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LOWER CHURCHILL PROJECT


CLIMATOLOGICAL DATA REPORT

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REVISION LIST

Revision					Remarks
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EXECUTIVE SUMMARY

This report presents the climatological data with respect to the Muskrat Falls Hydroelectric Project. The meteorological station located closest to the project site is Environment Canada Station 8501900 about 25 km away from Muskrat Falls in Happy Valley - Goose Bay.

In this report you will find Canadian Climate Normals at Station 8501900 – Goose Bay A as published by Environment Canada, the probability distribution of mean daily temperature, the probability of exceedance for cumulative degree days of freezing, IDF curves and statistical wind speeds and directions presented on wind roses.



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1 INTRODUCTION

SNC-Lavalin Inc. has signed an agreement with Nalcor Energy (the Client) to deliver engineering services for the Lower Churchill Project (LCP) in Newfoundland and Labrador, Canada.



As part of the LCP, the Muskrat Falls Hydroelectric Development is located on the Churchill River, about 291 km downstream of the Churchill Falls Hydroelectric Development which was developed in the early 1970's. The installed capacity of the project will be 824 MW (4 units of 206 MW each).

This report presents the climatological data with respect to the Muskrat Falls Hydroelectric Project. The meteorological station located closest to the project site is Environment Canada Station 8501900 about 25 km away from Muskrat Falls in Happy Valley - Goose Bay.

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2 GENERAL OVERVIEW

The Labrador plateau experiences a continental type of climate with a wide range of temperatures. Climate data in the Upper Churchill River basin is measured at Station 8501130 – Churchill Falls A. This meteorological station is located at 53°33'28"N and 64°05'30"W at an elevation of 439.50 m above sea level. Hourly data is available from February 1, 1994 to December 15, 2011. Meteorological information such as temperature, precipitation, visibility, wind speed and direction and pressure are recorded at this station. The average annual temperature is -4°C and the recorded extremes at the Churchill Falls meteorological station are -45.6°C and 33.4°C.



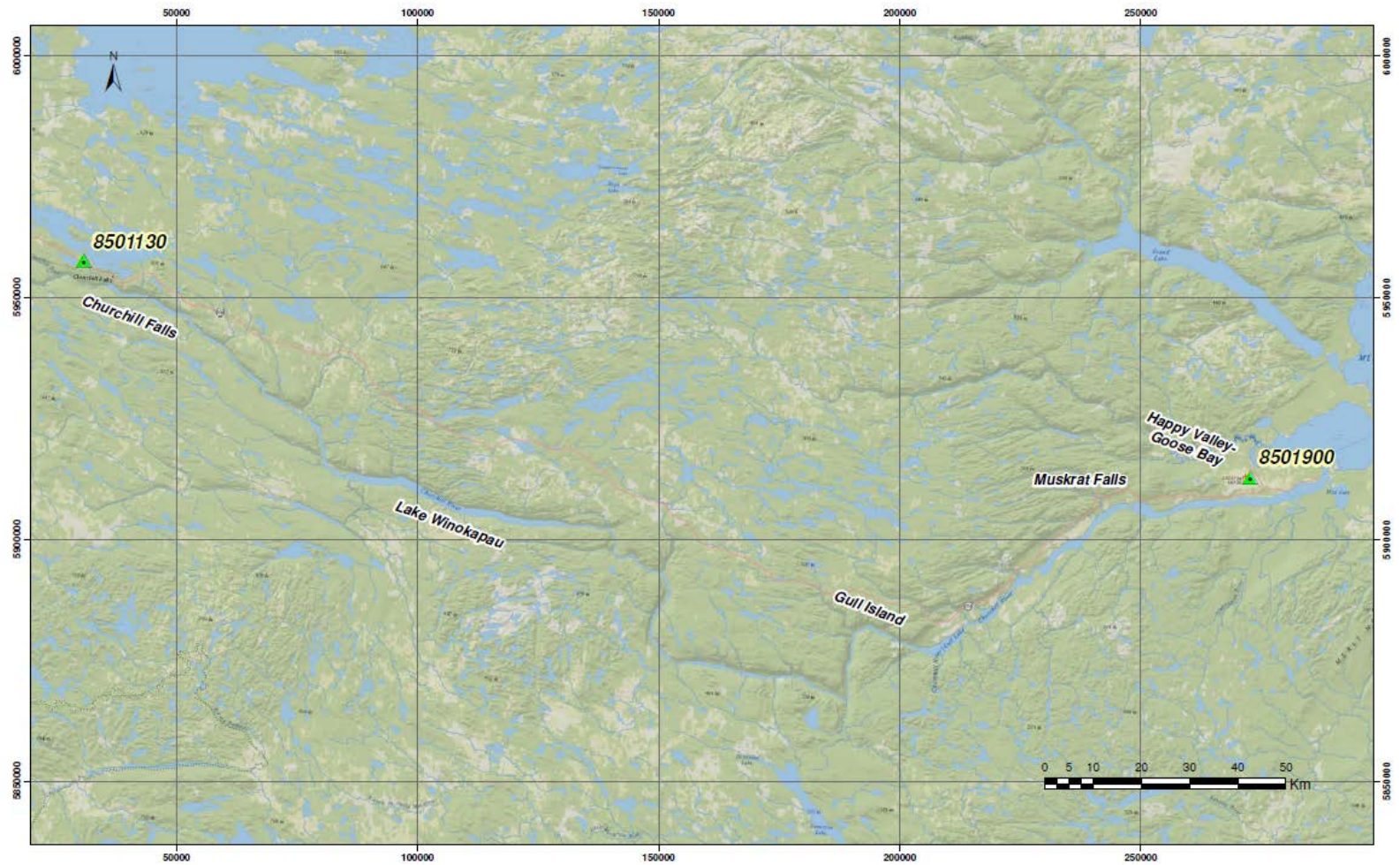
The Lower Churchill River basin climate is moderated by the Atlantic Ocean and experiences more of a maritime climate. Climate data in the Lower Churchill River basin is measured at Station 8501900 – Goose A. This meteorological station is located at 53°19'00"N and 60°25'00"W at an elevation of 48.80 m above sea level. Hourly data is available since January 1, 1953. Meteorological information such as temperature, precipitation, visibility, wind speed, wind direction and pressure are recorded at this station. The average annual temperature is 0°C and the recorded extremes at Happy Valley - Goose Bay are respectively -39°C and 38°C. The average annual precipitation is about 950 mm, of which 55% occurs as rainfall and 45% as snowfall. The frost free period occurs from June to September.



