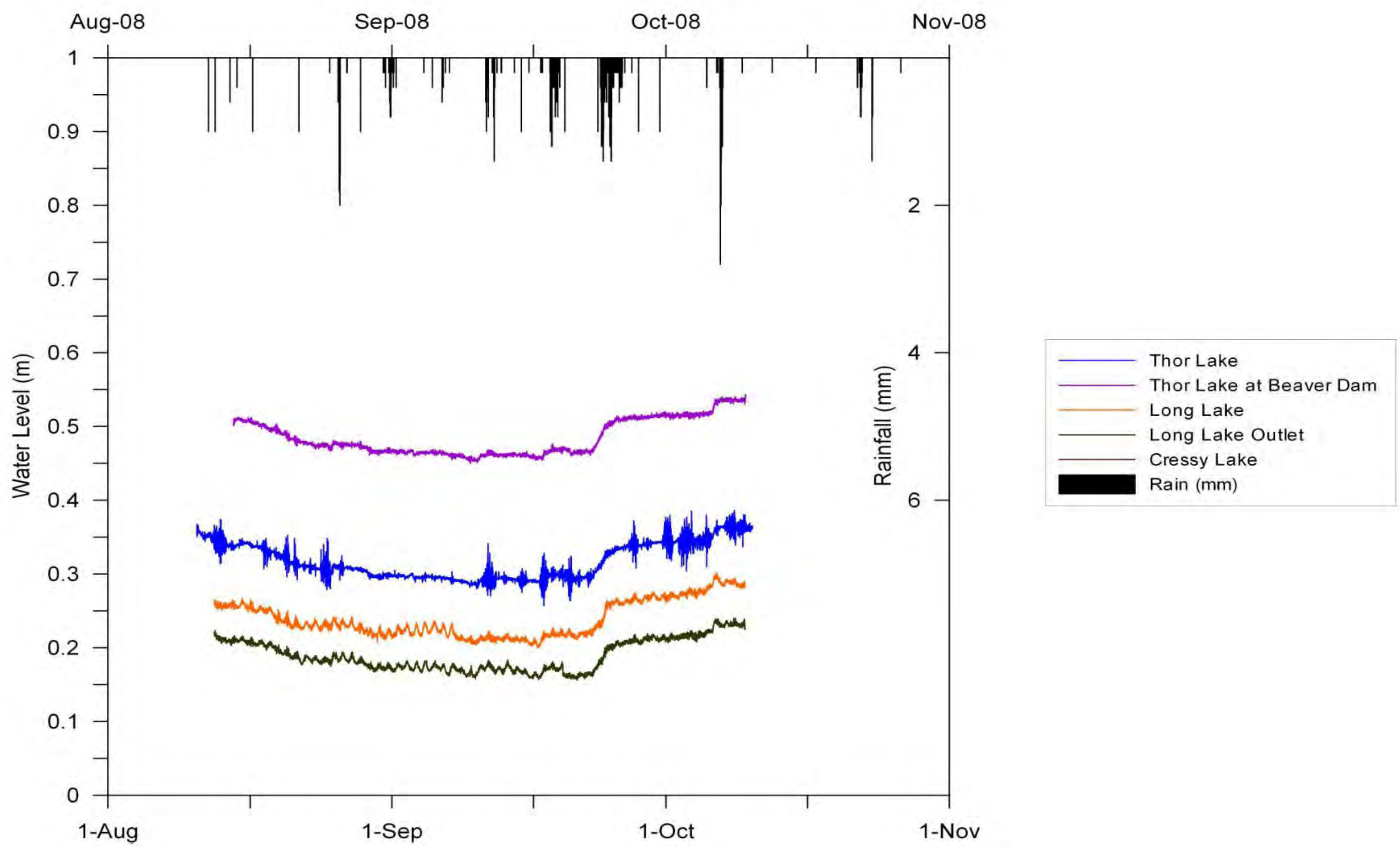
PROJECTION	DATUM
UTM Zone 12	NAD83

Scale: 1:24,000
500 250 0 500
Metres

AVALON RARE METALS INC.
EBA Engineering Consultants Ltd. eba

FILE NO.			
V15101007_DAR_Map041_HydroMonitoring.mxd			
PROJECT NO.	DWN	CKD	REV
V15101007.006	SL	RH	0
OFFICE	DATE		
EBA-VANC	May 9, 2011		

Figure 2.5-3



NOTES

1. Lake level elevations are on a relative datum and do not reflect absolute water level differences between the lakes.
2. Figure Source: Figure 4.12. Stantec 2010a.

