4. CLIMATE

4.1 Database

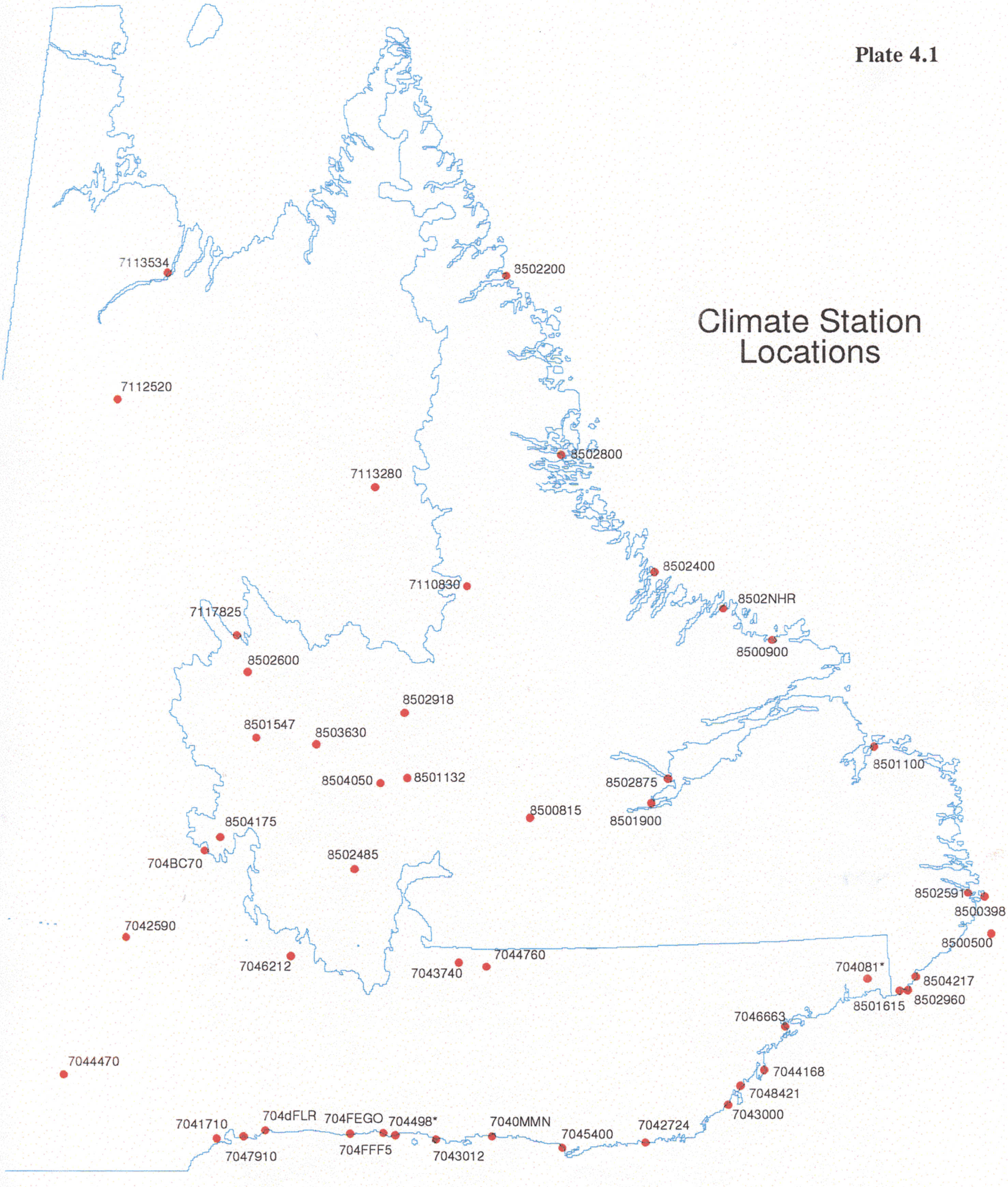
The climatological data for this study was provided by Environment Canada. All active and discontinued climate stations in Labrador are listed in Appendix A along with their latitude, longitude, elevation, start date, finish date and observing program. In addition, a number of stations in Quebec were selected for study because of their proximity to the provincial border between Labrador and Quebec. The selection criteria for climate stations in Quebec were that the stations have at least two years of record, a latitude greater than 50E N and a longitude less than 69E W. Quebec stations are listed in Appendix B. Labrador and Quebec stations, which were suitable for the calculation of mean annual values of either temperature, total precipitation, rainfall or snowfall, are listed in Table 4.1. The locations of these stations are shown in Plate 4.1. Generally, these stations had seven or more years of data. The mean annual values were either the 1951-80 normal, the 1961-90 normal, or derived from the available monthly and annual data.