Figure 2-1 shows the locations of the meteorological stations at Churchill Falls and Happy Valley – Goose Bay.



The Climate Normals prepared by Environment Canada for Happy Valley - Goose Bay are presented in Table 2-1. It includes monthly information about meteorological conditions such as air temperature, precipitation, wind, degree-days, soil temperature, humidity, sunshine, pressure and visibility.



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Figure 2-1: Meteorological Station Locations at Churchill Falls and Happy Valley - Goose Bay

Table 2-1: Goose Bay A – Station 8501900 Climate Normals From Environment Canada – 1971 – 2000

	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
TEMPERATURE														
Daily Average	(°C)	-18.1	-16.3	-9.6	-1.7	5.1	11.0	15.4	14.5	9.2	2.4	-4.5	-13.9	-0.5
Standard Deviation		2.9	3.5	3.0	2.1	1.9	1.5	1.3	1.2	1.2	1.3	2.0	3.3	1.2
Daily Maximum	(°C)	-12.9	-10.6	-3.7	3.3	10.5	16.8	20.9	19.9	13.9	6.2	-0.8	-9.4	4.5
Daily Minimum	(°C)	-23.3	-21.9	-15.4	-6.6	-0.3	5.2	9.7	9.0	4.5	-1.5	-8.1	-18.3	-5.6
Extreme maximum	(°C)	11.2	10.6	16.4	21.2	32.1	36.2	37.8	35.3	30.0	22.8	16.7	11.7	
Date	(yyyy/dd)	1979/03	1951/08	1979/25	1986/25	1979/20	1989/25	1944/04	1996/08	1959/10+	1947/13+	1977/11	1950/05	
Extreme Minimum	(°C)	-38.9	-39.4	-35.6	-29.7	-15.0	-4.2	0.1	0.0	-6.7	-17.0	-26.1	-36.7	
Date	(yyyy/dd)	1957/15	1973/17	1948/06	1984/09	1972/01	1984/04	1993/05	1947/25+	1947/28	1982/30	1986/20	1971/27	
PRECIPITATION														
Rainfall	(mm)	1.9	3.3	5.3	19.3	47.0	92.1	113.8	98.8	92.3	59.6	20.3	5.7	559.5
Snowfall	(cm)	80.2	62.6	75.8	52.3	19.9	3.2	0.0	0.0	2.6	22.1	62.0	78.3	458.8
Precipitation	(mm)	64.6	55.1	69.6	65.4	66.2	95.8	113.8	98.8	95.2	80.1	75.6	69.0	949.0
Average Snow Depth	(cm)	67	75	81	50	9	0	0	0	0	1	13	39	28
Median Snow Depth	(cm)	67	75	82	49	6	0	0	0	0	0	11	37	27
Snow Depth at Month-end	(cm)	74	78	67	28	0	0	0	0	0	2	24	55	27
Extreme Daily Rainfall	(mm)	7.2	26.2	24.4	30.2	29	69.6	66.8	79.2	68	44.7	36.8	26.2	
Date	(yyyy/dd)	1997/08	1968/05	1953/31	1976/04	1964/25	1963/30	1981/15	1953/16	1999/23	1968/26	1950/28	1981/07	
Extreme Daily Snowfall	(cm)	71.0	39.6	40.8	36.3	33.8	24.1	0.4	0.0	19.0	27.7	40.6	35.6	
Date	(yyyy/dd)	1985/16	1953/10	1982/08	1981/10	1957/16	1980/28	1991/01	1942/01+	1977/19	1958/11	1944/12	1968/16+	
Extreme Daily Precipitation	(mm)	40.8	39.6	52.3	42.9	33.8	80.1	66.8	79.2	68.0	45.7	41.2	32.5	
Date	(yyyy/dd)	1985/16	1953/10	1975/21	1958/25	1957/16	1980/28	1981/15	1953/16	1999/23	1966/20	2001/07	1968/16	
Extreme Snow Depth	(cm)	183	202	206	192	122	9	0	0	9	58	80	130	
Date	(yyyy/dd)	1956/17	1980/18	1978/30	1978/01	1972/01+	1980/28	1955/01+	1955/01+	1977/20	1962/30	1983/28+	1979/31+	

Table 2-1: Goose Bay A – Station 8501900 Climate Normals From Environment Canada – 1971 – 2000 (cont'd)

Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
DAYS WITH MAXIMUM TEMPERATURE													
< 0°C	28.9	25.7	21.4	8.3	0.37	0.0	0.0	0.0	0.0	2.0	16.3	27.2	130.2
> 0°C	2.1	2.5	9.6	21.7	30.6	30.0	31.0	31.0	30.0	29.0	13.7	3.8	235.0
> 10°C	0.13	0.03	0.33	3.1	14.8	25.3	30.3	30.3	23.8	5.5	0.83	0.0	134.4
> 20°C	0.0	0.0	0.0	0.03	2.2	9.0	17.8	14.9	3.1	0.07	0.0	0.0	47.1
> 30°C	0.0	0.0	0.0	0.0	0.17	0.8	1.3	1.1	0.0	0.0	0.0	0.0	3.3
> 35°C	0.0	0.0	0.0	0.0	0.0	0.13	0.03	0.03	0.0	0.0	0.0	0.0	0.19
DAYS WITH MINIMUM TEMPERATURE													
> 0°C	0.23	0.17	0.8	3.9	14.3	27.9	31.0	31.0	26.6	11.2	2.4	0.43	150.0
< 2°C	31.0	28.2	30.9	28.8	24.3	7.2	0.3	0.47	7.7	25.6	29.1	31.0	244.6
< 0°C	30.8	28.1	30.2	26.1	16.7	2.1	0	0.03	3.4	19.8	27.6	30.6	215.3
< -2°C	30.6	27.8	29.0	21.8	9.0	0.2	0	0	0.7	12.3	24.4	29.7	185.5
< -10°C	29.1	25.5	22.0	8.6	0.2	0	0	0	0	0.8	11.5	25.9	123.5
< -20°C	22.7	19.0	10.7	0.6	0	0	0	0	0	0	0.93	13.9	67.9
< -30°C	4.8	4.8	3.3	0.73	0	0	0	0	0	0	0	1.2	10.1
DAYS WITH RAINFALL													
> 0.2 mm	1.3	1.2	2.5	5.3	12.2	16.4	18.8	17.7	17.7	12.7	5.2	2.0	113.1
> 5 mm	0.07	0.2	0.37	1.4	3.3	6.1	7.4	6.0	5.5	3.9	1.2	0.37	35.8
> 10 mm	0	0.07	0.07	0.4	1.3	2.8	3.8	3.3	2.8	1.9	0.60	0.07	17.1
> 25 mm	0	0	0	0.1	0	0.3	0.57	0.53	0.53	0.17	0.07	0.03	2.3
DAYS WITH SNOWFALL													
> 0.2 cm	16.2	13.0	13.9	11.0	5.2	1.2	0.03	0	0.93	6.4	12.1	15.7	95.6
> 5 cm	5.3	3.9	4.9	3.5	1.4	0.17	0	0	0.17	1.3	4.1	5.1	29.9
> 10 cm	2.6	20.0	2.6	1.7	0.53	0.1	0	0.10	0.60	2.0	2.5	14.7	0.10
> 25 cm	0.37	0.23	0.27	0.13	0.03	0	0	0	0	0	0.20	0.33	1.6

Table 2-1: Goose Bay A – Station 8501900 Climate Normals From Environment Canada – 1971 – 2000 (cont'd)

Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
DAYS WITH PRECIPITATION													
> 0.2 mm	16.3	12.9	14.7	13.9	15.0	16.5	18.8	17.7	17.9	16.2	14.9	15.9	190.6
> 5 mm	4.2	3.5	4.4	4.5	4.5	6.3	7.4	6.0	5.7	5.3	4.9	4.6	61.3
> 10 mm	1.9	1.8	2.2	2.0	1.9	3.0	3.8	3.3	2.9	2.6	2.3	1.9	29.8
> 25 mm	0.27	0.17	0.27	0.2	0.17	0.3	0.57	0.53	0.57	0.27	0.40	0.20	3.9
DAYS WITH SNOW DEPTH													
> 1 cm	31.0	28.3	31.0	28.2	12.1	0.27	0	0	0.30	5.3	20.7	30.6	187.8
> 5 cm	30.7	27.9	31.0	27.3	9.2	0.07	0	0	0.13	2.7	16.5	29.4	174.9
> 10 cm	29.8	27.9	31.0	25.9	7.4	0	0	0	0	0.93	13.1	27.2	163.2
> 25 cm	27.8	27.1	30.0	23.6	4.5	0	0	0	0	0.14	8.5	22.0	143.6
DEGREE DAYS													
Above 24°C	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.6	0.0	0.0	0.0	0.0	1.8
Above 18°C	0.0	0.0	0.0	0.0	0.6	7.3	20.0	13.9	1.2	0.0	0.0	0.0	43.0
Above 15°C	0.0	0.0	0.0	0.0	2.1	19.9	57.4	41.8	4.4	0.0	0.0	0.0	125.5
Above 10°C	0.0	0.0	0.0	0.4	11.1	73.6	171.6	143.9	34.0	0.9	0.3	0.0	436.0
Above 5°C	0.1	0.0	0.5	6.5	51.1	185.2	321.1	293.4	132.3	16.2	2.7	0.0	1009.0
Above 0°C	0.7	1.0	7.0	39.8	163.8	330.9	476	448.4	276.1	93.4	17.4	2.1	1856.7
Below 0°C	562.5	461.5	304.4	89.6	5.3	0.0	0.0	0.0	0.1	18.8	150.9	432.5	2025.4
Below 5°C	716.9	601.8	452.9	206.2	47.5	4.4	0.1	0.0	6.3	96.5	286.2	585.4	3004.1
Below 10°C	871.8	743.1	607.4	350.1	162.5	42.7	5.6	5.5	58.0	236.2	433.9	740.4	4257.4
Below 15°C	1026.8	884.5	762.4	499.7	308.5	139.0	46.4	58.4	178.3	390.3	583.6	895.4	5773.2
Below 18°C	1119.8	969.3	855.4	589.7	400.1	216.4	101.9	123.6	265.1	483.3	673.6	988.4	6786.5



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Table 2-1: Goose Bay A – Station 8501900 Climate Normals From Environment Canada – 1971 – 2000 (cont'd)

Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
BRIGHT SUNSHINE													
Total Hours	98.7	126.3	135.9	150	183.2	182.1	197.7	184.9	116.1	87.1	73.9	76.9	1612.8
Days with measurable	21.1	20.9	22.1	21.9	25.0	24.5	26.9	26.9	24.1	21.6	18.7	18.7	272.3
% of Possible Daylight Hours	39.2	45.6	37.0	35.8	37.3	35.9	38.8	40.4	30.4	26.4	28.3	32.6	35.7
Extreme Daily	8.5	10.5	11.3	14.3	15.6	16.4	16.1	15.0	13.2	10.4	9.2	8.2	
Date (yyyy/dd)	1999/30	1985/25	1994/29	1991/30	1982/31	1994/19	1999/01	1994/06	1996/02	1979/12	1983/14	1977/01	
HUMIDEX													
Extreme Humidex	10.8	9.4	15.4	20.7	31.8	38.5	41.2	40.4	35.2	24.6	17.8	10.5	
Date (yyyy/dd)	1996/20	1955/12	1979/24	1986/25	1979/20	1967/28	1983/05	1996/08	1982/13	1970/11	1977/12	1966/01	
Days with Humidex >= 30	0	0	0	0	0.1	1.2	2.8	2.3	0.3	0	0	0	6.8
Days with Humidex >= 35	0	0	0	0	0	0.3	0.4	0.3	0	0	0	0	1
Days with Humidex >= 40	0	0	0	0	0	0	0.1	0	0	0	0	0	0.1
WIND CHILL													
Extreme Wind Chill	-54.5	-50.9	-49	-36.5	-26.2	-8.9	-2.5	-4.3	-8.8	-24.4	-36.0	-50.8	
Date (yyyy/dd)	1975/20	1994/08	1972/02	1984/09	1972/01	1984/04	1974/06	1976/26	1972/27	1986/25	1986/20	1984/26	
Days with Wind Chill < -20	27.3	24.1	17.2	3.7	0.1	0	0	0	0	0.2	6.3	22.6	101.4
Days with Wind Chill < -30	20.5	16.4	8.3	0.4	0	0	0	0	0	0	0.6	12.6	58.8
Days with Wind Chill < -40	7.5	4.5	0.9	0	0	0	0	0	0	0	0	3	15.9
HUMIDITY													
Average Vapor Pressure	kPa	0.1	0.2	0.3	0.4	0.6	0.9	1.2	1.2	0.9	0.6	0.4	0.6
Average Relative Humidity - 0600LST	(%)	68.2	68.2	71.9	76.8	76.8	78.3	80.9	82.2	83.5	80.6	79.8	76.7
Average Relative Humidity - 1500LST	(%)	63.4	60.1	60.8	61.0	55.1	55.8	57.0	57.1	60.8	64.4	71.0	61.3
PRESSURE													
Average Station Pressure	kPa	100.3	100.5	100.6	100.8	100.8	100.5	100.4	100.5	100.5	100.6	100.5	100.5
Average Sea Level Pressure	kPa	100.9	101.1	101.2	101.4	101.4	101.1	100.9	101.1	101.1	101.2	101.1	101.1

Table 2-1: Goose Bay A – Station 8501900 Climate Normals from Environment Canada – 1971 – 2000 (cont'd)

	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CLOUD AMOUNT (HOURS WITH)													
0 to 2 tenths		240.6	223.9	184.7	135.6	125.2	85.7	83.3	103.5	100.5	120.1	131.4	218.8
3 to 7 tenths		122.4	106.1	112.6	110.1	131.9	153.9	191.3	186.8	156.6	131.9	116.9	109.9
8 to 10 tenths		380.9	348.0	446.7	474.4	486.9	480.4	469.4	453.7	462.9	492.0	471.7	415.3
VISIBILITY (HOURS WITH)													
< 1 km		16.4	11.1	13.5	12.3	5.1	2.5	1.2	1.7	1.6	4.5	11.0	17.6
1 to 9 km		118.6	99.6	115.2	99.6	58.8	49.7	42.3	37.0	38.5	66.2	101.7	114.4
> 9 km		609.0	567.3	615.3	608.0	680.2	667.9	700.5	705.3	679.9	673.3	607.3	612.0
WIND													
Speed	(km/h)	16.9	15.9	16.3	15.3	14.3	14.6	13.5	13.6	14.7	15.5	16.6	17.0
Most Frequent Direction		SW	W	W	NE	NE	NE	NE	W	SW	SW	W	SW
Maximum Hourly Speed	(km/h)	84	77	77	65	77	58	64	69	72	74	81	81
Date	(yyyy/dd)	1962/16	1974/01	1954/29	1995/06	1953/11	1953/10	1969/07	1994/15	1954/12	1984/31	1993/29	1977/11
Maximum Gust Speed		143	129	106	98	103	122	101	101	122	111	133	111
Date	(yyyy/dd)	1985/28	1955/12	1972/26	1957/04	1959/28	1988/12	1963/14	1969/20	1959/08	1984/31	1984/03	1977/11
Direction of Maximum Gust		N	S	NE	W	W	W	W	SE	W	W	W	NW
Days with Winds 52 km/h		2.1	1.0	1.3	0.5	0.3	0.5	0.4	0.6	0.8	1.1	1.6	2.2
Days with Winds 63 km/h		0.6	0.3	0.3	0.1	0.1	0.1	0.1	0.2	0.3	0.3	0.5	0.7
SOIL TEMPERATURE													
at 5 cm depth (AM obs) (°C)	°C	-4.5	-5.4	-3.0	-0.3	2.9	9.7	14.4	14.1	9.8	3.7	-0.2	-3.3
at 5 cm depth (PM obs) (°C)	°C	-4.5	-5.3	-3.0	-0.1	5.5	13.3	17.8	17.1	12.0	4.7	0.0	-3.2
at 10 cm depth (AM obs) (°C)	°C	-4.3	-5.2	-3.1	-0.3	2.9	9.7	14.5	14.5	10.3	4.3	0.1	-3.0
at 10 cm depth (PM obs) (°C)	°C	-4.3	-5.2	-3.1	-0.3	4.4	11.7	16.5	16.2	11.5	4.7	0.2	-3.0
at 20 cm depth (AM obs) (°C)	°C	-3.3	-4.4	-2.7	-0.4	2.5	9.4	14.6	15.1	11.2	5.2	1.0	-1.9
at 20 cm depth (PM obs) (°C)	°C	-3.3	-4.5	-2.7	-0.3	2.8	9.8	14.8	15.2	11.2	5.2	1.0	-1.9
at 50 cm depth (AM obs) (°C)	°C	-1.7	-2.9	-2.3	-0.8	0.6	6.5	12.5	13.9	11.1	6.1	2.	-0.3
at 100 cm depth (AM obs) (°C)	°C	0.5	-0.8	-0.8	-0.2	0.3	4.2	10.5	13.0	11.6	7.6	3.8	1.5
at 150 cm depth (AM obs) (°C)	°C	1.6	0.5	0.4	0.5	0.5	3.2	8.3	11.3	11.1	8.4	5.0	2.7
at 300 cm depth (AM obs) (°C)	°C	4.2	3.4	2.9	2.2	1.7	1.8	3.9	6.7	8.3	8.3	7.0	5.3

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3 AIR TEMPERATURE

Air temperatures are recorded daily at Station 8501900 and the maximum, minimum and mean temperatures are reported. Figure 3-1 illustrates the probability of exceedance of mean daily air temperature for the period 1978 to 2009.

