6. CORRELATION OF HYDROLOGICAL AND CLIMATIC DATA

6.1 Selection of Watersheds

The primary criteria for selecting watersheds for the correlation of hydrological and climatic data were that the watersheds have adequate lengths of streamflow record, that they be geographically diverse, and that climatic data be available. In addition, smaller watersheds were preferred so that the transfer of hydrological information from these watersheds to smaller ungauged watersheds could be performed more confidently. Three watersheds were selected for study: Alexis River near Port Hope Simpson (03QC002), Ugjoktok River below Harp Lake (03NF001), and Ashuanipi River below Wightman Lake (03OA004).

Alexis River had 16 years of daily streamflow data with no data gaps. This watershed is in the south-western region which is characterized by the highest mean annual temperature and the highest mean annual precipitation in Labrador. Climatic data is available from 2 climate stations: Battle Harbour Loran (8500398) (1978-83) and Mary's Harbour (8502591) (1984-93). These climate stations are outside the watershed, and about 65 km from the divide. The elevation differences between the climate stations and the centroid of the watershed are about 500 m. The elevation difference is significant in terms of the adiabatic lapse rate and its effect on temperature. Despite the poor locations of the climate stations they were the best available. Many of the gauged watersheds in Labrador do not have climate stations within their boundaries.

Ugjoktok River had 15 years of daily streamflow data with only one data gap in the fall of 1981 for about 2 to 3 months. The watershed is the most northerly of the gauged watersheds in Labrador. Climatic data is available from 2 climate stations: Hopedale (8502400) (1979-84) and Nain (8502800) (1985-93). These climate stations are outside the watershed and about 75 and 105 km from the divide respectively. Again, the elevation differences between the climate stations and the centroid of the watershed were about 500 m. While this is a major concern, the data could be adjusted, or could be used as is, and any adjustments could be made when applying correlations to other watersheds.

Ashuanipi River is located in western Labrador and has a climate station inside the watershed which is only about 30 km from the watershed centroid. Streamflow data was somewhat lacking. Streamflow data was available for the calculation of 6 years of spring flood volume and for the extraction of 10 years of peak flow data. Other watersheds in western Labrador had a little more streamflow data, however none had a suitable climatic station within their watershed boundary.

6.2 Data Analysis

The following daily hydrometeorological data were extracted from Environment Canada databases: flow (m^3/s), rainfall (mm), snowfall (mm), total precipitation (mm), mean temperature (°C) and snow on ground (cm). Some of these data were processed to arrive at the following hydrometeorological parameter set: unit daily flow (mm), cumulative rainfall (mm), cumulative snowfall (mm), cumulative total precipitation (mm), cumulative melting degree-days (°C x day) and snow on ground (cm). Flows in (m3/s) were transformed into flows in (mm) by dividing by the watershed drainage area and multiplying by the number of seconds in a day. This transformation enabled interbasin flow comparisons. Cumulative rainfall, snowfall and total precipitation were summed from the occurrence of permanent snow on ground to a specified date after the spring flood. The occurrence of permanent snow on ground was defined as when both the snow on ground is greater than zero and that snow cover does not become zero until the spring flood. Cumulative melting degree-days were calculated by summing the positive mean daily temperatures from January 1.

To aid in the selection of hydrological and climatic variables for correlation, the hydrometeorological data set was plotted by year and watershed. Sample graphs for the only concurrent year, 1979, are shown in Figure 6.1a. All graphs are shown in Appendix R. Cumulative flow above the minimum annual daily flow was subsequently plotted against the climatic data set to get an indication of cumulative flow volumes. Sample