Table 4.1 Select Climate Stations in Labrador and Quebec

Station Number	Station Name	Lat. (ddmm)	Long. (ddmm)	Start Year	Finish Year	MAT[1.] (ºC)	MAR[1.] (mm)	MAS[1.] (cm)	MAP[1.] (mm)
8500398	Battle Harbour Lor	5215	5536	1957	1983	0.4	535.2	396.0	931.8
8500500	Belle Isle	5153	5523	1871	1970	-0.2	651.5	255.5	898.8
8500815	Cache River	5312	6214	1971	1977				808.8
8500900	Cape Harrison	5446	5827	1943	1961	-0.9	518.7	370.9	860.9
8501100	Cartwright	5343	5701	1934		-0.3	530.5	474.4	996.5
8501132	Churchill Falls A	5333	6406	1968	1993	-3.5	497.9	481.0	944.7
8501547	Esker	5352	6625	1971					734.5
8501615	Forteau	5128	5658	1871	1888		709.4	327.3	1038.2
8501900	Goose A	5319	6025	1941		-0.3	557.3	463.8	959.5
8502200[2.]	Hebron (+Saglek)	5813	6235	1947	1957	-4.5	251.8	374.2	691.6
8502400	Hopedale (Aut)	5527	6014	1942		-2.2	378.1	445.8	822.0
8502485	Kepimits Lake	5242	6451	1971					760.1
8502NHR	Makkovik A	5505	5911	1985		-2.4	487.6	395.9	872.8
8502591	Marys Harbour A	5218	5550	1983		-0.3	542.9	363.9	927.9
8502600	Menihek Rapids	5428	6637	1952	1961	-3.7	406.9	247.0	654.7
8502800	Nain A	5633	6141	1926		-2.9	331.1	424.4	739.8
8502875	North West River	5332	6009	1901	1985	-1.9	399.7	414.7	822.9
8502918	Orma Lake	5409	6410	1972					740.6
8502960	Point Amour	5128	5651	1889	1935		448.1	237.8	664.1
8503630	Sandgirt Lake	5350	6530	1939	1948	-4.0	467.5	350.4	830.3
8504050	Twin Falls	5330	6430	1960	1967	-3.8	370.9	319.5	682.1
8504175	Wabush Lake A	5256	6652	1960		-3.6	476.0	455	880.6
8504217	West St Modeste	5135	5643	1984		-0.1	793.6	376.7	1198.9
704MMN	Baie Johan Beetz	5017	6248	1965		1.7	740.0	256	987.1
704081*[2.]	Blanc Sablon	5225	5713	1965		0.5	695.8	429.8	1129.6
7110830	Border A	5520	6313	1965	1979	-5.3	346.0	366.6	698.9
7041710	Clarke City	5011	6638	1902	1981	0.9	749.7	363.5	1105.5
704BC70	Fermont	5248	6705	1976		-3.8	510.6	271.5	752.4
7112520	Fort Mckenzie	5653	6903	1938	1951	-5.0	330.3	187.6	517.8
7042590	Gagnon A	5157	6808	1965	1985	-2.5	609.9	460.0	1019.5
7042724	Gethsemanie	5013	6040	1965	1989	1.4	805.4	190.5	985.5
7043000	Harrington Hr	5032	5930	1911	1978	1.3	782.5	421.4	1235.5
7043012	Harve St Pierre	5015	6335	1964	1985	1.5	729.2	271.1	1008.0
7113280	Indian House Lake	5614	6444	1944	1964	-5.4	362.4	244.2	594.5
7113534	Kuujjuaq A	5806	6825	1947		-5.8	256.4	251.3	500.5
7044168	La Tabatiere	5050	5858	1971	1985	1.4	874.9	337.4	1223.4
7043740	Lake Eon	5152	6317	1955	1977	-2.9	487.9	470.3	941.2
7044470	Manicouagan A	5039	6850	1961	1971	-2.3	535.2	413.1	900.3
704DFLR	Matamek	5017	6558	1975		1.6	744.7	283.2	1039.1
7044760	Mecatina River	5150	6253	1943	1952	-2.1	446.9	345.3	812.0
704498*[2.]	Mingan	5017	6409	1943	1981	1.0	707.6	299.8	1007.3
7045400	Natashquan	5011	6149	1914		1.1	781.7	332.7	1121.0
7046212	Poste Montagnais	5153	6544	1973		-3.9	502.2	260.4	762.3
704FEGO	R au Tonnerre	5017	6447	1965		1.1	823.6	262.4	1053.0
7046663	R St Augustin	5113	5838	1967		0.6	843.6	299.6	1141.1
704FFF5	R St Jean	5018	6419	1972	1986	0.9	781.8	226.8	1012.7
7117825	Schefferville A	5448	6649	1948		-5.0	402.2	415.0	793.6
7047910	Sept-Iles A	5013	6616	1944		0.9	728.5	415.1	1127.9
7048421	Tete a la Baleine	5042	5919	1965		1.0	806.1	300.4	1101.9

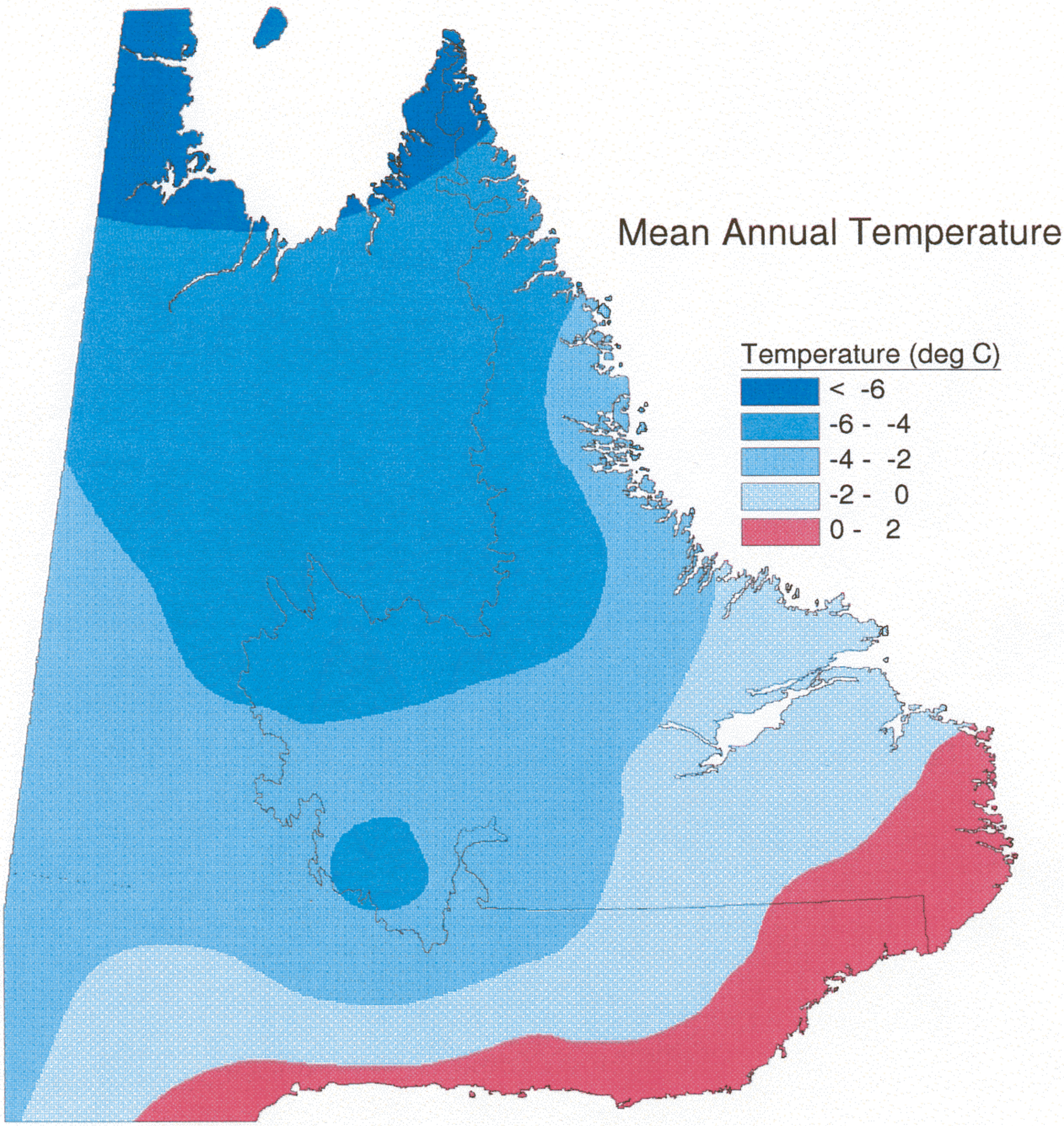
1. MAT - mean annual temperature, MAR - mean annual rainfall, MAS - mean annual snowfall, MAP - mean annual precipitation
2. Indicates that 2 or more stations were combined for the calculation of mean annual values.