The daily average, daily maximum, daily minimum, extreme maximum and extreme minimum temperatures by month (based on observations from 1971 – 2000) can be found in Table 2-1.

The degree days for various threshold air temperatures between 0 and 24°C is presented in Table 2-1. A degree-day of freezing (°C) is defined as one day where the average temperature is 1 degree below the freezing point (0°C). 2 degrees below the freezing point would count as 2 degree-days of freezing. The cumulative annual degree-days of freezing for the period 1942-2011 as recorded at the meteorological station at Happy Valley - Goose Bay is presented in Figure 3-2. At the end of the winter, the cumulative degree-days of freezing vary between 1000 and 2500°C with an average of 2000°C. 2009, 1957 and 2010 were the three warmest winters and 1971, 1992 and 1972 were the three coldest winters to date based on their cumulative degree days of freezing at the end of April.



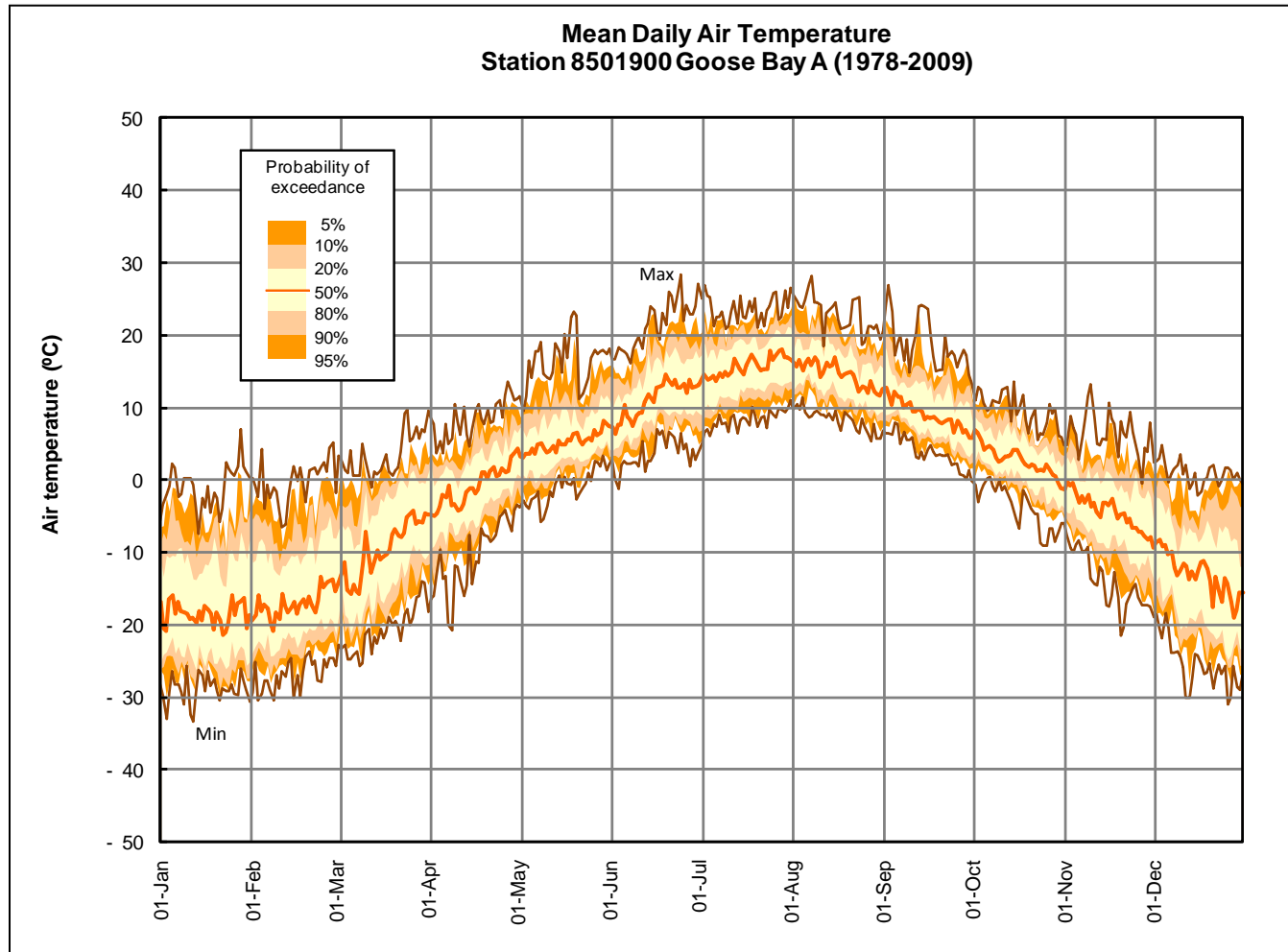
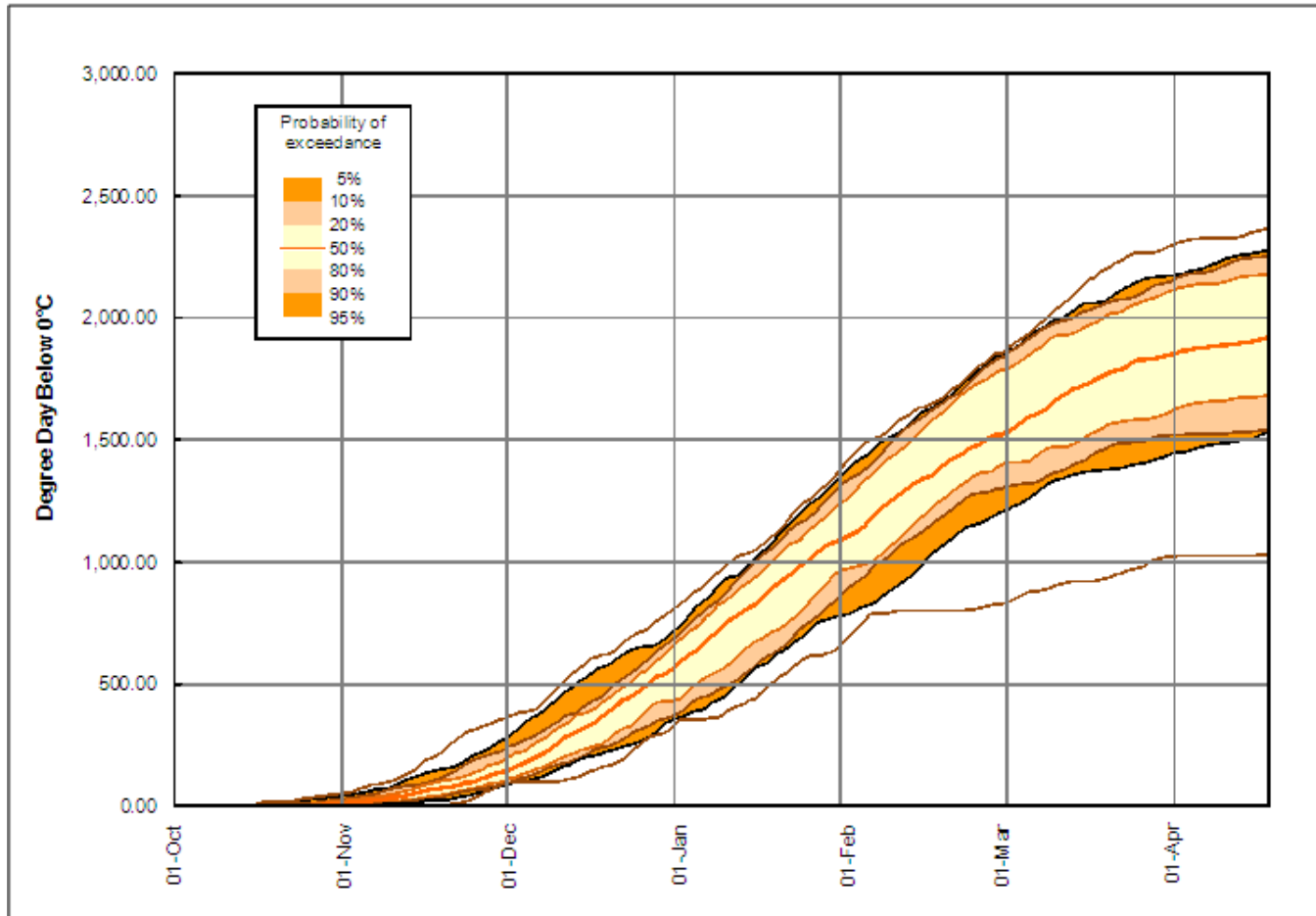