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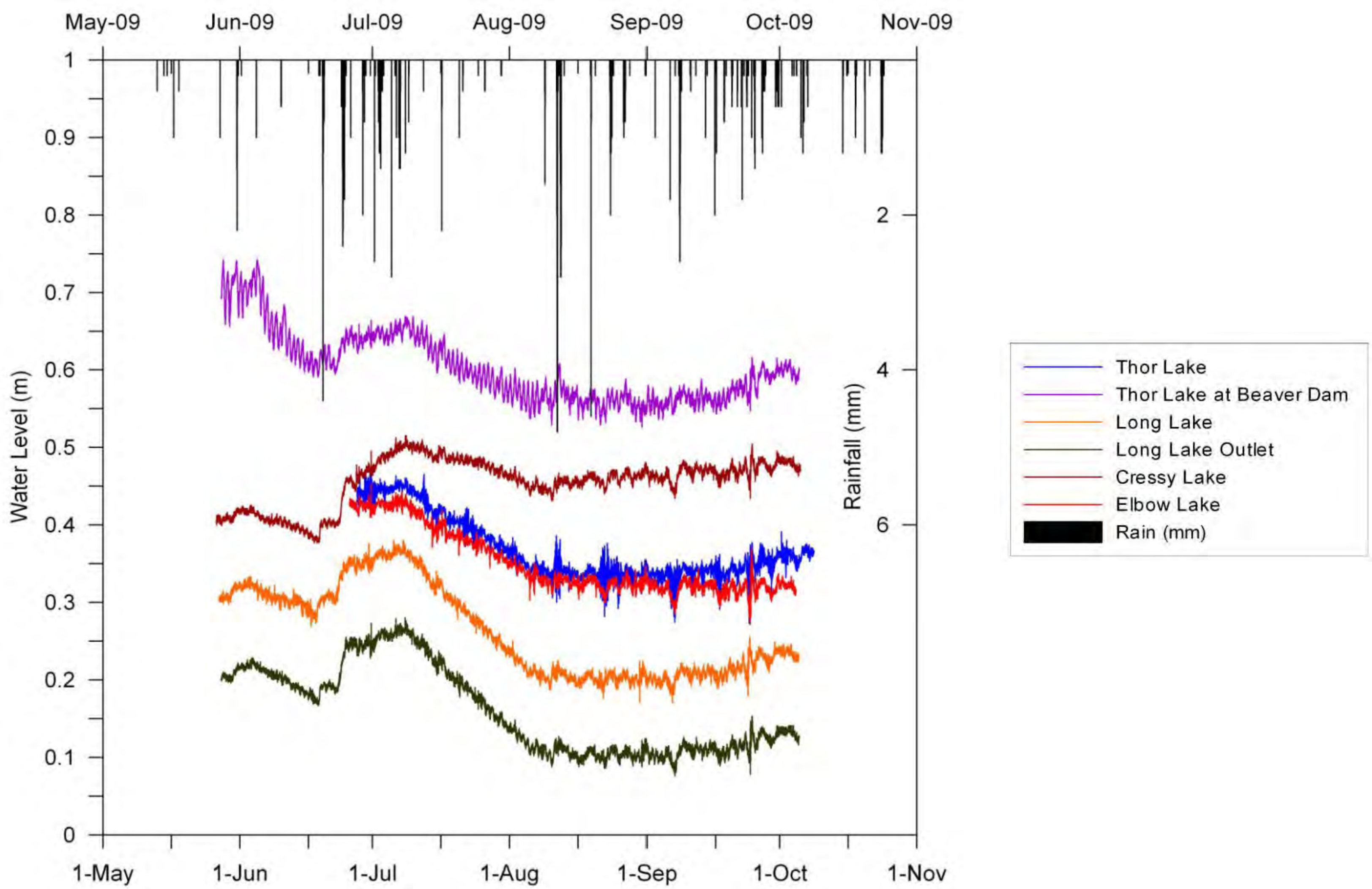
THOR LAKE PROJECT

Lake Water Levels and Rainfall 2008

PROJECT NO.	DWN	CKD	REV
V15101007.006	SL	RH	0
OFFICE	DATE		
EBA-VANC	May 9, 2011		

Figure 2.5-4



NOTES
1. Lake level elevations are on a relative datum and do not reflect absolute water level differences between the lakes.
2. Figure Source: Figure 4.13. Stantec 2010a.

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THOR LAKE PROJECT

Lake Water Levels and Rainfall 2009

PROJECT NO.	DWN	CKD	REV
V15101007.006	SL	RH	0
OFFICE	DATE		
EBA-VANC	May 9, 2011		

Figure 2.5-5

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