Plate 4.1



Climate Station Locations
7113534
8502200
7112520
8502800
7113280
8502400
7110830
8502NHR
7117825
8500900
8502600
8502918
8501547
8503630
8504050
8501132
8501100
8502875
8500815
8501900
8504175
704BC70
8502485
8502591
8500398
8500500
7042590
7046212
7043740
7044760
704081*
8504217
8501615
8502960
7046663
7044470
7044168
7048421
7043000
7041710
704dFLR
704FEGO
704498*
7040MMN
7042724
7045400
7047910
704FFF5
7043012

Plate 4.2



4.2 Air Temperature

In hydrology, air temperature is one of the most important of the recorded climatological parameters. It determines the form of precipitation, and the rates of snowmelt and evapotranspiration. While other climatic parameters affect these components of the hydrologic cycle, temperature is usually the most important. Air temperature is the most widely recorded climatic parameter in Canada.

4.2.1 Mean Annual Air Temperature

The spatial distribution of mean annual air temperature is show in Plate 4.2. Plate 4.2 was generated using SPANS^{TM} GIS (Geographical Information System) and is based on the mean annual values shown in Table 4.1. Not all stations were used to generate the map. Stations with short periods of record were eliminated in favour of nearby stations with longer periods of record. Values from stations in close proximity were averaged in a few instances. Altitude was not taken into consideration when drawing isolines. The isolines are reasonably representative of mean annual air temperature conditions in Labrador. Isolines outside Labrador are not as reliable.

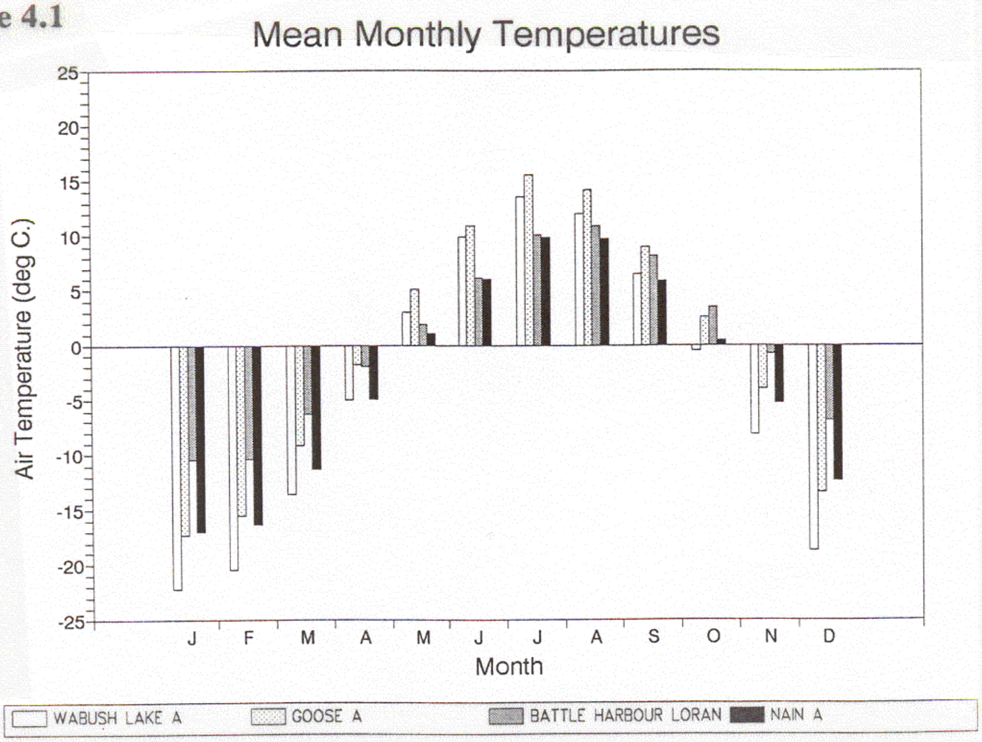
In Labrador, the mean annual temperature varies from about 1EC in the south-east and gradually decreases to the north and west. Mean annual temperatures are near -2EC in central Labrador, and near -4EC in western Labrador. A localized low of about -5EC in the southern part of the western region may be due to the influence of the predominantly north facing slopes in this area. The mean annual temperature in northern Labrador is projected to be less than -6EC. Based on 10 years of data, the mean annual temperature at the Saglek-Hebron station was about -4.5EC. The major influences on air temperatures in Labrador are the proximity to the Labrador Sea, latitude and altitude.

4.2.2 Mean Monthly Air Temperature

Typical distributions of mean monthly temperatures at the Battle Harbour Loran, Goose A, Wabush Lake A and Nain A, index stations are shown in Figure 4.1. These climate stations represent the eastern, central, western and northern regions of Labrador respectively. Monthly temperatures at other climate stations are shown in Appendix C.