Figure 3-1: Goose Bay A – Station 8501900 Daily Temperature 1978 – 2009



2

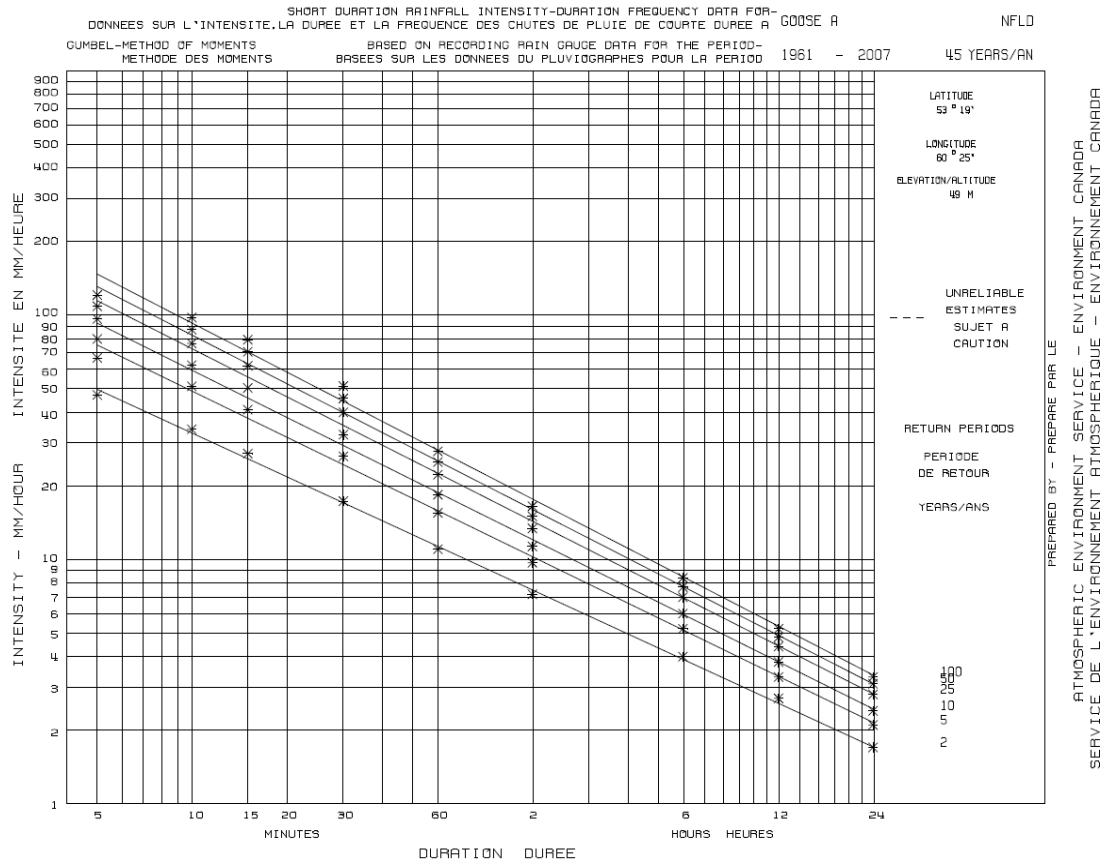
**Figure 3-2: Goose Bay A – Station 8501900
Probability of Exceedance Cumulative Degree Days Below 0°C – 1978-2009**

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4 PRECIPITATION


Environment Canada also publishes the intensity-duration frequency (IDF) curve for different meteorological stations in Canada. Figure 4-1 presents the IDF curves at Goose Bay.

