1. INTRODUCTION

1.1 Background

Detailed information on the relationships between physiography, climate, and streamflows in Labrador is lacking at present. This information is critical for the preliminary planning and design of water resources systems such as water supply systems for municipal and industrial uses, and hydroelectric power developments. This information is also needed for the design of hydraulic structures such as dams, bridges and culverts, and also for the general management of the water resources of this area of the province.

The first comprehensive assessment of water resources in the province was completed in 1968 by The Shawinigan Engineering Company Limited and James F. MacLaren Limited in: *The Water Resources Study of the Province of Newfoundland and Labrador*. This study was undertaken to provide information to assist the provincial and federal governments in planning the future utilization of the water resources. It remains the only comprehensive assessment of water resources in Labrador. From 1968 to 1994, the streamflow gauging network in Labrador expanded from 7 to 14 hydrometric stations. The climate network also expanded. At this point in time, a detailed assessment of the regional hydrologic characteristics of Labrador, based on the expanded hydro-meteorological database, is warranted. The knowledge gained would be used to make

more informed decisions on the planning and management of water resources in Labrador.

Compared to insular Newfoundland, Labrador is sparsely populated, has a harsh climate, and most areas are not easily accessible. Under these conditions, climate and streamflows are monitored at a limited number of locations. Climate stations are located in coastal communities and the few population centers in the interior. Streamflow gauging stations are located on relatively large watersheds. At the end of 1993 the lower and upper quartiles for the drainage areas of active and discontinued stations were 3650 km^2 and 20,600 km^2 respectively. Many water supply systems and small scale hydro systems, however, tend to be within much smaller watersheds for which hydrological information is non-existent. Hence, a methodology is needed to transfer hydrological information from large gauged watersheds to small ungauged watersheds.

1.2 Objectives

The objectives of this study were:

1. to characterize the hydrology of Labrador; and
2. to develop procedures for transferring hydrological information from *"large"* gauged watersheds to *"small"* ungauged watersheds.

1.3 Literature Review

A number of publications were reviewed to obtain general information on the hydrological characteristics of Labrador and to assist in the selection of hydrological analysis methodologies. These publications, along with a brief abstract of their contents, are listed below.

The *Water Resources Study of the Province of Newfoundland and Labrador* (1968) was the first comprehensive assessment of water resources in the province. This study brought together all of the then available information on surface water quantity and quality, groundwater quantity and quality, meteorology and physiography. These data were analyzed and regional hydrological characteristics were quantified. Unfortunately the level of analysis and regionalization in Labrador was deficient due to a lack of suitable hydrometeorological data. The study also provided an analysis of existing and future water supply and demand. In addition, several river basins and study areas were selected for further analysis.

The *Water Resources Atlas of Newfoundland* (1992) describes the physiography, geology, climatology, hydrology, water quality, groundwater, and water uses of the province. The hydrology section provides information on: drainage basins, river gauges, major lakes, reservoirs, river ice, flood zones, as well as maximum, minimum, mean, monthly and annual streamflows. The atlas is intended to be a source of general

information on water resources in the province, as well as a reference in the preliminary planning and design stages of water resource projects.

The *Hydrological Atlas of Canada* (1978) describes hydrological information for all of Canada. Plates include those relating to monitoring networks, climate (rainfall, snowfall, total precipitation, depth-duration-frequency of point rainfall, air and soil temperatures, radiation, snow cover, river ice, wind, and lake evaporation), streamflows (annual and monthly), geology (surficial and bedrock), river and lake ice, permafrost, and water quality (surface water and groundwater). While this publication is quite comprehensive, detailed information on Labrador is not available.

The *Natural Environment of Newfoundland* (1981) provides information of the past and present natural environment of the province. This publication describes the tectonic evolution and surface morphology of the province as well as the ocean environment, climate, surface waters, landforms, plants and animals. The climate section provides detailed information on climatic zones, and shows the spatial distribution of several useful climatic parameters. The section on surface waters and land forms is however only applicable to the island portion of the province.

The *Atlas of Newfoundland and Labrador* (1991) describes the geography, climate, culture, population and the economy of the province. Relevant plates for this study include: Relief and River Systems, Climate, Forestry: The Physical Characteristics, and

Mining and Geology. Six classes of elevation are shown on the relief plate. The climate plate shows three climate zones in Labrador: the northern, coastal and interior. Isolines of sunshine, snowfall, precipitation, frost free days, average January temperate, and average July temperature are shown as well as other charts showing the month distribution of precipitation and temperature. Wind data is also given. The forestry plate shows the distribution of 5 cover types: Tundra, Forest/Tundra, Barrens, Peatlands and Forest. These cover types are useful because they have different hydrological properties.

The Rivers of Labrador (1985) presents the physical and biological characteristics of 120 river systems in Labrador. Based on bio-physical characteristics, Labrador has been divided into six regions. A general description of each region is given as well as detailed descriptions of each river in that region. Fishery statistics are included. The descriptors of each river system are: the latitude and longitude at the mouth, general direction of flow, drainage area, mean width, axial length, basin perimeter, maximum relief, length by meander (main stem), total length including tributaries, number of tributaries, and geological formation. Streamflow gauging stations are not as a rule located near the mouth. Some of the characteristics may be useful on some rivers.

1.4 General Approach

Initially a number of publications were reviewed to obtain general information on the hydrological characteristics of Labrador and to assist in the selection of hydrological analysis methodologies. This information was useful in describing the hydrological setting of Labrador. Next, the available physiographic data was reviewed, followed by detailed reviews and analyses of climatic and hydrologic data.

A database of all climate stations in Labrador and select climate stations in Quebec, which could assist in the analysis of climatic and hydrometric data in Labrador, was created from Environment Canada databases (1994 and 1995). Those stations which had long term records were used to generate maps of mean annual: air temperature, rainfall, snowfall and total precipitation. Other analysis included: mean monthly air temperature; melting degrees-days; mean monthly rainfall, snowfall and total precipitation; snow on ground; evaporation; wind; and permafrost.

A database of all hydrometric stations in Labrador and select hydrometric stations in Quebec, which could assist in the analysis of hydrometric data in Labrador, was created from Environment Canada's database (1994). Daily, monthly, seasonal, and annual runoff was examined. The timing of streamflow extremes was documented. Mean peak flows were analyzed and a single station frequency analysis was performed on watersheds which had sufficient data. Winter and summer minimum flows were compiled. Recession

characteristics were analyzed.

With detailed descriptions of climate and hydrology, and the available physiographic data, correlations were sought between hydrological and climatic data and also between hydrological and physiographic data. These correlations were used to develop procedures for transferring hydrological information from *"large"* gauged watersheds to *"small"* ungauged watersheds.