Based on the four index stations shown in Figure 4.1, the warmest month was typically July with mean monthly temperatures between 9.8EC and 15.5EC. The warmest month in the eastern region was August. August was the second warmest month in the northern region by only 0.1EC. The coldest month was January with mean monthly temperatures in the -10.3EC to -22.3EC range. February was the second coldest. Mean monthly temperatures move above the freezing point during May and return to below freezing during October or sometimes September. The Wabush Lake A and Goose A

Figure 4.1

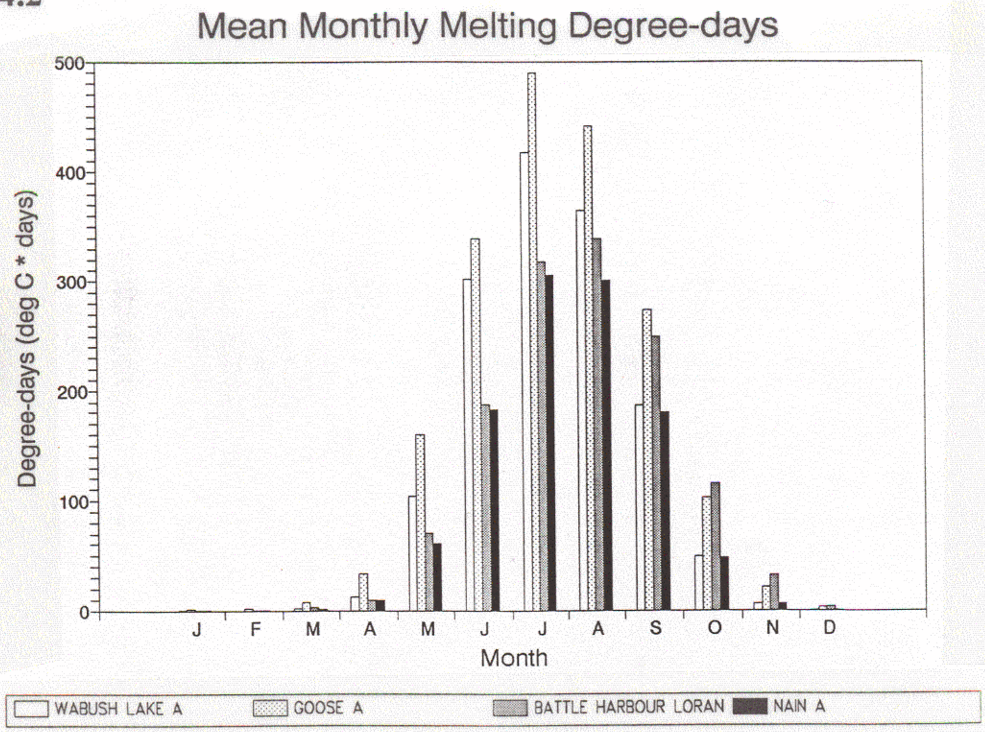


stations exhibit a continental type climate - hot summers and cold winters, while the Battle Harbour Loran and Nain A stations exhibit a more maritime climate - cooler summers and warmer winters.

4.2.3 Melting Degree-days

A melting degree-day can be defined as a day with a mean temperature of 1°C. Melting degree-days are defined as the sum of the positive mean daily temperatures over the period of interest. Melting degree-days are also an index of the amount of heat available for snowmelt. Widespread use has been made of melting degree-days in

Figure 4.2



forecasting spring snowmelt and runoff. The standard practice is to correlate melting degree-days with basin runoff.

Typical distributions of mean monthly melting degree-days are shown in Figure 4.2. These climate stations represent the eastern, central, western and northern regions of Labrador. The distributions of mean monthly melting degree-days at other climate stations are shown in Appendix D.

For the index stations shown in Figure 4.2, the mean monthly melting degree-days were less than 10 degree-days for each of the months of December through to March. Significant snowmelt is very unlikely during this four month period. December through to March is a snow accumulation period. During April, May, and June, the mean monthly melting degree-days for the index stations ranged from 9.6 to 34.1, 61.5 to 160.2, and 182.8 to 339.0 respectively. Significant snowmelt and runoff can start during these months.

4.3 Precipitation

Precipitation is the primary input in the hydrologic cycle. Its basic forms are rainfall and snowfall. Streamflows are determined primarily by the type and amount of precipitation. The distribution of precipitation is altered by the physical, vegetative and climatic characteristics of the area before it returns to the river as streamflow.

4.3.1 Mean Annual Precipitation

The spatial distribution of mean annual precipitation is show in Plate 4.3. Plate 4.3 was generated using SPANS™ GIS (Geographical Information System), and like the mean annual temperature map, is based on the mean annual values shown in Table 4.1.