Table 2-1 presents average total rainfall, average total snowfall, precipitation, average snow depth, median snow depth at month-end, extreme daily rainfall, extreme daily snowfall, extreme daily precipitation and extreme snow depth by month for 1971 to 2000.



Duration	2 yr (mm/h)	5 yr (mm/h)	10 yr (mm/h)	25 yr (mm/h)	50 yr (mm/h)	100 yr (mm/h)
5 min	47.1 ± 6.0	66.8 ± 10.1	79.9 ± 13.6	96.4 ± 18.3	108.6 ± 21.9	120.7 ± 25.6
10 min	34.1 ± 5.2	51.1 ± 8.7	62.4 ± 11.8	76.6 ± 15.9	87.2 ± 19.0	97.7 ± 22.1
15 min	27.1 ± 4.2	41.0 ± 7.1	50.3 ± 9.7	62.0 ± 13.0	70.7 ± 15.6	79.3 ± 18.2
30 min	17.3 ± 2.8	26.4 ± 4.6	32.4 ± 6.3	40.0 ± 8.4	45.6 ± 10.1	51.2 ± 11.8
1 h	11.0 ± 1.4	15.5 ± 2.3	18.4 ± 3.1	22.2 ± 4.2	25.0 ± 5.0	27.7 ± 5.8
2 h	7.2 ± 0.8	9.7 ± 1.3	11.3 ± 1.7	13.4 ± 2.3	15.0 ± 2.8	16.5 ± 3.2
6 h	4.0 ± 0.4	5.2 ± 0.6	6.0 ± 0.8	7.0 ± 1.1	7.7 ± 1.3	8.4 ± 1.5
12 h	2.70 ± 0.2	3.3 ± 0.4	3.8 ± 0.5	4.4 ± 0.6	4.8 ± 0.8	5.2 ± 0.9
24 h	1.7 ± 0.1	2.1 ± 0.2	2.4 ± 0.3	2.8 ± 0.4	3.1 ± 0.5	3.3 ± 0.6

Figure 4-1: Goose Bay A – Station 8501900
Return Period Rainfall Rates (mm/h)
From Environment Canada (Based on Data from 1961 to 2007)

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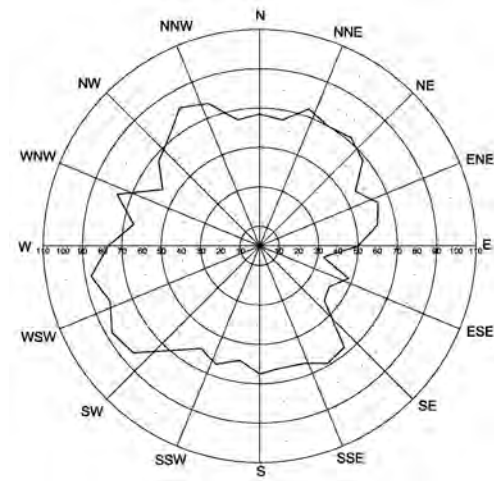
5 WIND

The wind data has been obtained from the historical climate database located on Environment Canada's website. Wind speed is measured in km/h and is observed at 10 m above the ground. Data is reported hourly.

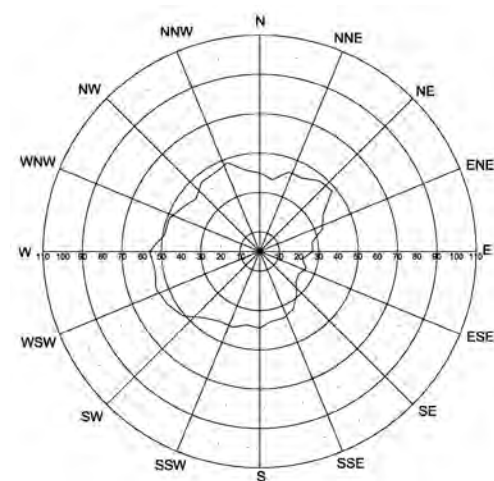
Data is available from 1953 to present and the wind direction and speed from 1953 to 2010 was extracted for the analysis. The data was organized to determine the maximum wind speed per direction taking into account data for the entire year as well as the open water season (June to November) for each year of recorded data.

A statistical analysis using a Gumbel distribution was performed on the two sets of data. The statistical analysis was performed using software known as HYFRAN-PLUS (*B. Bobée et al., 2008*). HYFRAN-PLUS (HYdrological FREquency ANalysis PLUS DSS) is a software used to fit statistical distributions. It includes a number of powerful, flexible, user-friendly mathematical tools that can be used for the statistical analysis of extreme events. Also, it can perform basic analysis of any time series of Independent and Indentically Distributed (IID) data. A Gumbel distribution statistical law was applied for each direction and the results recorded.

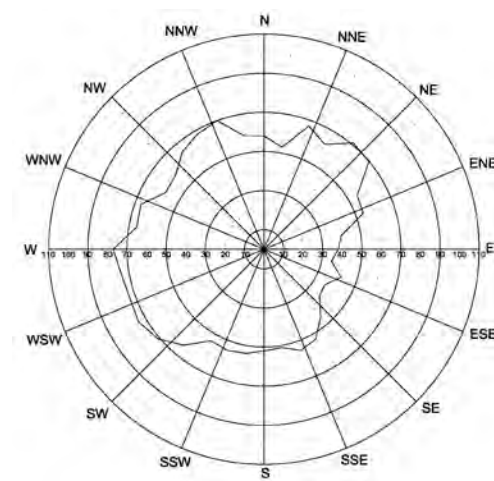
A wind rose was sketched for the over land wind speed in km/h. The results are presented on Figure 5-1.



