Fisheries and Environment Canada
Pêches et Environnement Canada

Research Projects in Glaciology - 1976

REPORT SERIES NO. 49

Canada
INLAND WATERS DIRECTORATE,
WATER RESOURCES BRANCH,
OTTAWA, CANADA, 1977.

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PREFACE

This is the sixth report on the glaciological research program carried out by what is now the Water Resources Branch of Environment Canada. In previous years, the following reports were issued:

1) "Research Projects in Glaciology, 1968"
Inland Waters Branch, Department of Energy
Mines and Resources, 1968, 34 pp.

2) "Ice Studies in the Department of Energy Mines
and Resources, 1969"
Report Series No. 7, Inland Waters Branch
Department of Energy Mines and Resources, 1969, 95 pp.

3) "Research Projects in Glaciology, 1971"
Report Series No. 15, Inland Waters Branch
Department of Energy Mines and Resources, 1971, 94 pp.

4) "Research Projects in Glaciology, 1972"
Report Series No. 23, Inland Waters Branch
Department of the Environment, 1972, 115 pp.

5) "Research Projects in Glaciology, 1974"
Report Series No. 36, Water Resources Branch
Inland Waters Directorate, Environment Canada, 1974, 130 pp.

An examination of the list shows that changes have occurred in the name of the Branch and in the Department within which the program has developed.

This report describes the present structure and organization of the GLACIOLOGY DIVISION and presents the general objectives and responsibilities of each of its components. The catalogue section provides details of work done on projects since publication of the 1974 report. Projects which have been terminated, transferred, suspended or absorbed into other studies are listed separately. A bibliography of published material not contained in previous reports is included.

Limited numbers of previous reports for 1972 and 1974 are available and may be obtained from: Glaciology Division, Water Resources Branch, Environment Canada, Ottawa, Ontario K1A 0E7.

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DIVISION OBJECTIVE AND ORGANIZATION

The principal objective of the GLACIOLOGY DIVISION is to maintain within the Federal Government a centre of expertise in snow and ice, particularly in relation to our inland water resources. This includes the establishment of an inventory of the perennial snow and ice masses and their changes from year to year; studies of Arctic hydrology; studies of lake and river ice; of the role of snow and ice in hydrology; of the fundamental properties of these materials and of avalanche problems. Increased attention is being given to applied studies, the results of which can be used operationally in water management projects or in the Environmental Review and Assessment process.

The Division is divided into 5 sections to achieve this objective.

Arctic Hydrology

The Section carried out basic and applied research in Northern Canada. Basic research involves all components of the hydrologic cycle including lake and river ice and is emphasized in research basin studies. Applied research is directed toward the needs or northern resource and transportation developments such as water supply systems for settlements and the impact of highway and oil/gas pipelines (Mackenzie Valley and Arctic Islands) on the hydrologic environment.

Glacier

The Glacier Section carries out research relating to glaciers and the current programme has three main thrusts:

Research into the physical properties of glaciers to permit a better assessment of environmental hazards related to glaciers such as jökullhlaups and surges; and the investigation of flow characteristics of glaciers to establish criteria governing large scale mass losses by calving with its concomitant threat to coastal zone activities.

Development of a comprehensive information system on snow and ice resources in Canada to maximize the usage of all existing glacier data and information to provide a datum for satellite based research, to permit the selection of representative areas for future research, to aid in the extrapolation of data from the selected glacier basins, and to identify all glacierized areas potentially hazardous to human activity.

Climatic change is studied by collecting deep ice cores from the accumulation area of cold glaciers and by analyzing ice samples from various strata. The results contribute to broader studies of recent environmental change and allow an assessment of long-term discharge records, particularly from glacierized basins.

Ice Properties

Basic properties of ice are studied under controlled laboratory conditions. Studies of mechanical and electrical properties of ice are typical of investigations carried out in close cooperation with field-oriented studies, e.g. radio echo sounding techniques to measure glacier depth and to study the internal structure of glaciers. Light transmission through floating ice sheets affected by oil pollution is studied as part of the Beaufort Sea Program and the characteristics and behaviour of ice and water under high pressure are studied in the context of deep ice coring of glaciers.

*Avalanche Research**

This section is located in Calgary and its objective is to study the environmental impact of avalanches. Current emphasis is on determining snow pack release mechanisms as a means of developing more accurate avalanche hazard forecasts and on determining impact pressures in different parts of avalanche paths.

Snow Hydrology and Instrumentation

The objective of the Section is 1) to construct snowmelt models for operational use, particularly in reservoir management and 2) to research new sources of data to be used as input to these models, particularly those based on remote sensing in the visible infrared and microwave spectra. New approaches to modelling are required since remotely sensed data are usually continuous in one or two dimensions, whilst conventional data are point samples.

Glacier mass balance studies are also included to study the glacier meltwater contribution to streamflow.

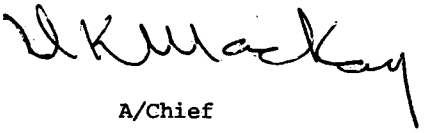
The Instrumentation part provides technical advice on data acquisition systems. The workshop now includes a facility for designs based on macro-integrated circuits (micro-processors, programmable read only memories, etc.).

*Now known as Snow Physics Section.

RECENT CHANGES IN THE GLACIOLOGY PROGRAM

Since the 1974 Project Catalogue was published, the GLACIOLOGY DIVISION has undergone some modifications which affect its role in the field of hydrology. The Floating Ice Section has been transferred to Ocean and Aquatic Sciences, D.O.E., and personnel transfers have been effected between C.C.I.W. and the Division. In addition, administrative control of the Avalanche Research Section has been returned to Ottawa. Further refinements in the structure and thrust of the GLACIOLOGY DIVISION's research program will occur as new problems are perceived and research priorities are modified.

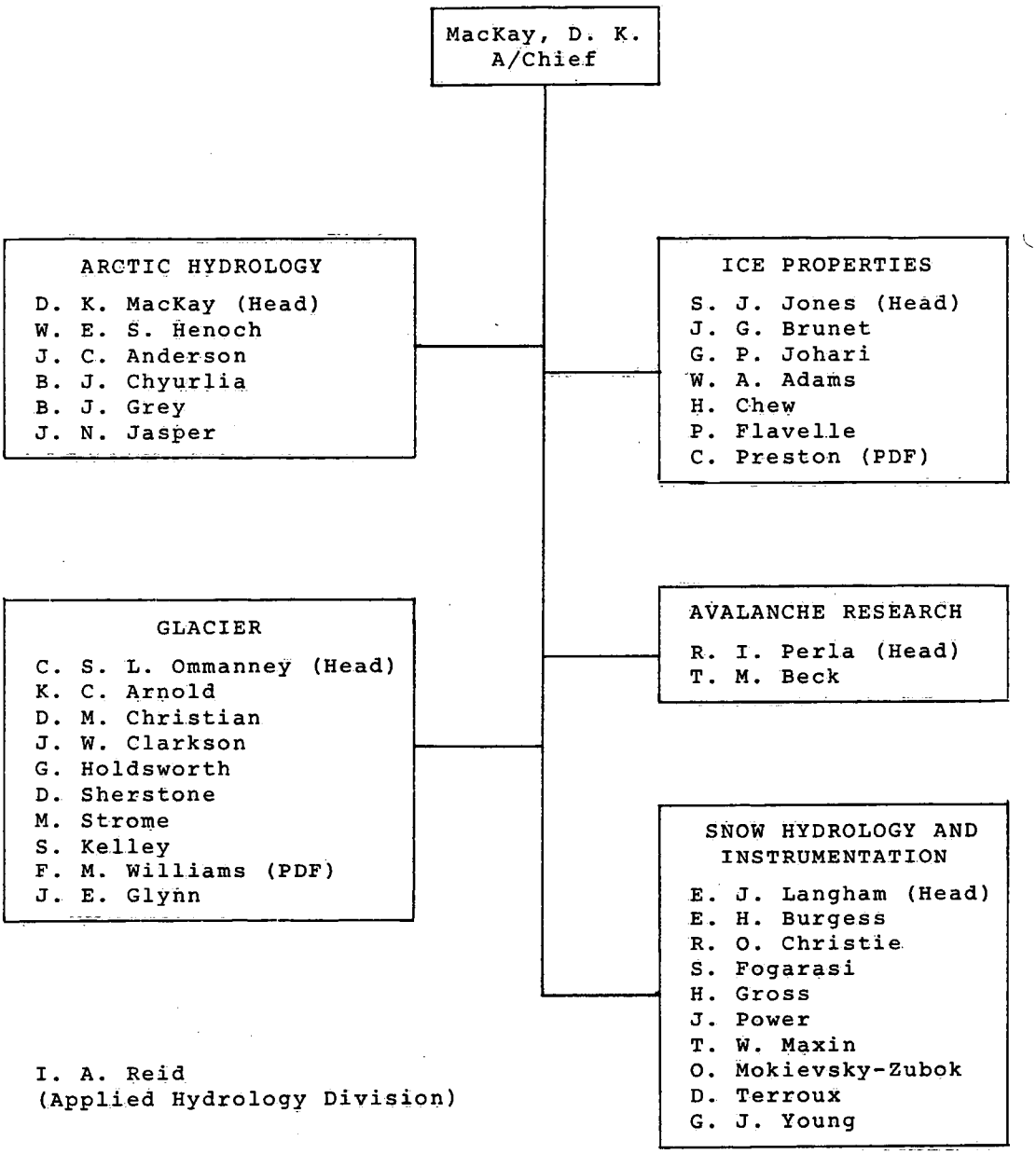
It should be noted that the design and development of the Glaciological Research Program outlined in this catalogue, and the past accomplishments of the GLACIOLOGY DIVISION, owe much to the leadership of the former Division Chief, Dr. Olav H. Løken. After many years devoted to research in snow and ice, Dr. Løken left Environment Canada to take up a position within the Department of Indian and Northern Affairs.