Figure 6.1a Hydrometeorological Data for Select Stations 1979

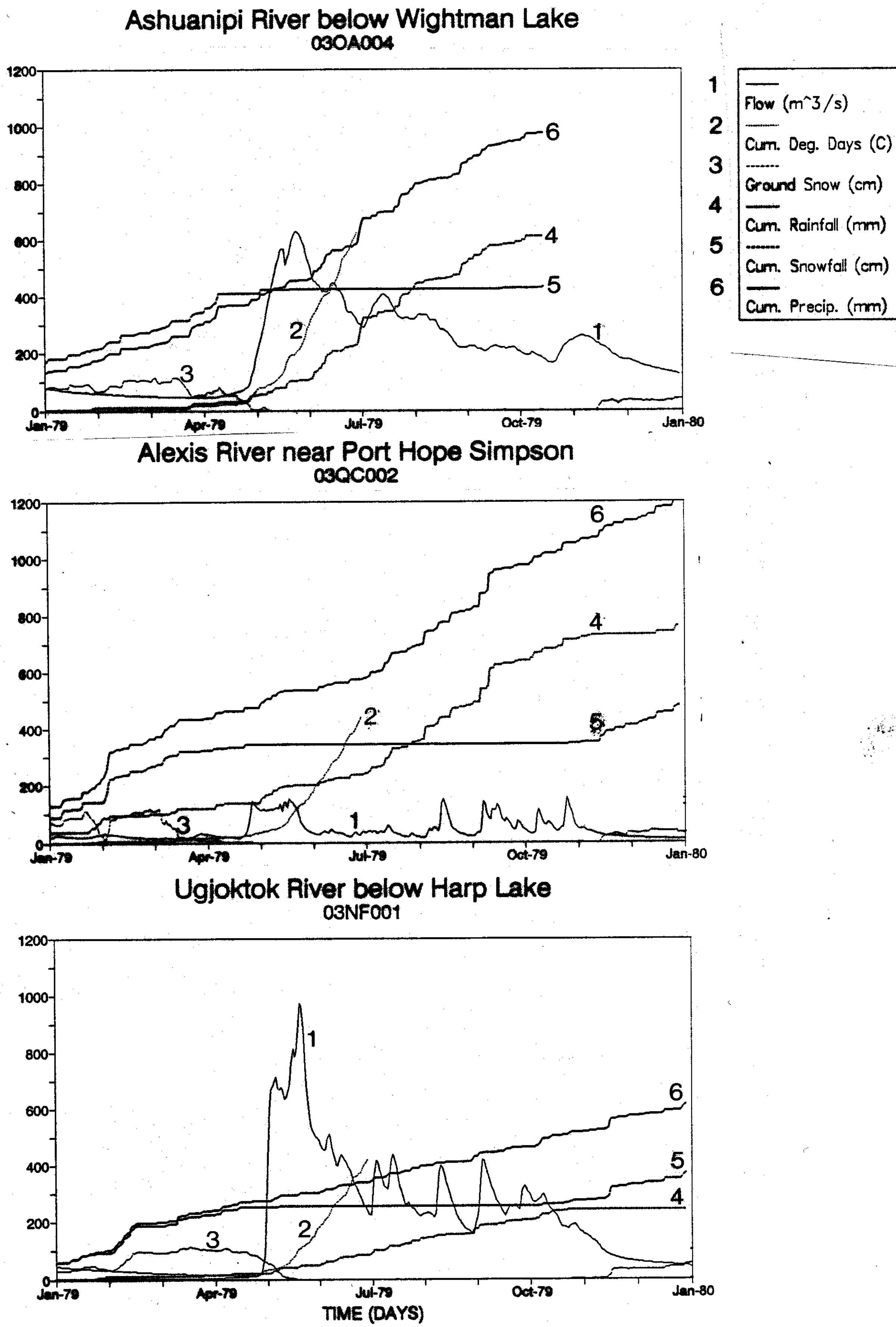
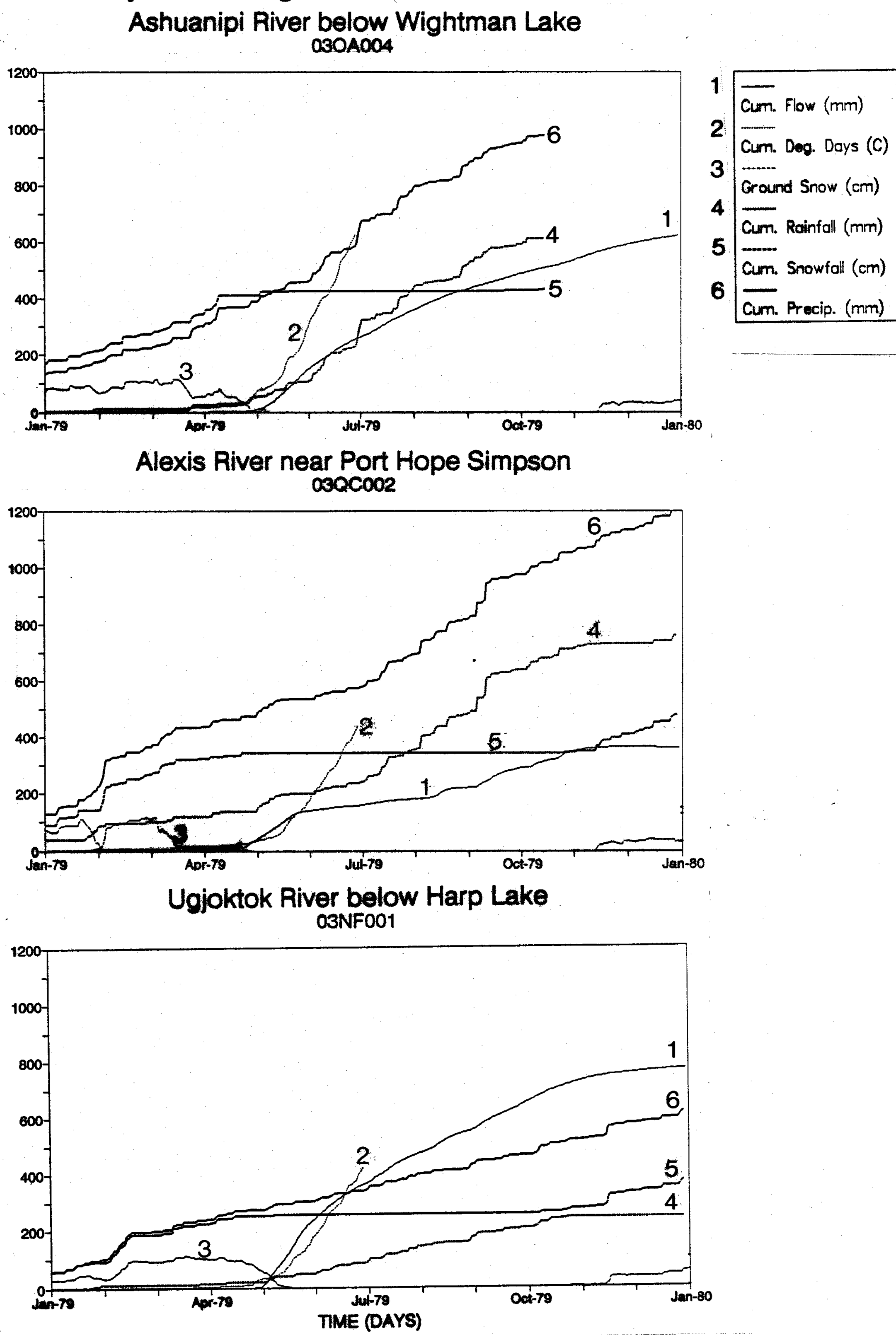