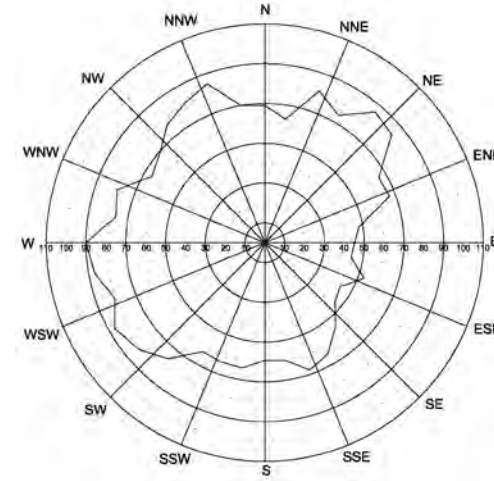
All Months – Maximum Per Direction



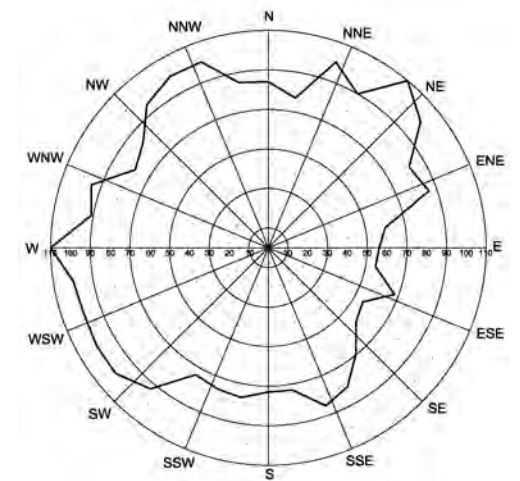
1:2 Year Gumbel Analysis Results, All Months



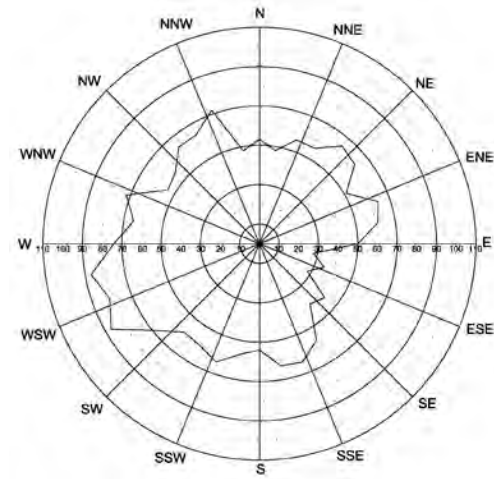
1:20 Year Gumbel Analysis Results, All Months



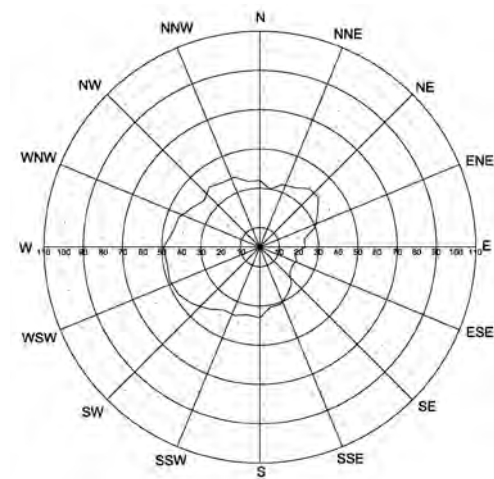
1:100 Year Gumbel Analysis Results, All Months



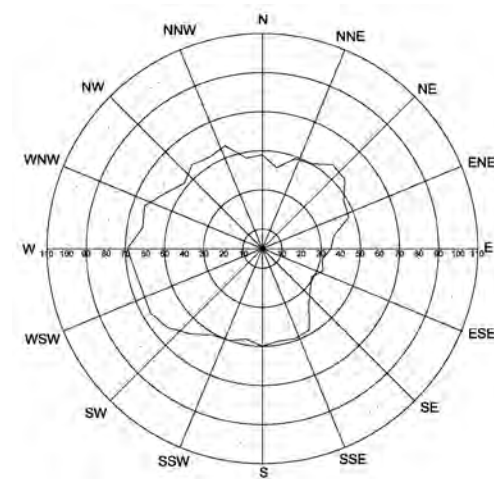
1:1,000 Year Gumbel Analysis Results, All Years



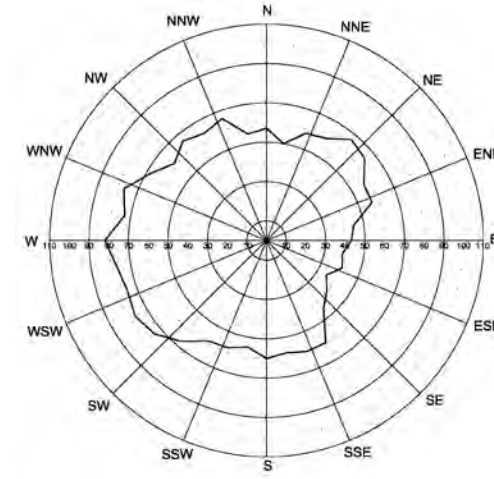
Open Water Season – Maximum Per Direction



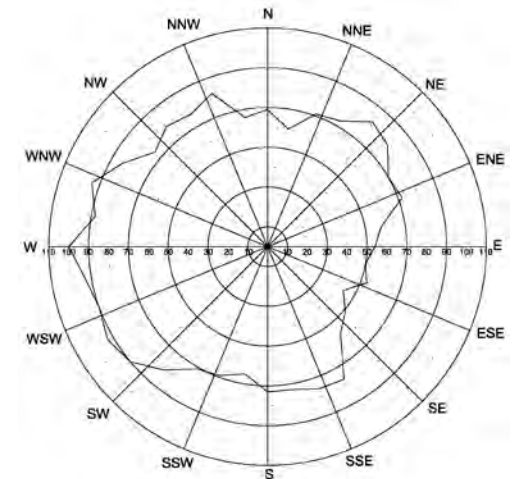
1:2 Year Gumbel Analysis Results, Open Water Season



1:20 Year Gumbel Analysis Results, Open Water Season



1:100 Year Gumbel Analysis Results, Open Water Season



1:1,000 Year Gumbel Analysis Results, Open Water Season

Figure 5-1: Wind Rose for Happy Valley-Goose Bay Maximum Winds (km/h)