Ottawa
December, 1976

A/Chief
Glaciology Division

GLACIOLOGY DIVISION



*Now known as Snow Physics Section.

TECHNICAL AND SCIENTIFIC REPORTS 1974-1976

The following list contains publications written or co-authored by GLACIOLOGY DIVISION personnel since the publication of the 1974 Project Catalogue. Scientific reports which have been written under contract agreement with the Division are also listed herein.

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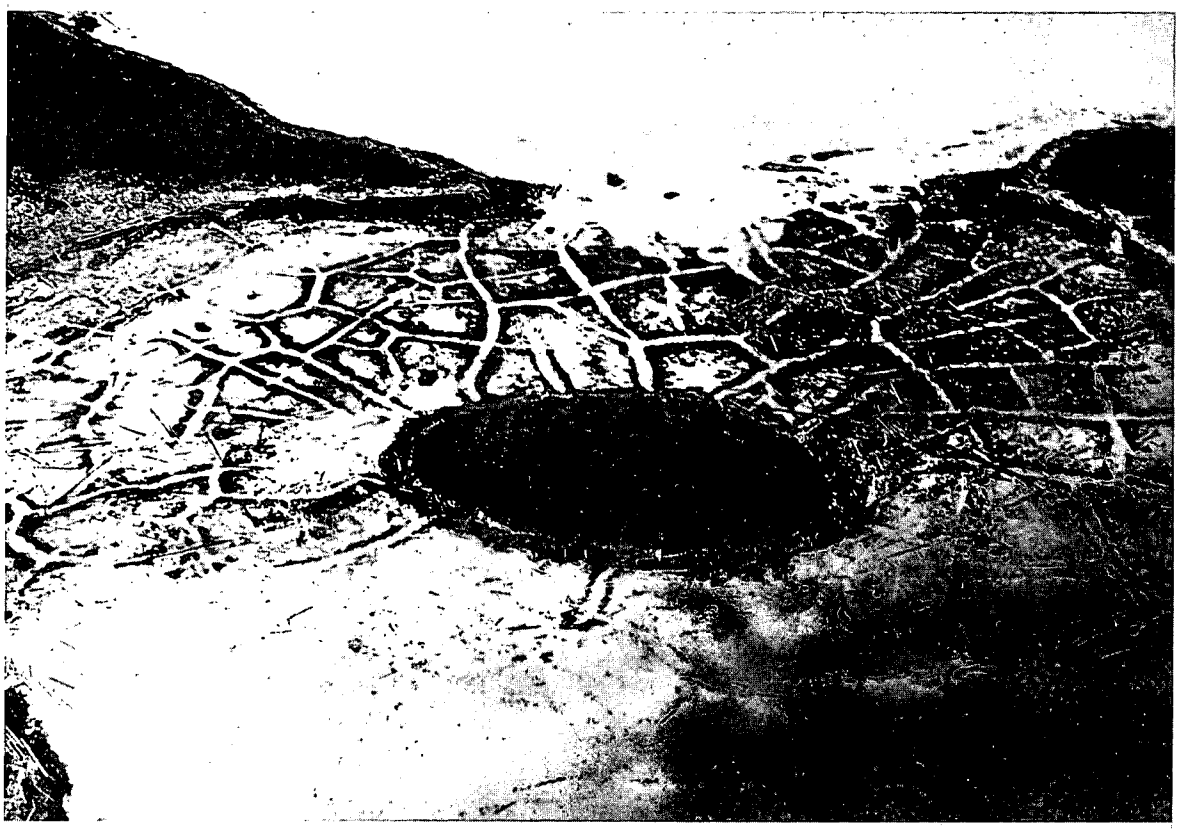
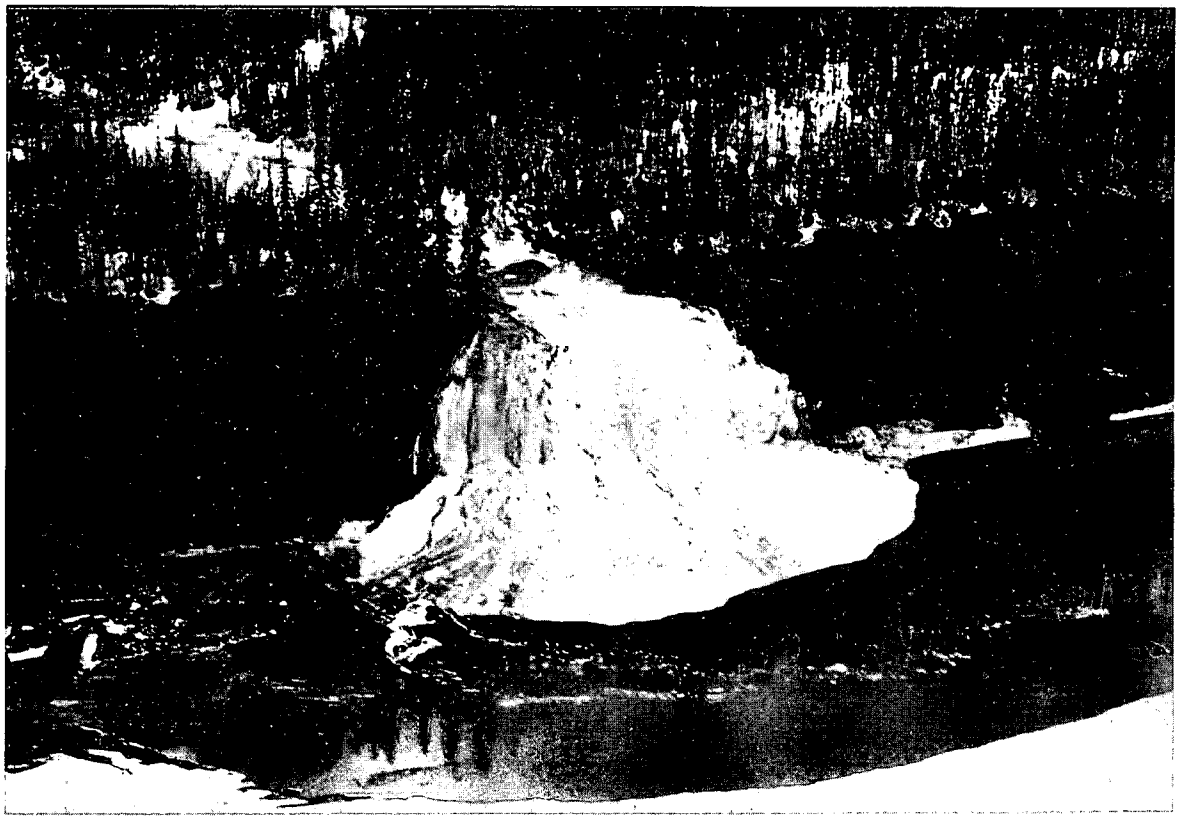
Project Catalogue

Arctic Hydrology



Pingo on Tuktoyaktuk Peninsula surrounded by polygonal ground in partially drained lake.

Icing generated by perennial stream flowing into the Mackenzie River near Sans Sault Rapids.



PROJECT G-67-8

PEYTO GLACIER AREA MAP

Principal Investigator: W. E. S. Henoch

Cooperating Agencies: Surveys and Mapping Branch; National and Historic Parks Branch, Department of Indian and Northern Affairs

Objectives: To prepare a final edition, multicoloured, map of the Peyto Glacier area (scale 1:10,000) using Swiss cartographic techniques to portray a glacier in an Alpine environment. The map will have marginal notes about the local environment, thus providing map users of diverse interests with a map of high technical and artistic value.

Location: Peyto Glacier (51°40'N, 116°34'W), 45 km northwest of Lake Louise, Alberta

Publications: Henoch, W. E. S. (1975)
Sedgwick, J. K., and Henoch, W. E. S. (1975)

Project Completed

PROJECT G-68-2

DENDROCLIMATIC DATA AND GLACIER FLUCTUATIONS

Principal Investigator: W. E. S. Henoch

Cooperating Agencies: None

Objectives: To compare the responses of trees and glaciers to climate by comparing chronologies derived from tree rings and ice cores.

Previous Work: Increment cores collected in the Mackenzie Basin are being processed in an effort to develop regional master chronologies. Partial results were reported in our previous catalogue, Research Projects in Glaciology - 1974.

Future Work: Depends on data from the pending Mount Logan ice core operation.

Field Work: Increment cores will be taken in the summer of 1976 near Mount Logan, Kluane National Park, and near Whitehorse, Yukon Territories.

