8. CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

8.1 Conclusions

1. The mean annual air temperature in Labrador varies from about -6ºC in the far north to about +2ºC in the south-east.
2. On average the warmest month is July and the coldest month is January.
3. Significant snowmelt is unlikely from December to March because the mean monthly melting degree-days are less than 10 degree-days per month for each of these months. Significant snowmelt can start in April or May when mean monthly melting degree-days range from 9.6 to 34.1 and 61.5 to 160.2 respectively.
4. 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.
5. The distribution of precipitation in Labrador is fairly uniform throughout the year with mean monthly precipitation ranging from 40 mm to 120 mm.
6. The mean annual rainfall in Labrador varies from an estimated low of about 200 mm in the far north to a high of about 800 mm in the south-east. South of 55EN mean annual rainfall ranges between 400 mm and 800 mm.
7. The mean annual snowfall in Labrador varies from an estimated low of about 250 cm in the north to localized highs of about 525 cm further south. More than 75% of Labrador has a mean annual snowfall of between 400 cm and 500 cm.
8. Mean monthly rainfall amounts are generally less than 25 mm from December to

April. It is likely that the rainfall from December to April would be absorbed by the snowpack. Mean monthly rainfall ranges between about 50 mm and 110 mm per month from June to September.

9. From November to April mean monthly snowfall amounts range between about 40 cm and 90 cm.

10. The mean month-end snow cover peak during February and March at about 80 cm to 100 cm. From the end of March to the end 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. A snow cover returns by the end of November.

11. The mean annual calculated lake evaporation is estimated to be about 350 mm.

12. Mean wind speeds range between 14 km/h and 27 km/h.

13. Discontinuous permafrost is widespread in western, central, and northern Labrador.

14. Naturally flowing rivers in Labrador enter the recession phase when air temperatures drop below zero and a permanent snow cover is established. Typically, the hydrographs are in recession for the winter months of December through until April. Base flow recession sometimes started as early as November and sometimes finished as late as May. The spring flood accounts for a large portion of the total discharge. After the spring flood, a number of rainfall-runoff events are evident, especially on the smaller watersheds. The rainfall-runoff events continue until November or December when streamflows return to base flow recession.

15. The mean annual runoff in Labrador ranges between 600 mm and 800 mm with the exception of the extreme south-eastern corner of Labrador where it is greater than 1000 mm. For the 17 selected watersheds the average standard deviation of mean annual runoff was 126 mm and the range went from 101 mm to 181 mm.

16. The annual distributions of mean monthly runoff show than low flows (less than 20 mm water equivalent) persist from January until April or May when streamflows increase dramatically. Monthly streamflows peak in May or June at between 100 mm and 300 mm water equivalent and then gradually decline until August or September. A secondary peak of monthly discharge has been observed in October. Monthly discharges decline from October to December and on through until the spring flood.

17. Three seasons of equal duration were defined as follows: **WINTER** - January to April, **SPRING** - May to August, and **FALL** - September to December. **WINTER** runoff for naturally flowing guaged watersheds ranged between 31 mm and 77 mm, **SPRING** runoff ranged between 376 mm and 552 mm, and **FALL** runoff ranged between 161 mm and 214 mm.

18. The highest daily discharges are experienced in the spring and are due mostly to snowmelt runoff. The lowest daily discharges are experienced prior to the spring flood when temperatures are below freezing, precipitation is in the form of snowfall, and snow cover is near maximum. The mean date of the minimum daily discharge (the start of the spring flood) was March 15th. The mean date of the maximum daily discharge (the peak of the spring flood) was June 3rd. The mean

time to peak was 50 days. Over 99% of the annual minimum daily discharges occurred between March 6th and May 21st. Over 99% of the annual peak flows occurred between April 23rd and July 31st.

19. The mean annual peak flow per unit area on 13 selected watersheds in Labrador was 0.1189 $m^3/s/km^2$. The standard deviation was 0.0509 $m^3/s/km^2$, and the range went from 0.0400 $m^3/s/km^2$ to 0.2238 $m^3/s/km^2$. Watersheds which are controlled at the outlet have a lower mean peak flow per unit area of 0.0882 $m^3/s/km^2$, a standard deviation of 0.0310 $m^3/s/km^2$, and a range that went from 0.0400 $m^3/s/km^2$ to 0.1366 $m^3/s/km^2$. Watersheds which are not controlled at the outlet have a higher mean peak flow per unit area of 0.1681 $m^3/s/km^2$, a standard deviation of 0.0342 $m^3/s/km^2$, and a range that went from 0.1403 $m^3/s/km^2$ to 0.2238 $m^3/s/km^2$.