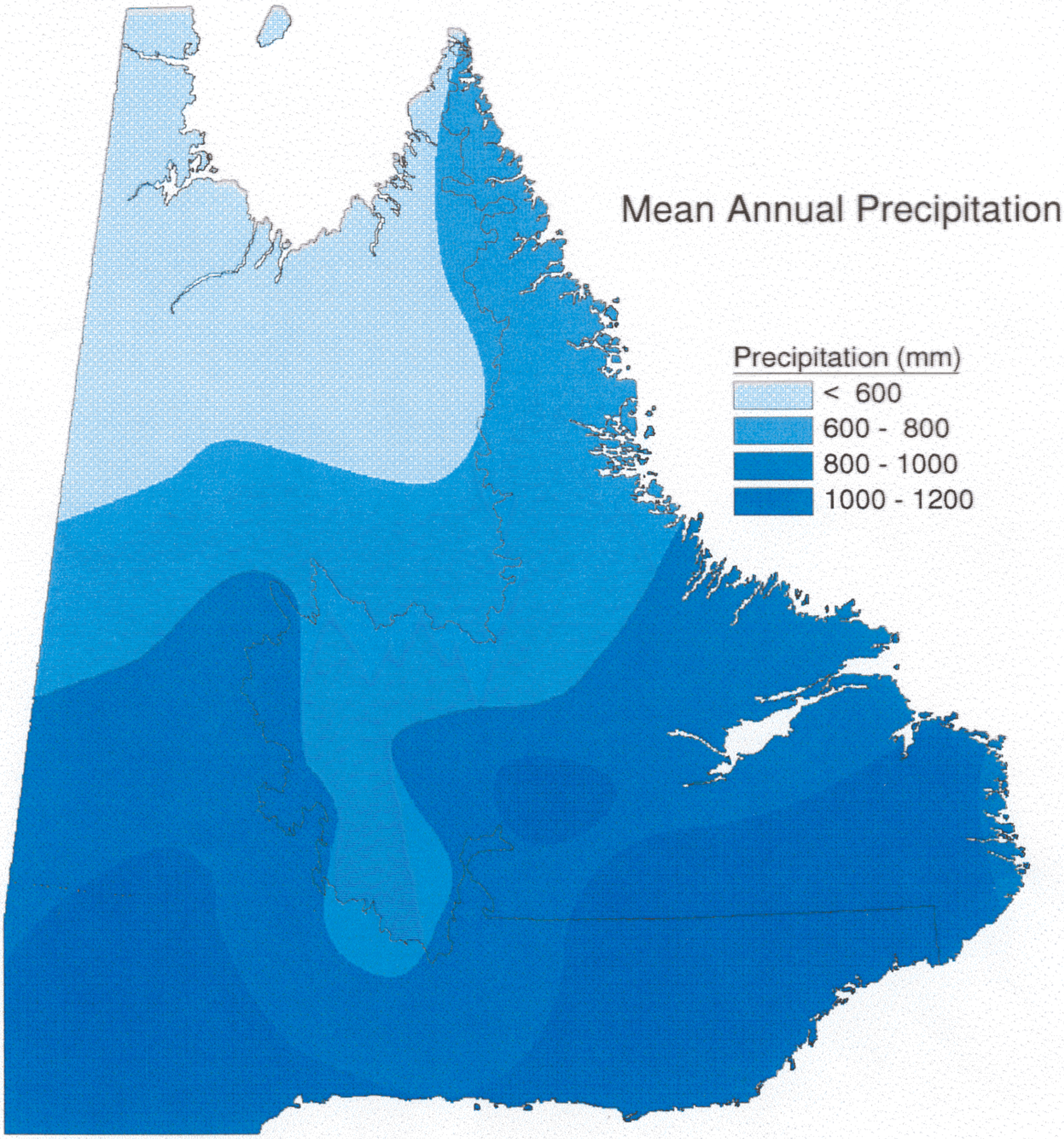
The mean annual precipitation in Labrador varies from a low of about 600 mm in the north to a high of about 1200 mm in the south-east. Due to the lack of climate stations in the north, and in the inland areas of the south-east, the maximum and minimum values of mean annual precipitation across Labrador are estimated to be 1400 mm and 400 mm respectively. Generally, mean annual precipitation in Labrador is highest in the south and east and lowest in the north and west. The localized mean annual precipitation low in western Labrador is probably due to the drier air associated with the predominately westerly winds in this region. Mean annual rainfall plus mean annual snowfall does not necessarily sum to mean annual precipitation due to several factors which include: different types of recording equipment, the non-concurrence of data records, and widely varying snowfall densities.

4.3.2 Mean Monthly Precipitation

Typical distributions of mean monthly precipitation are shown in Figure 4.3. The distributions of mean monthly precipitation at other climate stations in Labrador are shown in Appendix E.

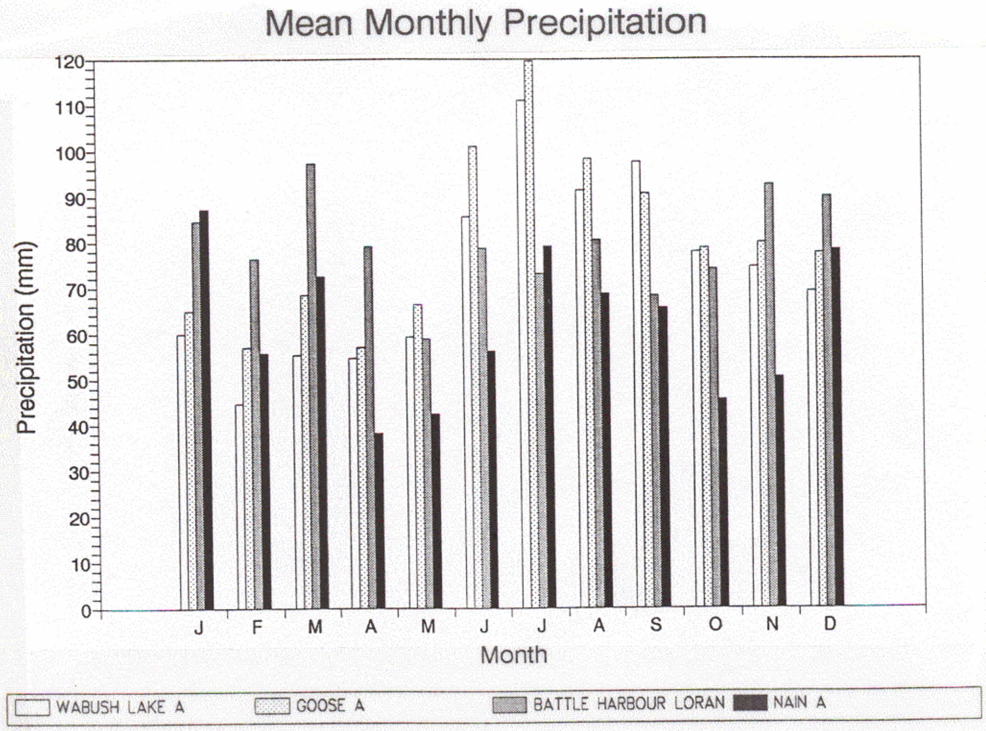
The distribution of precipitation in Labrador is fairly uniform throughout the year. Mean monthly precipitation ranges from 40 mm to 120 mm at the index stations. The central and western index stations receive slightly higher precipitation from June to September and slightly lower precipitation in the January to May period. Conversely, at the Battle Harbour Loran station, the wettest period was from November to May. At the

Plate 4.3



Mean Annual Precipitation
Precipitation (mm)
< 600
600 - 800
800 - 1000
1000 - 1200

Figure 4.3



Nain A station, there appears to be two low precipitation periods during the year - April to May and October to November. The high precipitation months at Nain A are January and July.

4.3.3 Mean Annual Rainfall and Snowfall

The spatial distributions of mean annual rainfall and mean annual snowfall are shown in Plates 4.4 and 4.5. Plates 4.4 and 4.5 were generated using SPANS™ GIS, and similar to the mean annual temperature and mean annual precipitation maps, are based on the mean annual values shown in Table 4.1.

The mean annual rainfall in Labrador varies from a projected low of about 200 mm in the far north to a high of about 800 mm in the south-east. Isolines are roughly parallel to the lines of latitude. South of 55EN mean annual rainfall ranged between 400 mm and 800 mm. The local high in central Labrador is probably due to summertime convective type rainfall.