PROJECT G-70-1

MACKENZIE BASIN STUDIES

Principal Investigators: D. K. MacKay and J. R. Mackay

Cooperating Agencies: University of British Columbia (J. R. Mackay); Geological Survey of Canada; Water Survey of Canada

Objectives: In general, to conduct hydrologic and fluvial geomorphic studies in the Mackenzie Basin to add to the information base on water in the northern environment. Part of this information is of value in assessing the environmental impact of pipeline and highway construction in the north.

Location: Mackenzie Basin, N.W.T.

Previous Work: A broad range of data has been collected since 1967. For results see publications.

Work in Progress: Data collection and analysis.

Future Work: Depends on progress of present studies.

Publications:
MacKay, D. K. and Mackay, J. R. (1974)
Mackay, J. R. and MacKay, D. K. (1974)
MacKay, D. K., Sherstone, D. and Arnold, K. C. (1974)
Swami, K. (1974).

PROJECT G-70-5

REGIONAL HYDROLOGIC CHARACERISTICS OF MACKENZIE RIVER BASIN

Principal Investigator: T. Thakur

Cooperating Agency: None

Objectives:

1) To collect data and study complete basin morphometry from all available sources.

2) To evaluate and mathematically analyze the available geomorphic and hydrometric data.

3) To estimate selected stream flow characteristics of the gauged Mackenzie watersheds.

4) To develop mathematical models to estimate streamflow characteristics of ungauged basins.

5) To carry out statistical analysis to measure influence of geomorphic parameters on stream flow.

Location: Mackenzie River Basin

Publications: Thakur and Lindeijer (1974)

Project Completed

PROJECT G-71-7 (formerly part of G-70-1)

SEASONAL DISTRIBUTION OF FLOW IN THE MACKENZIE DELTA

Principal Investigator: J. C. Anderson

Cooperative Agencies: Water Survey of Canada; Atmospheric Environment Service

Objectives:

1) Establish annual regimes of inflow to the Mackenzie Delta and the distribution of that flow within the Delta;

2) Investigate the hydraulic geometry of Delta channels with respect to flow during the open water season;

3) Investigate variations in water levels, ice levels and ice thicknesses on major Delta channels;

4) Investigate causes of flooding within the Delta.

Location: Mackenzie Delta, N.W.T.

Previous Work: Field work commenced in the summer of 1971. Late winter flow distribution surveys began in 1972, and continued through 1974, when full responsibility for flow distribution data collection was assumed by Water Survey of Canada.

Work in Progress: None.

Future Work: Possible study of the occurrence and explanation of deep "holes" in some Mackenzie Delta channels.

Publications: Anderson, J. C. and R. J. Anderson (1974).

PROJECT G-71-8

RIVER ICE CHARACTERISTICS DURING BREAK-UP

Principal Investigators: D. K. MacKay; D. A. Sherstone; K. C. Arnold

Cooperating Agencies: Polar Continental Shelf Project; Department of Energy Mines and Resources

Objectives: To examine river ice dynamics on northern rivers during break-up and jamming in an attempt to isolate stream flow, ice and stream bed characteristics responsible for initiating and maintaining break-up and initiating and destroying ice jams. Particular emphasis to date has been placed on location and formation of ice jams during air photo coverage and study of the effects of ice jamming on stream beds and shoreline erosion. As well, densitometric analyses of ice in motion upstream of jamming and ice block characteristics within the jam have been undertaken.

Previous Work: Air photo coverage of ice jams has been obtained during 1971 through 1975 break-up seasons and 1971 and 1972 data analyzed manually for ice block characteristics. 1973 and 1974 data have been analyzed using a quantimet densitometric system (Dr. Roger Glass - Ontario Research Foundation - under contract). ERTS (LANDSAT) imagery had also been studied as a tool in detecting macro scale break-up features. For results, see publications.

Work in Progress: Study of applicability of densitometer derived data to ice jamming characteristics and limits of densitometer analysis. Study of ice jams and ice block characteristics from 1975 data.

Future Work: Continued monitoring of ice jams along the Mackenzie at least through the 1976 season. Study of break-up using aerial photography for several river basins in the central arctic regions near predicted pipeline crossings.

Publications: MacKay, D. K., Sherstone, D. A., and Arnold, K. C. (1974)
Sherstone, D. A., Arnold, K. C., and MacKay, D. K. (1974)

PROJECT G-72-18

HYDROLOGICAL STUDIES, VENDOM FIORD AREA,
ELLESMERE ISLAND, N.W.T.

Principal Investigators: Profs. S. B. McCann and M-K. Woo, McMaster University, under contract to GLACIOLOGY DIVISION

Cooperating Agency: Polar Continental Shelf Project (EMR)

Objectives: To study the present and past hydrologic regime of the major streams that reach the head of Vendom Fiord, with particular emphasis on extreme events such as those caused by sudden draining of ice dammed lakes. To investigate soil moisture conditions in the active layer and their dependence on time of year, slope and meteorologic conditions.

Location: Vendom Fiord, Ellesmere Island (78°10'N. 82°W.)

Previous Work: Following reconnaissance in 1972, a major field project was started in 1973. For results see: McCann, Cogley, Woo and Blachut (1974); McCann and Woo (1975).

Work in Progress: Field work with increased emphasis on studies of the hydrology of the ice dammed lakes and on soil moisture conditions.

Future Work: Final report for 1975 received. A summary report to be prepared for publication.

PROJECT G-72-19

BANK EROSION IN THE MACKENZIE DELTA

Principal Investigator: D. Outhet

Cooperating Agency: Department of Geography, University of Alberta

Objectives: To study the causes and rates of erosion of channel banks in the Mackenzie Delta (south of 68°N.), on bi-weekly and yearly time scales; to categorize bank profiles and erosion rates for each type.

Location: Mackenzie Delta, N.W.T.

Publications: D. Outhet (1974)

Project Completed

PROJECT G-72-20

LAKE CHARACTERISCTICS IN THE MACKENZIE DELTA

Principal Investigators: D. K. MacKay and J. R. Mackay

Cooperating Agency: University of British Columbia

Objectives: A number of lakes in the Mackenzie basin which emphasize the range of physical and limnological conditions along the pipeline routes have been selected for study. The emphasis is on the observation and analyses of lake thermal regimes, bathymetric and regional differences among lakes.

Location: Mackenzie Basin

Previous Work: Field: Instrumentation of lakes to collect water temperature data and bathymetry.

Work in Progress: Continuation of data collection and analysis of results.

Future Work: Data collection to continue.

PROJECT G-72-27

PHYSICAL CHARACTERISTICS OF SNOWBED COMMUNITIES IN THE RICHARDSON MOUNTAINS, N.W.T.

Principal Investigator: N. J. K. Peterson

Cooperating Agencies: Geography and Biology Departments, Carleton University

Objectives: To investigate distribution and ablation of snow banks and their effects upon ground temperature, soil moisture regime, active layer development, ice content of underlying soils, the annual temperature regime and the energy flux at the air-snow and snow-ground surface interfaces.

Location: Canoe Lake, Richardson Mountains, N.W.T. (68°4'N, 135°30'W.)

Publications: Peterson, N. J. K. (1974)

Project Completed

PROJECT G-73-4

BOOT CREEK AND PETER LAKE RESEARCH WATERSHEDS, N.W.T.

Principal Investigators: J. C. Anderson and J. N. Jasper

Cooperative Agencies: Atmospheric Environment Service; Water Survey of Canada; Mackenzie Highway Environmental Working Group

Objectives:

1) To measure components of the water balance in a tundra (Peter Lake) and a taiga (Boot Creek) watershed;

2) To examine the data collected in order to establish statistical parameters (variability, etc.) of the individual hydrologic variables and to ascertain relationships existing between variables;

3) To apply results of this research to hydrologic aspects of engineering design and construction (e.g. roads; community water supply).

Time Period: Open water season.

Location: Mackenzie Delta Region, N.W.T.;

Boot Creek Basin (68°22'N, 133°33'W)
Peter Lake Basin (68°45'N, 134°8'W).

Previous Work: Data collection at Boot Creek in 1967. Project resumed in 1970, with data collection at both basins. Focus has been on measurement and analysis of precipitation and runoff data, and establishment of relationships between the two variables.

Work in Progress: Continued data collection and analysis by J. N. Jasper, as part of Project G-73-13.

Future Work: Continued data collection and analysis.

Publications: Anderson, J. C. (1974)
Anderson, J. C. and D. K. MacKay (1974).

PROJECTS G-73-5

TWISTY CREEK WATERSHED STUDY

Principal Investigator: J. N. Jasper

Cooperating Agencies: None

Objectives:

1) To collect base meteorologic and hydrologic data for a subarctic upland watershed;

2) To evaluate temporal relationships between rainfall, runoff, and erosion in the catchment;

3) To determine the magnitude and significance of extreme events and their influence on engineering problems in the north.

Location: Foothills of the Mackenzie Mountains, N.W.T. at Longitude 131°16'W, Latitude 65°23'N.

Previous Work: See publications.

Work in Progress: Field work completed in August, 1974 after third field season.

Future Work: Writing of summary report on the study.

Publications: Jasper, J. N. (1973, 1974a, 1974b, 1976b)
Sellars, C. D. (1973a).