20. Flood flow estimates for the 1 : 10, 1 : 25, 1 : 50 and 1 : 100 year return periods as well as flow estimates for the upper and lower 90% confidence limits for select stations and distributions are shown in Table 5.7. The Log-Normal probability distribution was the best fitting distribution on for most of watersheds which were tested. The only distribution which passed the goodness-of-fit test on all watersheds was the Normal distribution.

21. Two low flow periods occur during the year. The average winter minimum flow on 13 select watersheds ranged between 0.00149 $m^3/s/km^2$ and 0.00563 $m^3/s/km^2$ with a mean of 0.00340 $m^3/s/km^2$ and a standard deviation of 0.00130 $m^3/s/km^2$. The average summer minimum flow on 20 select watersheds ranged between

0.00554 $m^3/s/km^2$ and 0.02836 $m^3/s/km^2$, with a mean of 0.01400 $m^3/s/km^2$ and a standard deviation of 0.00552 $m^3/s/km^2$. Average summer minimum flows were on average about 4 times higher than the average winter minimum flows. The earliest date of the winter minimum was March 6th and the latest date of the winter minimum was May 21st. While, the earliest and latest months of the summer minimum were June and November, nearly 75% of the summer minimum flow events occurred during August or September.

22. Streamflows in Labrador steadily decrease for about 4 months during the winter. The median start date of recession for most watersheds was November 15th. The mean date of the minimum annual flow was March 15th.

8.2 Discussion and Recommendations

The physiographic, climatic and hydrometric databases are not adequate to meet modelling requirements for water resources management.

Physiographic data specific to all gauged or previously gauged watersheds is lacking. The easily extracted physiographic data such as: latitude and longitude of the basin centroid, basin orientation, basin aspect and outlet control were available. Other physiographic data such as: area controlled by lakes and wetlands, land cover types, basin slope, and drainage density, are important physiographic parameters which may have been useful in the modelling of hydrology with physiography. These parameters are time consuming to extract. **It is recommended that: Detailed physiographic data be abstracted from watersheds in Labrador which have been gauged for natural streamflow for a period of 5 years or more.**

The climate network in Labrador has the lowest gauging density of any climate network in the Atlantic Provinces. Further, the climate stations on the coast are not representative of conditions on gauged watersheds further inland. In most cases, gauged watersheds do not have a climate station within the basin, consequently, correlations between climatic and hydrologic data were difficult to obtain, weak and site specific. Since most of the gauged watersheds are in uninhabited areas, climatic data collection would have to be done at relatively expensive unmanned sites. **It is recommended that: Climate stations be established in all gauged watersheds in Labrador.**

The hydrometric network in Labrador is inadequate in terms of the distribution of drainage area sizes. The smallest watershed in Labrador with at least ten years of continuous record was Riviere Joir near Provincial Boundary at 2060 km^2. Consequently, a lot of uncertainty surrounds the estimation of flood flows on watersheds which were significantly smaller than 2060 km^2. Peak flow data in Labrador, combined with peak flow data from hydrologically similar regions in Quebec and Newfoundland, were correlated with drainage area for watersheds which had large lakes near their outlet and also for those that did not. Mean peak flow analysis on data sparse small watersheds were used to confirm the results of the regression analysis. **It is recommended that: The calculation of flood flows for various return periods on small to medium sized watersheds in Labrador utilize the methodology developed in Section 7.**

During this study a number of changes have occurred in the hydrometric network in Labrador. The following stations have closed: Riviere Joir near Provincial Boundary (2060 km^2), North Brook near Red Bay (35.5 km^2), Kanairiktok River below Snegamook Lake (8930 km^2), Minipi River below Minipi Lake (2330 km^2), and Naskaupi River below Naskaupi Lake (4480 km^2). The following stations were established: Big Pond Brook below Big Pond (71.4 km^2), Reid Brook at Outlet of Reid Pond (75.7 km^2), and Camp Pond Brook below Camp Pond (23.8 km^2). This redistribution of the hydrometric network is in keeping with a recommendation that the hydrometric network in Labrador be redistributed so that data may be obtained from watersheds with drainage areas in the 50 km^2 to 1000 km^2 range. While data collection on small watersheds started in 1994, there remains a gap in the size distribution of watersheds. No streamflow data has been collected on watersheds with drainage areas between 100 km^2 and 1000 km^2. **The final recommendation is that: Streamflow gauging stations be installed on Labrador rivers with drainage areas in the 200 km^2 to 800 km^2 range.**