The mean annual snowfall in Labrador varies from a projected low of about 250 cm in the north to localized highs of about 525 cm in central and also in south-eastern Labrador. Mean annual snowfall is fairly consistent throughout most of Labrador. More than 75% of Labrador has a mean annual snowfall of between 400 cm and 500 cm.

4.3.4 Mean Monthly Rainfall and Snowfall

Temperature determines the form of precipitation. Since mean monthly temperatures vary considerably above and below the freezing point, it is not surprising to find an annual cycle of rainfall and snowfall as shown in Figure 4.4.

For the index stations shown, mean monthly rainfalls were less than 25 mm from December to April. If the Battle Harbour Loran station is ignored, the mean monthly rainfalls drop to less than 8 mm. It is likely that the rainfall from December to April would be absorbed by the snowpack. Mean monthly rainfall ranges between about 50 mm

Plate 4.4

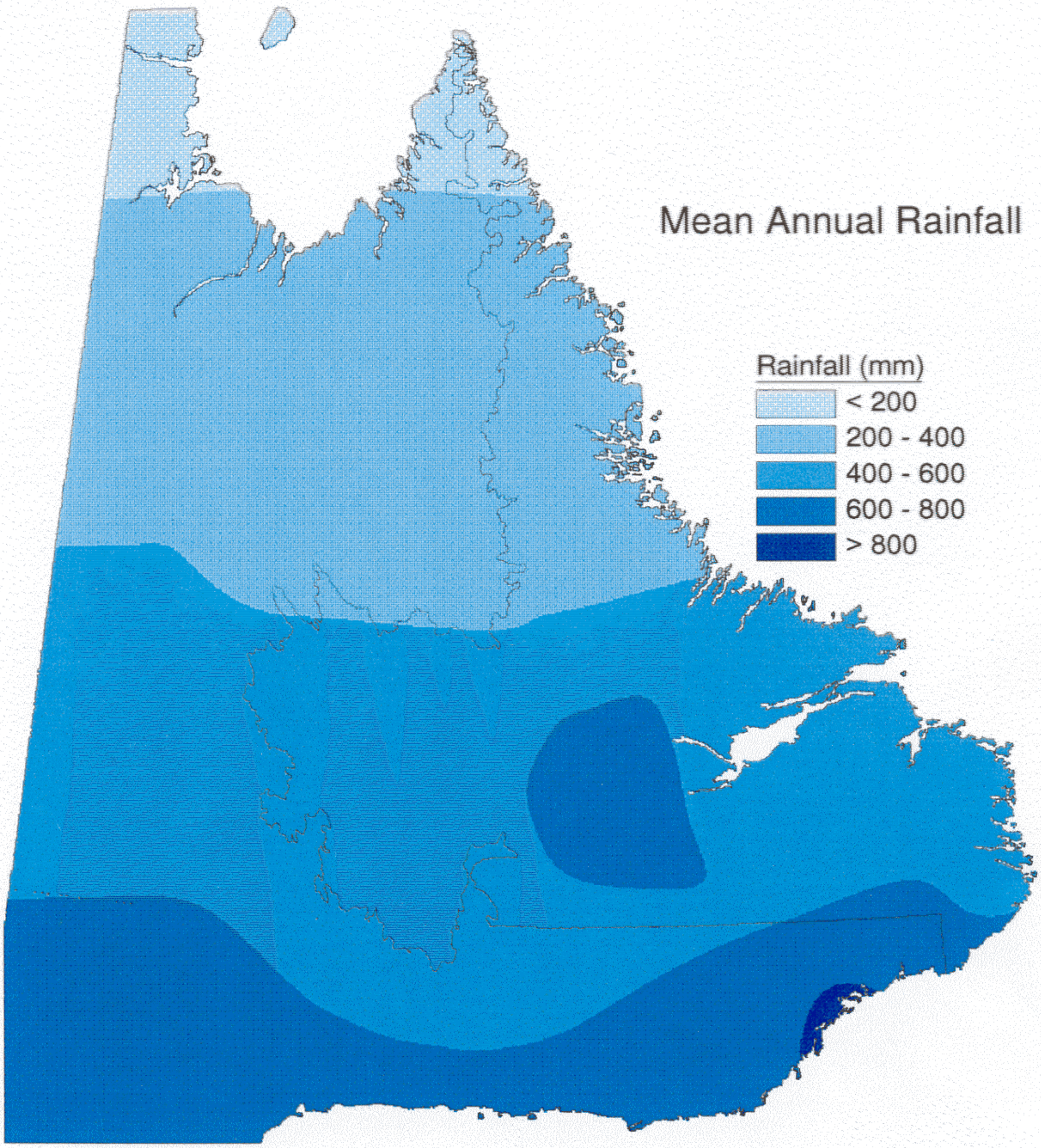

Mean Annual Rainfall
Rainfall (mm)
< 200
200 - 400
400 - 600
600 - 800
> 800

Plate 4.5

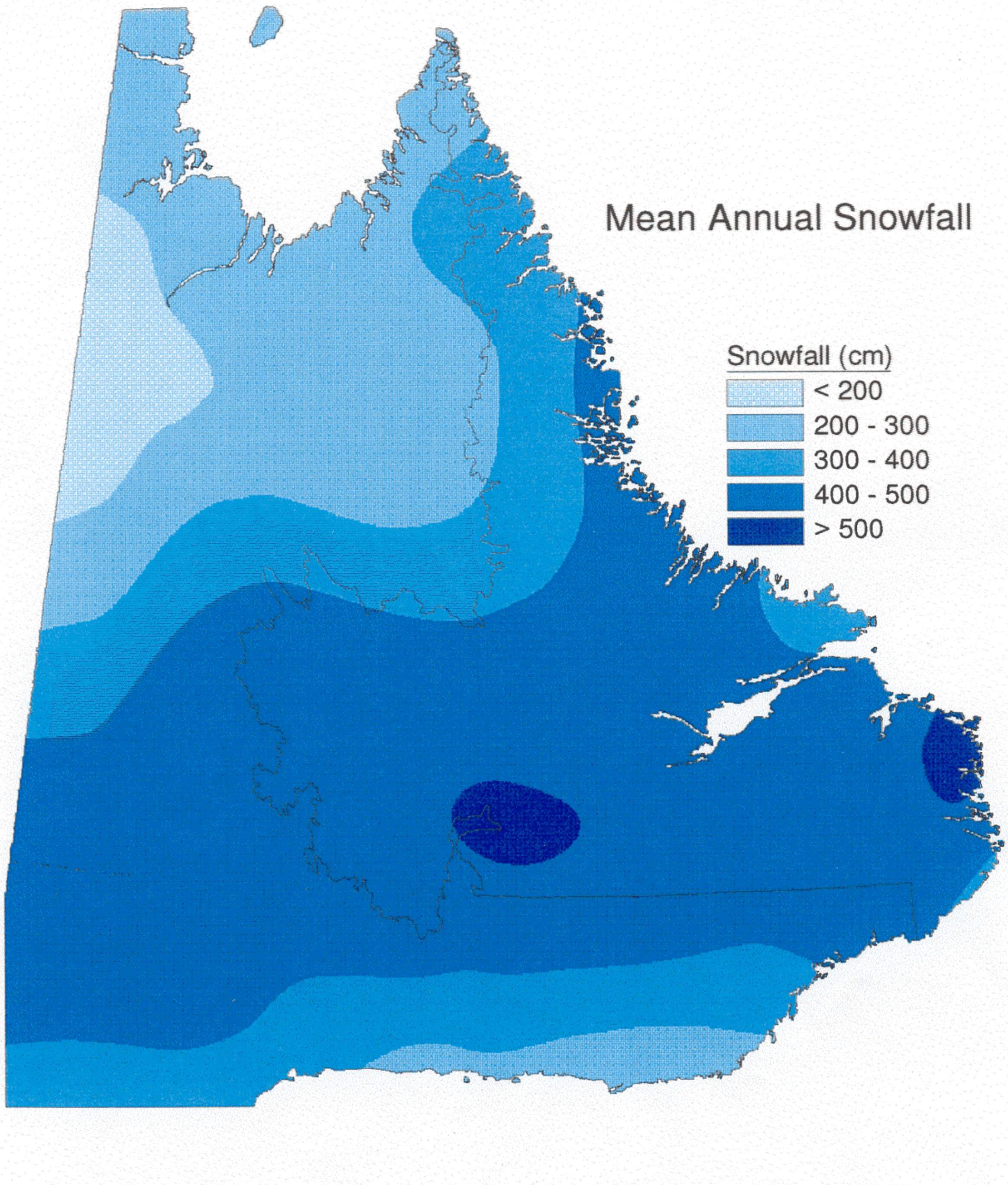
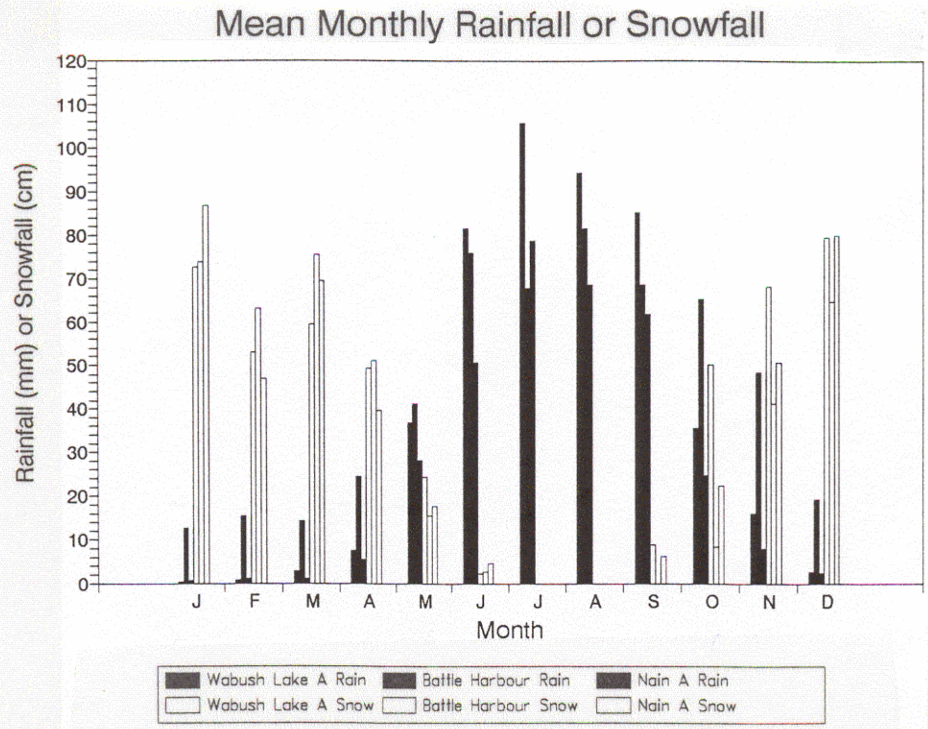