PROJECT G-73-13

HYDROLOGIC STUDIES AT CULVERT SITES ON THE MACKENZIE HIGHWAY

Principal Investigator: J. N. Jasper

Cooperating Agencies: Atmospheric Environment Service, Department of Public Works; Ministry of Transport; Water Survey of Canada

Objectives: To investigate hydrologic processes in a number of small watersheds in the Mackenzie Valley and to assist in establishing construction guidelines in the area by:

1) collecting basic data on snowmelt, rainfall, and runoff in the selected drainage basins;
2) determining temporal relationships between meteorologic parameters and streamflow and representing them in a simple mathematical model;
3) extending streamflow data to ungauged basins and through time by extrapolation of long term climatic data available at nearby meteorologic stations; and
4) deriving estimates of the magnitude and frequency of extreme events in small watersheds in the region and their influence on engineering design.

Time Periods: April - September inclusive

Location: In a number of drainage basins along the route of the Mackenzie Highway, from Wrigley to Tuktoyaktuk, N.W.T.

Previous Work: See publications

Work in Progress: Analysis of 1976 snowmelt and summer flow periods is almost completed.

Future Work: Spring runoff will continue to be monitored in the original 5 study basins as well as in some 15 others. Summer precipitation and streamflow will be recorded in those drainage basins exhibiting marked response to summer rainfall. In addition, mountainous basins in the Wrigley, N.W.T. area will be studied intensively during 1977 to document their response characteristics to heavy summer rainfall.

Publications: Jasper, J. N. (1974c, 1976a)
Sellars, C. D. (1973b).

PROJECT G-74-1

ARCTIC ISLAND PIPELINE STUDIES

Principal Investigator: D. K. MacKay, B. J. Grey and J. P. Chyurlia

Cooperating Agencies: Water Survey of Canada

Objectives: In general, to study aspects of hydrology relevant to environmental assessment of construction, operation and maintenance of proposed Arctic Island pipelines.

More specifically, in 1976 to carry out:

1) Aerial and ground examination of spring break-up on river stretches crossed by the proposed Polar Gas pipeline route between 60°N. Lat. and Spence Bay. Emphasis is placed on the fluvial geomorphic response of channels to ice shove and ice jamming and on the physical characteristics of ice jams. The proposal is to photograph 10 line miles at major crossings and to analyze the air and ground data to report preparation and publication stage; and

2) A study of lakes north of Spence Bay suitable as water supply lakes for pipeline construction and operation. The emphasis is placed on the physical limnology, particularly the ice cover, temperature and bathymetry parameters.

Location: Along proposed Arctic Island pipeline route.

Publications: Grey, B. (1975)

PROJECT G-75-1 (Geological Survey of Canada, Project 740079)

HYDROLOGIC RECONNAISSANCE, THOMSEN RIVER BASIN,
BANKS ISLAND, DISTRICT OF FRANKLIN, N.W.T.

Principal Investigator: J. C. Anderson

Cooperating Agencies: Geological Survey of Canada (Terrain Sciences Division); Polar Continental Shelf Project; Hydraulics Research Division (C.C.I.W.); Applied Hydrology Division (Special Surveys; Sediment Surveys); Water Survey of Canada.

Objectives: To obtain an insight into some elementary hydrologic processes, in an environment where very little hydrologic research has been conducted. The basic objectives were:

1) To measure discharge of the Thomsen River Basin (above 73°14'N) and three tributaries of the Thomsen;

2) To make observations on snow distribution, snowmelt, and river ice;

3) To take periodic samples for suspended sediment concentration and for basic water chemistry, of the Thomsen and its tributaries;

4) To obtain meteorologic data at the Thomsen River camp;

5) To establish relationships, where possible, between the various hydrometeorologic variables which were studied.

Location: Central Thomsen River Basin, eastern Banks Island, N.W.T.

Previous Work: None.

Work in Progress: Preliminary report of findings completed. Data analysis and preparation of final report are continuing.

Future Work: Terminate reconnaissance study with issue of final report in 1976.

Publications: Anderson, J. C. and R. L. Durrant (1976)
Day, T. J. and J. C. Anderson (1976)

PROJECT G-75-2

WATER QUALITY AND SNOWMELT RUNOFF IN D'IBERVILLE FIORD

Principal Investigator: J. P. Chyurlia

Cooperating Agencies: Water Survey of Canada (Halifax); Frozen Sea Research Group (Victoria).

Objectives:

1) To establish relationships between water quality parameters and snowmelt runoff rates;

2) To investigate soil temperature and soil heat flux variations in time and space during the snowmelt season;

3) To compare the dissolved solids composition of runoff waters to the salinity of the fiord water;

4) To investigate rates of snowpack disappearance in relation to soil moisture changes and hydrometeorological factors.

Location: D'Iberville Fiord, Ellesmere Island, N.W.T.; Hull, Quebec

Previous Work: Internal report entitled: "Water Quality and Snowmelt Runoff - D'Iberville Fiord - June 1975" has been written. All data have been analyzed.

Work in Progress: Report is being written for publication.

Project Completed

PROJECT G-75-3a

HYDROLOGIC RECONNAISSANCE: SOMERSET ISLAND, DISTRICT OF FRANKLIN

Principal Investigator: B. J. Grey

Cooperating Agencies: Water Survey of Canada; Geological Survey of Canada

Objectives: To examine the drainage systems and the distribution of semi-permanent snow on Somerset Island. To observe temporal changes in river flow of the Hunting River and to monitor the melting of a semi-permanent valley-bottom snowbank. To estimate snowmelt flood potential for possible pipeline crossings.

Location: Somerset Island, District of Franklin (72°N to 74°N and 90°W to 96°W).

Reference: Grey, B. J. (1975).

Project Completed

PROJECT G-75-3b

SEASONAL SNOWLINES FROM LANDSAT IMAGERY,
SOMERSET ISLAND AND BOOTHIA PENINSULA
1973, 1974 AND 1975

Principal Investigator: B. J. Grey

Cooperating Agency: Water Survey of Canada

Objectives: To map the changing snow pattern using the satellite imagery for the stated years. To attempt to explain the pattern of snow loss in terms of physiographic controls and snow accumulation and redistribution factors.

Location: Somerset Island and Boothia Peninsula, District of Franklin, N.W.T.

Reference: Grey, B. J. (1976a).

Project Completed

PROJECT G-76-1

WATER QUALITY AND BREAK-UP IN A SMALL ARCTIC LAKE NEAR BAKER LAKE, NORTHWEST TERRITORIES

Principal Investigator: J. P. Chyurlia

Cooperating Agency: Water Survey of Canada (Winnipeg)

Objectives:

1) To monitor snowmelt and break-up rates in a small basin in the vicinity of Baker Lake, N.W.T.;

2) To monitor variations in water quality parameters during the snowmelt period with specific reference to dissolved oxygen and carbon dioxide;

3) To monitor soil moisture during the snowmelt season;

4) To monitor soil temperatures and meteorological parameters during the snowmelt period.

Location: Baker Lake, N.W.T. and Hull, Quebec

Previous Work: None

Work in Progress:

1) Runoff data has been analyzed and basin mapped via aerial photographs;

2) Dissolved oxygen and $CO_2(g)$ concentration in runoff waters have been computed;

3) Lake temperature data and time-lapse photography record of break-up pattern is presently being investigated.

Future Work: Further data analysis and writing of report to be submitted to Glaciology Division.

PROJECT G-76-2

SNOWMELT RUNOFF STUDIES IN A TAIGA ENVIRONMENT

Principal Investigator: J. C. Anderson

Cooperating Agencies: Atmospheric Environment Service.

Objectives:

1) To select a small, open woodland basin near Inuvik, suitable for this study;

2) To measure snowpack water equivalent in the basin prior to spring snowmelt;

3) To assess snowpack water equivalent variation over the basin, owing to differences in surface exposure and surface cover;

4) To study the thermal regime of the active layer in a permafrost environment, during snowmelt;

5) To observe snow cover ablation, meltwater infiltration and runoff, in hummocky terrain, in order to gain a better understanding of snowmelt runoff processes in the taiga environment.

Time Period: Spring-summer field season.

Location: Near Inuvik, N.W.T.

Previous Work: Thermistors and soil moisture cells installed at seven sites in lower Boot Creek Basin in the autumn of 1973. Some data obtained the following summer, after snowmelt.

Work in Progress: Preparation to study and instrument a smaller watershed in the taiga zone, near Inuvik.

Future Work: Reconnaissance during snowmelt season to obtain suitable watershed, and make preliminary measurements and observations of snowmelt processes. Install thermistors at chosen sites in autumn, 1976.

PROJECT G-76-3

GLACIERS IN NATIONAL PARKS

Principal Investigator: W. E. S. Henoch

Cooperative Agencies: Surveys and Mapping Branch, Parks Canada (Department of Indian and Northern Affairs)

Objectives: To produce a series of high quality maps of glacierized regions in Canada for multiple use. These maps will conform to requirements for glaciological research in addition to being of value to a wide range of map users in alpine environments.