Figure 6.1b Hydrometeorological Data for Select Stations 1979



graphs are shown in Figure 6.1b. All graphs are shown in Appendix R. Two of the most important hydrological variables in water resources engineering are the spring flood volume and the peak flow. These variables are used in a wide array of engineering projects which include: water supply for municipal and hydropower uses, delineation of floodplains, and the design of instream structures (spillways, dams, bridges, culverts, etc). The spring flood volume and the peak flow rate were correlated with climatic variables.

Four measures of the spring flood volume were used for correlation with climatic variables. These were:

< May 1 - June 30 Discharge

- the sum of monthly discharges from May to June inclusive.

< April 1 - July 31 Discharge

- the sum of monthly discharges from April to July inclusive.

< Cumulative Discharge above the Minimum to June 30,

- the cumulative daily discharge above the annual minimum daily discharge from the date of the annual minimum to June 30.

< Cumulative Discharge above the Minimum to July 31.

- the cumulative daily discharge above the annual minimum daily discharge from the date of the annual minimum to July 31.

The start and finish dates of the spring flood were varied because of the stochastic nature of the spring flood in general and more especially the uncertainty associated in identifying the end of the spring flood. The annual minimum occurs immediately prior to the spring flood and has been defined as the start date of the spring flood. Cumulative discharges above the annual minimum were used to account for differences in the spring flood volume which are associated with differences in baseflow. Discharges were normalized by drainage area. The units of cumulative discharge were mm.

Peak flows were normalized by drainage area so that interbasin differences could be compared. The units of peak flow were $m^3/s/km^2$. Peak flows were defined as follows:

< Peak Flow

- annual maximum instantaneous flow per unit area

Climatic variables were selected for correlation with hydrological variables based on the analysis of the hydrometeorological data sets. The following climatic variables were selected for correlation with hydrological variables:

- December 1 - May 31 Precipitation

  - the sum of monthly total precipitation from December to May inclusive.

- Cumulative Precipitation to May 31

  - the sum of daily precipitation from the occurrence of permanent snow on ground to the end of May.

- Maximum Snow on Ground

  - the highest value of “Snow on Ground” during the season.

- Average Snow on Ground

  - the average daily “Snow on Ground” for the combined months of February and March.

- Snow on Ground at Minimum Flow

  - the value of Snow on Ground when the annual minimum flow is attained.

- Snow on Ground Depletion Rate

  - the average rate which Snow on Ground depletes during the snowmelt event which started the spring flood. Its extraction was somewhat subjective.

6.3 Results

No correlations between hydrological and climatic variables could be found which could be applied throughout all of Labrador. However, hydrological and climatic variables were significantly correlated on some individual watersheds. These are shown in Figures 6.2 to 6.4. All plots are shown in Appendix S.

The correlations found on Ugjoktok River with cumulative discharge and average snow on ground or snow on ground at minimum flow could not be found on the other watersheds. The correlation of peak flow with the snow on ground depletion rate on Alexis River was not found on other watersheds. The shortness of streamflow records combined with the non-representativeness of the climatic data made correlations difficult.