Mean Annual Snowfall
Snowfall (cm)
< 200
200 - 300
300 - 400
400 - 500
> 500

Figure 4.4

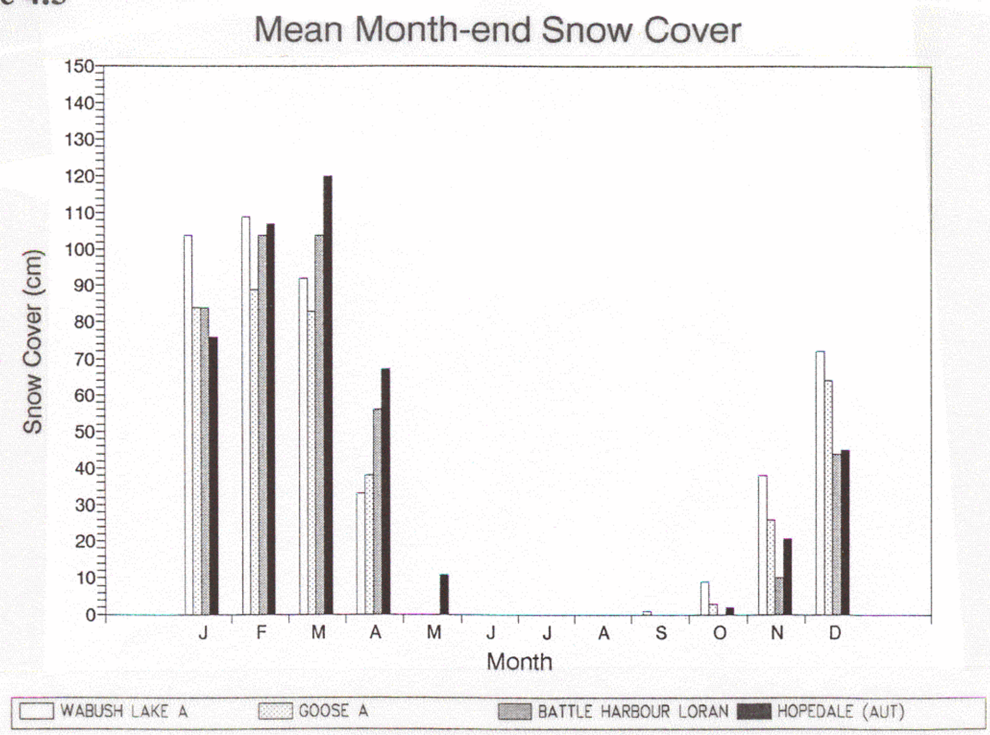


and 110 mm per month from June to September. Mean monthly snowfall was zero in July and August for the index stations shown. From November to April mean monthly snowfalls range between about 40 cm and 90 cm. Mean monthly rainfall and snowfall for other climate stations in Labrador are shown in Appendix F.

4.4 Snow on Ground

Snow cover is a very important hydrological parameter in Labrador. Water stored as snow cover is released when temperatures climb above zero, and is responsible for the high flows experienced in the spring throughout Labrador.

Figure 4.5



Typical distributions of mean month-end snow cover are shown in Figure 4.5. The distributions of mean month-end snow cover at other climate stations in Labrador are shown in Appendix G.

The mean month-end snow cover at the stations shown in Figure 4.5 peak during February and March. From March to April a 48% reduction in snow cover can be anticipated on average. In most areas, and on average, the snow cover is gone by the end of May. The snow cover returns by the end of November with mean month-end snow cover values ranging from 10 cm to 38 cm.

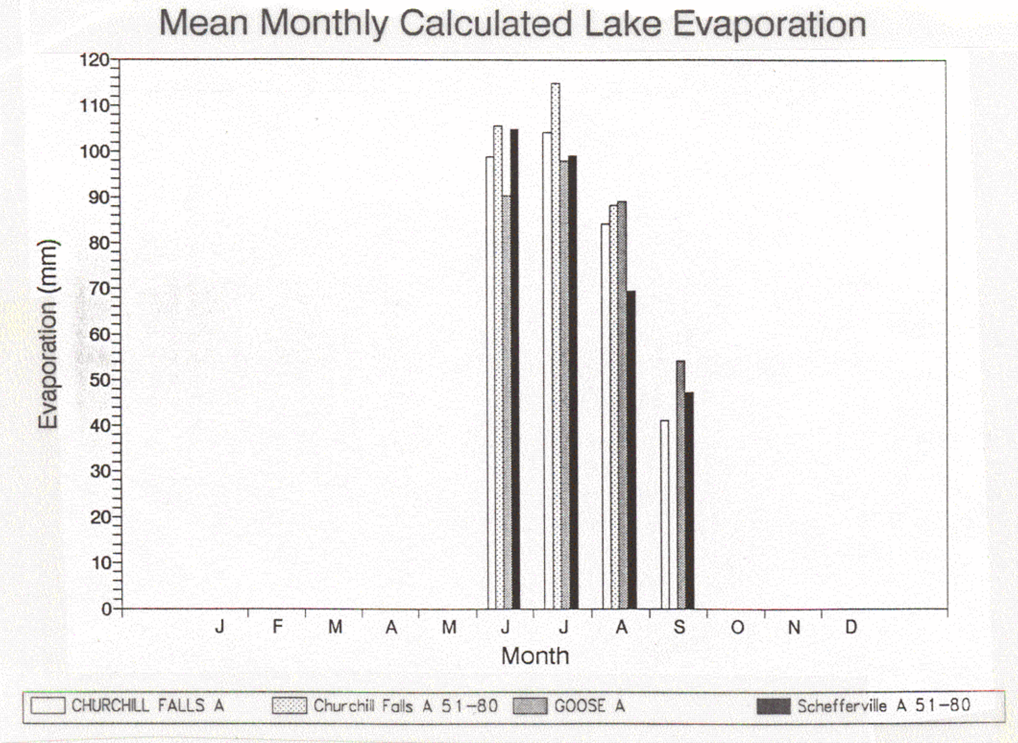
4.5 Other Parameters

4.5.1 Calculated Lake Evaporation

Lake evaporation is calculated from measurements of evaporative loss from Class A evaporation pans, the mean temperature of the water in the pan and of the nearby air, and the total wind run over the pan. It represents the amount of evaporation which is expected to occur from ponds and small reservoirs which have negligible heat storage capacity. Evaporation data are collected during the summer months. Only three stations in the region are equipped with evaporation pans. The Goose A, Churchill Falls A, and Schefferville A climate stations provided some data for the central and western regions. Evaporation data for coastal and northern areas are non-existent. The monthly distributions of calculated lake evaporation are shown in Figure 4.6. The 1951-80 climatic normals were used as well as the calculated monthly averages.

Mean monthly calculated lake evaporation peaks in July at about 100 mm. The approximate totals for June, August, and September, are 95 mm, 80 mm, and 45 mm respectively. The totals for May and October are estimated to be about 20 mm and 10 mm. Evaporation can be assumed to be negligible from November to April. The mean annual calculated lake evaporation is estimated to be about 350 mm.

Figure 4.6



4.5.2 Wind

The 1961-90 normal wind speeds range between 14 km/h and 27 km/h for six long term stations in Labrador. Coastal areas were the windiest, especially in the south-east. Western areas were the calmest. On the coast, winds were more frequently from the south and south-east. A northerly air flow was second most common on the coast. Inland, winds were predominately from the west.

4.5.3 Permafrost

Permafrost is defined on the basis of the temperature within the ground. The National Research Council of Canada defines permafrost as ground which is continuously below 0EC for two or more years. There are two zones within the permafrost region, a continuous and a discontinuous zone. Continuous permafrost generally exists in areas with a mean annual air temperature of less than -8.5EC. The southern limit of the discontinuous zone is generally accepted to coincide with the -1EC mean annual air isotherm. Permafrost can exist further south especially in peatlands. The map of mean annual air temperature shows that discontinuous permafrost is widespread in western, central, and northern Labrador.