Previous Work: None

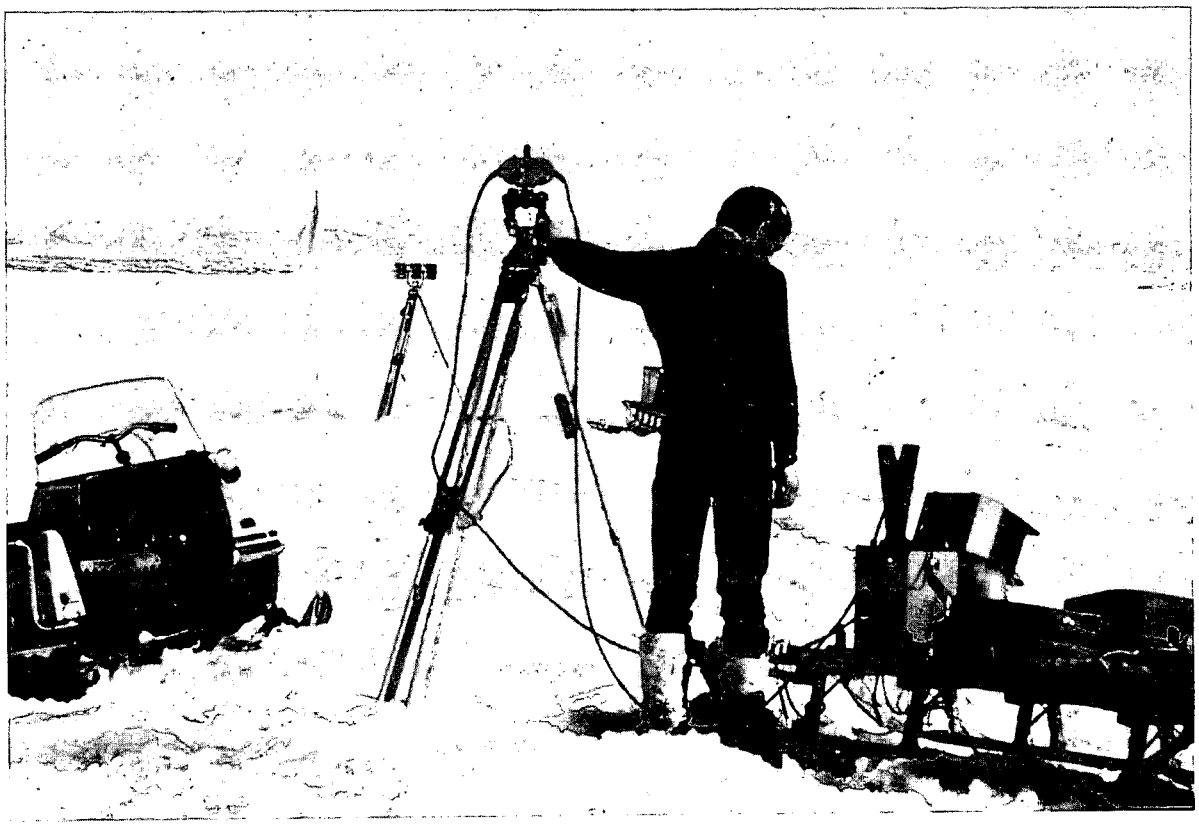
Work in Progress: Consultations with Parks Canada and Surveys and Mapping Branch on mapping glacier and alpine regions in National Parks.

Future Work: Depends on further cooperation between interested agencies.

Publications: Henoch, W. E. S., and Croizet, J. L. (1976).

Glacier

Greenland icebergs off coast of Newfoundland. ▲



▼ Ice strain surveying on Barnes Ice Cap.

PROJECT G-67-11

BARNES ICE CAP STUDIES

Principal Investigator: G. Holdsworth

Cooperating Agencies: Surveys and Mapping Branch, Geodetic Survey, (Department of Energy, Mines and Resources); University of Minnesota; University of Victoria, B.C.; University of Cambridge, England; McMaster University.

Objectives: To determine the thermal and flow regimes and the mass balance of the South Dome area of the Barnes Ice Cap. To identify significant parameters connected with the surge area on the south part of the South Dome and to construct a surge model for an ice cap with cold edges.

Location: Barnes Ice Cap, Baffin Island (70°10'N, 73°30'W).

Previous Work: Movement, strain, mass balance in 1970-1971; 1974-1975. Echo-sounding for ice thickness determination, 1970-1974. Deep temperature measurements, 1975. Strain rates, 1976.

Work in Progress:

1) Assessment of the mass balance of the South Dome up to 1976 is being completed. Deformation data for the 1970-71 period have been prepared for publication.

2) Reduction of velocity, strain rate and temperature measurements are being undertaken for 1974-75.

3) An outline of a surge model for a sub-polar ice cap is being studied.

Future Work: Major field work is nearly completed. More deep thermistors will be emplaced in 1979 using hot water drills. Sensitive wire strain meters will be installed at key locations over the surge area in 1979 in order to help find the switch-over from wet to frozen base. Surveys will include remeasurement of the poles established in 1974 and 1975. Modelling of the surge in 3 dimensions will be done using the finite element method (McMaster University).

PROJECT G-67-15

GLACIER INVENTORY

Principal Investigator: C. S. L. Ommanney

Cooperating Agencies: None

Objectives:

1) To prepare an inventory of perennial ice and snow masses on and beneath the land surfaces in accordance with the UNESCO recommendations.

2) To develop the necessary computer programs for storage, analysis and reduction of the glacier inventory data.

3) To investigate, on the basis of the collected data, factors that influence the geographical distribution and types of ice masses, the role of perennial ice in the Canadian water balance and changes over time caused by climatic change and environmental degradation.

Location: Hull, Quebec.

Previous Work: The progress of the Canadian Glacier Inventory has been summarised by Müller and Ommanney (1971) and by Ommanney (1971b and 1974b). The procedures manual for the glacier inventory was revised in 1973 (Ommanney et al., 1973).

A computer program for obtaining totals, averages, weighted averages and histograms from the data so far collected (Axel Heiberg Island and Vancouver Island) has been converted to run on a CDC 6400 computer.

Work in Progress: Recently emphasis has been on the identification and glacier delineation aspects of the study with resulting progress on the Glacier Atlas of Canada (G-69-1) but little data acquisiton.

Future Work: The inventory will be extended to include all perennial ice areas in Canada. Analysis of data and selection of suitable benchmarks for continuous monitoring will follow. All data will be published in a series of Glacier Inventory of Canada reports. Consideration will be given to undertaking a ground ice and permafrost inventory.

PROJECT G-67-16

DETERMINATION OF ICE ABLATION BY TERRESTRIAL PHOTOGRAMMETRY

Principal Investigator: K. C. Arnold

Cooperating Agencies: Polar Continental Shelf Project; Department of Energy Mines and Resources; McGill University; Geographical Institute, Swiss Federal University of Technology.

Objectives: To measure ice ablation by photogrammetric methods, which have an accuracy of approximately ±10 cm, in order to:

1) develop a system for measuring the movement and height change of bench-mark glaciers, with special reference to those changes taking place within a single ablation period.

2) by developing a sufficiently adequate model of all the factors causing the height of a specific point on a glacier to change, develop a technique for estimating ablation at a far larger number of points on a glacier than can be economically attained with the conventional ablation stake method.

Location: White Glacier, Axel Heiberg Island, N.W.T. (79°28'N, 90°45'W).

Previous Work: Peyto Glacier (1966-68), Per Ardua Glacier, Ellesmere Island, N.W.T. (1964, 1966, 1968) and White Glacier, Axel Heiberg Island (1969-1970) have been photographed with the Wild-P-30 photo-theodolite. Emphasis has been given to the working up of the White Glacier data. A Ph.D. thesis will be submitted shortly to McGill University, and the ideas contained in the thesis will be examined at that time.

Future Work: As terrestrial photogrammetry involves setting a field party out on the ground each time photos are taken, from a logistic point of view it appears impracticable to base an annual survey of several glaciers in the High Arctic on this method. Project G-71-5 was designed to make use of aerial photography, to allow a larger sample of glaciers to be photographed near the end of the budget year and so extend our knowledge of glacier variations in the High Arctic. As terrestrial photogrammetry is often superior to aerial photogrammetry for the study of small features at close range, its use should be very seriously considered when embarking on detailed surveys, on a yearly or more frequent basis, of a single bench-mark glacier.

PROJECT G-69-1

GLACIER ATLAS OF CANADA

Principal Investigator: C. S. L. Ommanney

Cooperating Agencies: Surveys and Mapping Branch, Department of Energy, Mines and Resources.

Objectives: To compile and publish index maps showing the location and identification of every glacier in Canada, as part of the national and international hydrological program for an inventory of perennial ice and snow masses.

Location: Hull, Quebec

Previous Work: 48 maps covering Axel Heiberg Island, Devon Island, Baffin and Bylot islands, the Nelson River drainage basin, index maps of these areas, Vancouver Island and two maps from Ellesmere Island have been published.

Work in Progress: A French language edition of the Glacier Atlas of Canada map sheets compiled to date is in preparation. Maps covering all but one major basin in Ellesmere Island have been compiled and are in stages of preparation for publication. Basic mapping and identification of glaciers in the Canadian portion of the St. Elias Range, Yukon Territory, is near completion. Further compilation is being done in the Columbia River basin, part of the Pacific drainage.

Future Work: Index maps for all the glaciers in Canada will be compiled and printed at a scale of 1:500,000. Maps issued individually when completed, will be included with the glacier inventory reports and, at the termination of the project, be presented as a complete Glacier Atlas of Canada.

PROJECT G-69-2

GLACIOLOGICAL ARCHIVE

Principal Investigator: C. S. L. Ommanney

Cooperating Agencies: Archives of the Canadian Rockies; American Geographical Society; World Data Centre A, Glaciology, Boulder, Colorado.