Figure 6.2

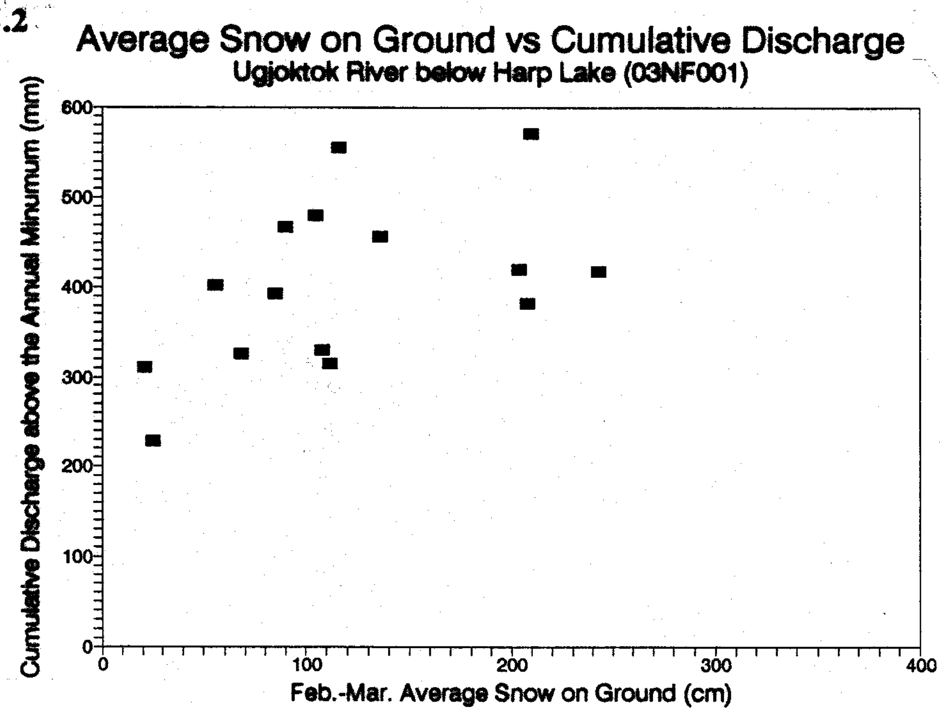


Figure 6.3

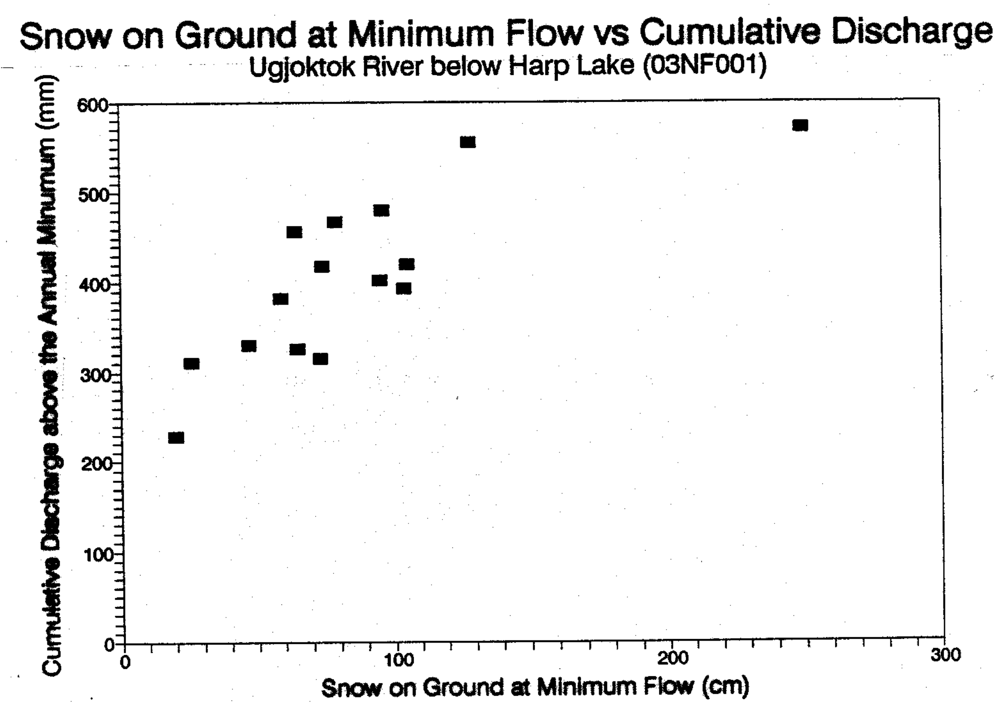


Figure 6.4