Objectives: To develop a glaciological archive, referenced to the glacier inventory index numbers (Project G-69-1), for filing all available information on individual ice masses in Canada in the form of data sheets, maps, photographs, published and unpublished literature.

Location: Hull, Quebec

Work in Progress: Aerial photography of the Canadian Cordillera acquired by Austin Post in 1972 was obtained from the U.S. Geological Survey.

Virtually all the issues of the Canadian Alpine Journal have now been reviewed with a view to identifying individuals who may have information on glaciers suitable for deposit in the archive.

In cooperation with the Canadian Alpine Club and the Canadian Exploration Group, new glacier photographs were obtained from Baffin Island and the Selkirks.

A comprehensive list of all glacier names is being prepared.

Future Work: All glacier information obtained or kept with Federal, Provincial, Municipal and private sources will be identified. When possible, foreign sources of information on Canadian glaciers will also be identified.

Individuals will be encouraged to observe glaciers and photograph them, depositing the records in the archive.

PROJECT G-70-2

ICEBERG PRODUCTION SURVEY IN ARCTIC CANADA

Principal Investigator: C. S. L. Ommanney and K. C. Arnold

Cooperating Agencies: Polar Continental Shelf Project and Department of National Defence.

Objectives: To investigate the distribution of tidal glaciers in Arctic Canada, the present rate and volume of iceberg production and variations during the past 25-30 years.

Location: Queen Elizabeth Islands, N.W.T. and Hull, Quebec.

Previous Work: Calving glaciers in Baffin, Bylot, Devon, Axel Heiberg, Coburg and Southern Ellesmere islands have been identified through the Glacier Inventory project. Since 1971, aerial photography of most of the calving glaciers in the High Arctic has been obtained, through Project G-71-9. (Løken and others, 1972).

Work in Progress: Calving glaciers in the remaining parts of Ellesmere Island are being identified. The aerial photography programme continues.

Future Work: The identification of all calving glaciers, based on 1960 aerial photography, will be completed. Our own aerial photography programme continues. Using the 1960 high level (11,111 - 22,222 M ASL) photography as a datum, the later photography will be used to assess changes in calving activity and flow rates. Selected glaciers will be photographed more frequently to determine ice discharge and shorter-term changes in the position of termini. Our aerial photography program provided data for a similar project, G-72-1.

PROJECT G-71-5

REGIONAL MASS BALANCE MEASUREMENTS IN THE QUEEN ELIZABETH ISLANDS, USING AERIAL PHOTOGRAMMETRY

Principal Investigator: K. C. Arnold

Cooperating Agency: Polar Continental Shelf Project

Objectives: This project was conceived as a practical continuation to G-67-16. By extending the limited number of mass balance measurements made in the conventional manner to a larger number of locations, regional and altitudinal variations in mass balance might be determined, and the concept of "representative" glaciers might be tested. Dynamically simple ice bodies were chosen, as mass balance changes can then be more easily deduced from height changes. Low altitude aerial photography was planned for the end of the budget year at all sites, and for both the beginning and end of the melt season at a limited number of sites.

Location: Queen Elizabeth Islands, N.W.T.

Previous Work: Five sites on Axel Heiberg Island and one on Meighen Island have been chosen. These are:

Axel Heiberg Island:	Cape Stallworthy	Photo	Control
	"Mokka Ice Cap"	Photo	No Control
	"Sherwood Head Ice Cap"	Photo	No Control
	"Good Friday Ice Cap"	Photo	No Control
	"Li Fiord Ice Cap"	Photo	No Control
Meighen Island:	North end of ice cap	Photo	Control

Work in Progress: In general, aerial photography has not been obtained at the onset of the ablation season. This can occur between June 1st and July 15th. The photo-aircraft is shared with others on a fixed-date basis. Supplementary control was established on Meighen Island and around the central ice cap at Cape Stallworthy in 1972. This was accomplished with Twin Otter support. Later in the season, this aircraft, on wheels, was not able to land on the ice cap at Sherwood Head. A helicopter is necessary to establish the ground control, but this has not been available during the period when the land is free of snow.

Future Work: Dependent on the acceptance of ideas presented in G-67-16, and on logistic support for regional mass balance studies. The lack of a photogrammetric plotting technician has been a difficulty. This is expected to become less important with the increasing use of automated orthophotography.

PROJECT G-71-9

ARCTIC AERIAL AND SCIENTIFIC PHOTOGRAPHY

Principal Investigators: K. C. Arnold, D. A. Sherstone, A. C. D. Terroux, and D. M. Christian (logistics)

Cooperating Agencies: Polar Continental Shelf Project, Department of Energy, Mines and Resources

Objectives: Originally, to take aerial photography for projects G-70-2 (Iceberg Production) and G-71-5 (Regional Mass Balance), in an area where specific (but not fixed-date) timing, remote location or the small size of the areas to be photographed made the usual contract system unsuitable. Other Glaciology Division projects, other Federal Government programs and other scientists assisted by the Polar Continental Shelf Project (about 50 projects in all) have been assisted by the A.A.A.S.P. project.

Location: Mackenzie Valley (1st - 31st May); Arctic Islands (1st June, 24th June - 9th July, and 24th July - 14th August)

Previous Work:

1) Aerial photography: All exposures meeting the standards of the Interdepartmental Committee on Air Surveys are kept in the National Photo Library.

2) A.A.A.S.P. Publications:

MacKay, D. K., Sherstone, D. A., and Arnold, K. C. (1974)
Sherstone, D. A., Arnold, K. C., and MacKay, D. K. (1974)

See previous catalogues for publications prior to 1974.

3) Exhibitions: 12th International Photogrammetric Congress, 1972
20th International Geographical Congress, 1972.

Work in Progress: In 1976 photography of the Mackenzie River break-up continued, and sites in the Arctic Islands are to be photographed to give a continuous record, weather permitting.

Future Work: Subject to the continuing availability of an aerial photo aircraft, this project is a continuing one.

PROJECT G-72-1

ICEBERG PROJECT

Principal Investigator: G. Holdsworth

Cooperating Agency: Polar Continental Shelf Project

Objectives: To determine the discharge rate of a typical Ellesmere Island tidewater glacier and to understand the factors leading to calving of icebergs, in terms of glacio/oceanographic parameters.

Location: Leffert Glacier and D'Iberville Glacier, Ellesmere Island. (78°40'N, 75°15'W) (80°34'N, 78° W)

Previous Work: Field work completed on Leffert Glacier, 1972. Aerial photography of D'Iberville Glacier, 1974-75.

Work in Progress: Field data from Leffert Glacier is to be reduced, and maps to be prepared up till 1975. Some published data to appear in: "Tidal interaction with ice shelves" (Paper presented at I.U.G.G. Conference, Grenoble, France, August 1975).
Interpretation of photogrammetric data from D'Iberville Glacier.

PROJECT G-72-2

BIBLIOGRAPHY OF CANADIAN GLACIERS (ICEREF)

Principal Investigator: C. S. L. Ommanney

Cooperating Agencies: Computer Science Centre, Department of Energy, Mines and Resources

Objectives: To make available a computerized reference system for all bibliographic material on Canadian glaciers.

Location: Hull, Quebec

Previous Work: The project is designed around the RAID system used for storage and retrieval of geological information. To date 1750 have been key-worded for inclusion. A procedures manual for coding references has been published (Ommanney and Clarkson, 1973). Canadian glacier studies during the past 15 years were reviewed in 1975 (Ommanney, 1975).

Work in Progress: References in the following journals - Arctic, Canadian Alpine Journal, Canadian Geographic, Alpine Journal, Arctic and Alpine Research, and the Geographical Bulletin are being systematically processed for inclusion in ICEREF.

A comprehensive bibliography of Canadian glacier studies during the period 1960-1975 with abstracts is being prepared.

A bibliography of all rock glacier studies with cross-references is being compiled.

Future Work: The estimated 6,000 references related to Canadian glaciers and neighbouring mountain topography will be key-worded for input to ICEREF.

A cross-referenced thesaurus of acceptable key-words will be produced.

Photographic records will be coded for input so that photographic and literature references for individual glaciers can be retrieved together.

PROJECT G-72-3

GLACIATION LEVELS AND EQUILIBRIUM LINE ELEVATIONS IN THE CANADIAN HIGH ARCTIC

Principal Investigators: C. S. L. Ommanney - work done on contract by J. T. Andrews, Institute of Arctic and Alpine Research, Boulder, Colo.

Cooperating Agency: University of Colorado, INSTAAR

Objectives: To map the glaciation levels and equilibrium lines between latitudes 74° and 84°N and between longitudes 60° and 120°W and thus to provide a fundamental measure of the present state of glacierization; information on the sensitivity of the region to climatic change, a measure of the relationship of the present glaciation level to the contemporary climate and an integrated, regional, climatic picture to supplement that obtained from existing weather stations.

Previous Work: The project was completed in 1974 and the results published in Arctic and Alpine Research (Miller, Bradley and Andrews, 1975).

Project Completed

PROJECT G-72-4

IRRP GLACIER INVENTORY PROGRAM,
ST. ELIAS MOUNTAINS

Principal Investigator: C. S. L. Ommanney - work done on contract through the University of British Columbia by S. G. Collins.

Cooperating Agencies: Arctic Institute of North America; American Geographical Society.

Objectives: To complete an inventory of glaciers in the St. Elias Mountains in accordance with International and Canadian specifications for glacier inventory studies.

Locations: Hull, Quebec; Council Bluffs, Iowa; St. Elias Mountains, Yukon Territory and British Columbia.

Previous Work: All glaciers falling within drainage basins situated exclusively in the Canadian part of the St. Elias Range have been inventoried since 1972 under contract with the Arctic Institute of North America. Data collected consists of all basic data required except for measured areas. Source materials have been identified.

Work in Progress: Inventory investigation and compilation are in the final stages of completion.

Future Work: On completion of basic inventory requirements, a report containing all data, photographic and bibliographic sources will be submitted and published.

PROJECT G-73-6

ICE SHELF STUDIES

Principal Investigator: G. Holdsworth

Cooperating Agencies: Department of Defence (Defence Research Board); Parks Canada; Polar Continental Shelf Project.

Objectives:

1) To establish a calving model for the northern Ellesmere Island ice shelves and to predict the size of ice islands;

2) To examine the break-up of ice islands.

Location: Ward Hunt Ice Shelf, Ellesmere Island (83°10'N, 75°W) and Hull, Quebec

Previous Work: Contract with Department of Civil Engineering, University of Calgary to study vibration of rectangular ice plate.

Work in Progress: Preliminary model established.

Future Work: Development of more refined model. Monitoring of ice shelf build up and/or decay, geophysical measurements: 1979,80.

PROJECT G-73-7

SURGING GLACIER STUDIES - CORDILLERA

(see also Project G-67-11)

Principal Investigator: G. Holdsworth

Cooperating Agencies: Water Survey of Canada; U.S. Geological Survey

Objectives: To maintain observations covering surge-type glaciers in the Alsek River area of Yukon Territory: to relate the surge behaviour of these glaciers to physical parameters, leading to a possible basis for prediction of surges on these glaciers.

Location: Tweedsmuir Glacier, British Columbia (59°45'N, 138°W) and environs.

Previous Work:

1) Terrestrial photography 1973, 1974, 1975 of Tweedsmuir Glacier; Aerial photgraphy, 1973, 1974.

2) Investigation of surge response characteristics.

Work in Progress:

1) Completion of maps

2) Analysis of data extracted from maps and ERTS-1 imagery.

Future Work: Possible temperature/movement studies on Lowell Glacier.

PROJECT G-74-2

STREAM VELOCITY MEASUREMENT USING REMOTE SENSING

Principal Investigator: D. A. Sherstone

Cooperating Agency: Polar Continental Shelf Project, Department of Energy Mines and Resources

Objectives: To determine water velocity measurements of ice-choked northern rivers during break-up using stereophotogrammetry in areas where only rudimentary survey control is in existence.

Location: Several test areas along lower Liard and main stem of Mackenzie rivers.

Previous Work: Preliminary stereo plotting of test sites completed using 1972, 1973 and 1974 photography in testing usefulness of method to arctic hydrology research. For results see publications.

Work in Progress: Stereo plotting of 1975 photography and standardization of all previous work to permit interrelating yearly values.

Future Work: Study of ground water level values (where available) with photogrammetrically derived data. Examination of stream cross profiles to determine flow relationship to bed profile.

Publications: MacKay, D. K., Sherstone, D., and Arnold, K. C. (1974).

PROJECT G-74-11

MOUNT LOGAN STUDIES

Principal Investigator: G. Holdsworth

Cooperating Agencies: Arctic Institute of North America; Geological Survey of Canada; Geophysical Isotope Laboratory (Copenhagen); Radiation Protection Laboratory, Ottawa; Atmospheric Environment Service.

Objectives: To extract an ice core from the plateau glacier on Mount Logan for palaeo-climatic studies.

Location: Mount Logan, St. Elias Mountains, Y.T. (60°35'N; 140°30'W)

Previous Work: Establishment of Geodetic control on the plateau of Mount Logan in 1974 and 1975. Reconnaissance of proposed drill site on NW Col, 1975, 1976.

Work in Progress: Analysis of snow samples for Tritium and $\delta(^{18}O)$ variations over the last decade. Analysis of strain, movement and ice depth on the N.W. Col. Formulation of a suitable depth-time model for shallow deposits of cold snow and iced-firn.

Future Work:

1977 - Installation of geodesic domes on N.W. Col.
Installation of automatic weather stations.

1978 - Proposed drilling on the N.W. Col. Analyses expected to continue through 1980.

PROJECT G-75-16

STEREO-ORTHOPHOTOGRAPHY OF GLACIER BASINS

Principal Investigator: C. S. L. Ommanney with K. C. Arnold, W. E. S. Henoch, I. A. Reid and G. J. Young

Cooperating Agencies: Forestry Management Institute; Gestalt International, Vancouver.

Objectives: To assess the accuracy of a new automated orthophotograph technique for the mapping of glacier basins.

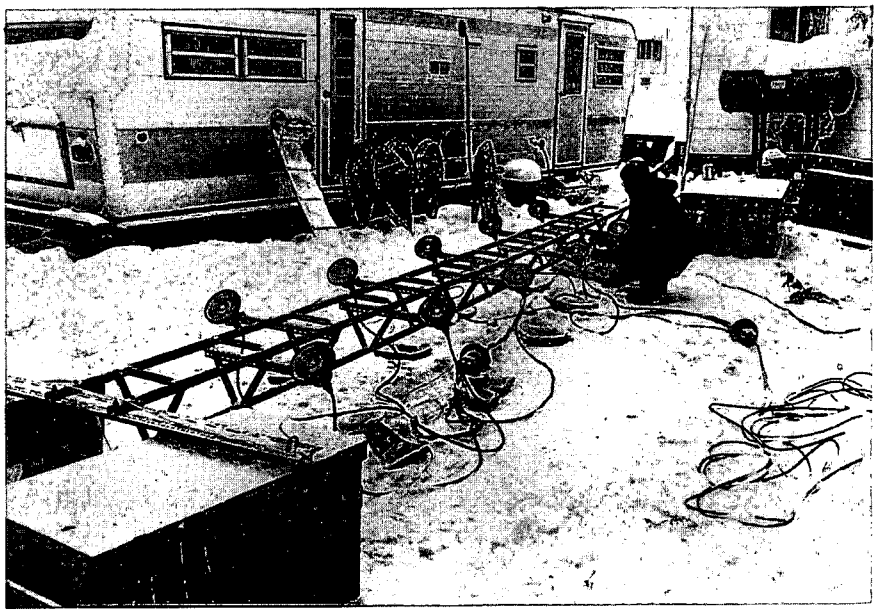
Location: Ottawa

Previous Work: Gestalt International has perfected a system for automated production of stereo-orthophotographs with simultaneous production of stereo-mate and digital terrain models.

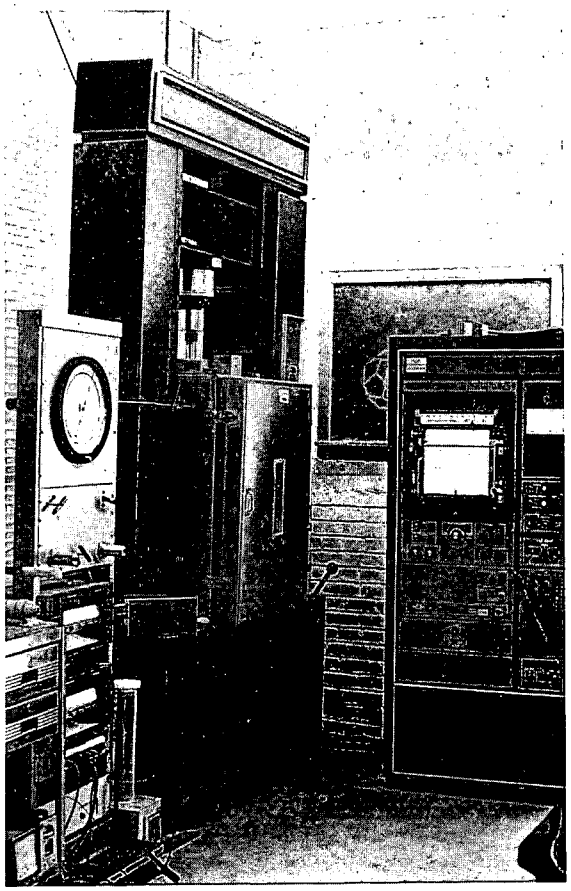
Present Work: The Forestry Management Institute is currently testing the capabilities of the system and the mapping of glaciers is part of this testing. Aerial photographs of the Peyto Glacier Basin will be used. Detailed maps have already been compiled by conventional techniques using these same photos and thus a direct evaluation of the new system will be possible.

Future Work: This technique holds very great promise for fast and efficient compilation of maps. It is particularly suited to areas of rapidly changing terrain as in the vicinity of glacier termini.

Ice Properties



Underwater solar radiation collector being prepared for installation under the ice cover at Lake St. George, Ontario.



Mechanical tester used for triaxial testing of ice.

PROJECT G-72-12

RADIO DEPTH SOUNDING OF BARNES ICE CAP

Principal Investigator: S. J. Jones

Cooperating Agencies: None

Objectives: To determine the depth of part of the Barnes Ice Cap, Baffin Island; to compare results at 35 MHz and 620 MHz radar frequencies; to measure attenuation in the ice.

Location: Barnes Ice Cap, Baffin Island, N.W.T.

Previous Work: See previous Project Catalogue

Present Work: Compilation of depth measurements on South Dome of the Barnes Ice Cap and preparation of maps and a report showing the depths.

Future Work: None planned.

PROJECT G-72-22

OIL POLLUTION IN ICE COVERED RIVERS

Principal Investigators: B. Keevil and R. O. Ramseier

Publications:
Keevil, B. E. (1974)
Keevil, B. E. and R. O. Ramseier (1974)
Keevil, B. E. and R. O. Ramseier (1975).

Project Completed

PROJECT G-73-2

VELOCITY AND ATTENUATION IN ICE FOR RADIO-ECHO SOUNDING

Principal Investigator: G. P. Johari

Cooperating Agency: None

Objectives: To determine the velocity and attenuation of electromagnetic waves in ice at frequencies relevant to radio-echo sounding. Measurements are to be made at several temperatures on both polycrystalline and single crystal ice and the effect of anisotropy in ice on the radio-echo sounding to be investigated.

Location: 562 Booth Street, Ottawa

Previous Work: None by the Ice Properties Section

Work in Progress: (March, 1976) Results have been obtained.

Future Work: Effect of the anisotropic properties of ice on the radio-echo sounding is to be continued.

Publications: Johari, G. P. and Charette, P. A. (1975).

PROJECT G-73-3

MECHANICAL PROPERTIES OF ICE UNDER HYDROSTATIC PRESSURE

Principal Investigator: S. J. Jones

Cooperating Agencies: None

Objectives: To determine the effect of a superimposed hydrostatic pressure on the mechanical properties of ice; to determine activation volumes for the flow of single crystal and polycrystal ice; to see what effect hydrostatic pressure has on the "flow law" for ice.

Location: 562 Booth Street, Ottawa, Ontario

Previous Work: None by Ice Properties Section

Work in Progress: Preliminary results have been obtained at -12°C in the strain-rate range 10^{-6} to 10^{-3} s^{-1}.

Future Work: Continue experiments and write report.

PROJECT G-74-6

MECHANICAL PROPERTIES OF ICE AT 77K

Principal Investigator: S. J. Jones

Publication: Parameswaran, V. R. and Jones, S. J. (1975).

Project Completed

PROJECT G-74-7

ELECTRICAL BEHAVIOUR OF HEAVY (D_2O) ICE

Principal Investigator: G. P. Johari

Publications: Johari, G. P. (1976a)
Johari, G. P. and Jones, S. J. (1976a)
Johari, G. P. and Jones, S. J. (1976b)

Project Completed

PROJECT G-74-8

GROWTH OF ZONE REFINED ICE CRYSTALS

Principal Investigator: S. J. Jones

Cooperating Agencies: None

Objectives: To prepare pure and highly perfect single crystals of ice for future experiments both for our own and for other scientists' use.

Location: 562 Booth Street, Ottawa

Previous Work: None by Ice Properties Section. Apparatus has been developed.

Present Work: Eight large crystals (100 cm long by 10 cm cylindrical diameter) have been grown, including one D_2O, and one HF-doped sample. X-ray topography indicates they have a low dislocation density and dielectric measurements indicate high purity. Experiments by two other groups have been done on our samples - see references below.

Future Work: Further pure and impure samples will be grown.
Any scientist interested in obtaining samples for his own use should write in the first instance to Dr. S. J. Jones, outlining his requirements.

References:

Mai, C. 1976. Etude par topographie X du comportement dynamique des dislocations dans la glace Ih. Comptes Rendue Academie Science, Paris, t.282 B, pp. 515-518.

Fitzgerald, W. J., Glen, J. W. and Paren, J. G. 1976. Are the anomalous dielectric properties of polar ice due to impurities. Proceedings, Symposium on Isotopes and Impurities in Snow and Ice, I.U.G.G., Grenoble, 1975 (in press).

PROJECT G-74-9

MECHANICAL PROPERTIES OF ICE CLOSE TO ITS MELTING POINT

Principal Investigator: S. J. Jones

Cooperating Agencies: None

Objectives: To determine the flow behaviour of single crystal ice very close to its melting point and to compare the results with published polycrystal data.

Location: 562 Booth Street, Ottawa, Ontario

Previous Work: None

Present Work: Experiments are nearly finished and a report is in preparation.

Future Work: Publish Report.

PROJECT G-75-5

STUDY OF THE DISSOLVED GASES IN LABORATORY AND NATURAL ICE

Principal Investigators: S. J. Jones and G. P. Johari

Cooperating Agencies: None

Objectives: To do laboratory measurements of the effect of hydrostatic pressure on the gases present in ice. To investigate the extent to which natural gases can be physically or chemically dissolved.

Location: 562 Booth Street, Ottawa

Previous Work: No laboratory work in literature; none by Ice Properties Section.

Work in Progress: One report is in press (S. J. Jones and G. P. Johari, 1976).

Future Work: Long-term project on which the experiments are being continued.

PROJECT G-75-6

STORAGE OF ELECTRICAL CHARGE IN ICE

Principal Investigator: G. P. Johari

Cooperating Agencies: None

Objectives: To do experiments on the storage of electrical charge in ice and on its dissemination by thermal stimulation. To use it as a technique for investigating the alleged structural changes in the ice.

Previous Work: None by Ice Properties Section

Publications: G. P. Johari (1974 [b])

G. P. Johari (1975)

G. P. Johari and S. J. Jones (1975).

Project Completed

PROJECT G-75-7

ELECTRICAL PROPERTIES OF ICE IN THE RADIO-FREQUENCY REGION OF THE ELECTROMAGNETIC SPECTRUM

Principal Investigator: G. P. Johari

Cooperating Agency: None

Objectives: To investigate the effect of molecular vibrations on the electrical properties of ice and to complete the electromagnetic spectrum of ice. Measurements are to be made on ice in the radio-frequency region at different temperatures.

Location: 562 Booth Street, Ottawa

Previous Work: None by the Ice Properties Section

Work in Progress: (March, 1976) Results have been obtained

Future Work: To write the report for publication

Publications:

1) Johari, G. P. (1976 [a])

2) Johari, G. P. and Jones, S. J. (1976 [c]).

PROJECT G-75-8

LOW-FREQUENCY DIELECTRIC PROPERTIES OF ICE

Principal Investigator: G. P. Johari

Cooperating Agency: None

Objectives: To obtain data on the permittivity and adsorption in single-crystal ice at frequencies below 100 kHz. The measurements are to be extended to liquid Nitrogen temperature and are to be made along the various crystallographic axes of ice.

Location: 562 Booth Street, Ottawa

Previous Work: None by the Ice Properties Section

Work in Progress: (March 1976) Instrumentation is complete. Few data have already been obtained.

Future Work: This is a long-term project, the results of which are likely to appear in several reports. To continue experiments.

PROJECT G-76-4

BEHAVIOUR OF WASTE UNDER SIMULATED
CONDITIONS OF SUBSURFACE DISPOSAL. PHASE I

Principal Investigators: W. A. Adams, H. Chew, and C. Preston (P.D.F., 1976-78)

Cooperating Agency: Hydrology Research Division, Inland Waters Directorate

Objectives: To determine the changes in acidity and other chemical parameters of importance that occur when waste products are pumped into geological formations for storage or final disposal. Selected systems will be subjected to similar conditions of temperature and pressure in the laboratory with the objective being the prediction of the safety and/or feasibility of disposing of waste products in this manner.

Location: 562 Booth Street, Ottawa

Previous Work: Several reports by R. van Everdingen, Hydrology Research Division, Calgary, Alberta have outlined the geological and groundwater problems (e.g. Subsurface disposal of waste in Canada, Hydrologic Sciences Division, Confidential Report, 1970, and Inland Waters Directorate, Technical Bulletins 49, 78 and 82). High pressure studies of chemical equilibria and of modifications to aqueous systems have been conducted as part of the Inland Waters Directorate, Water Quality research program for several years. (e.g. Kingham et al. (1974), Davis et al. (1974), Chatterjee et al.(1974), Sze et al. (1975)).

Work in Progress: (March, 1976) Results from studies on several aqueous ionic equilibria and gaseous systems are being prepared for publication (manuscripts are available on $Th(NO_3)_4$ (Adams and Davis, 1972), HSO_4^- (Chatterjee and Adams, 1974) CH_4 and SO_2 (Sze and Adams, 1976)). Results on the interfacial energy between aqueous and organic phases are available. (Adams and Guarnaschelli, 1974). Raman spectroscopic and electrical conductivity measurements on aqueous phosphate solutions and gas hydrates in brine solutions under high pressure have begun (July 1976).

Future Work: Phase I will be a survey of chemical systems that are relevant to deep well disposal problems in Canada and will be used to select some representative systems for intensive study in the deep well simulation equipment in the Ottawa high pressure laboratory.

PROJECT G-76-5

OPTICAL PROPERTIES OF ICE AND SNOW

Principal Investigator: W. A. Adams

Cooperating Agency: None

Objectives: To establish the relation between the interaction of radiation (300 nm to 1000 nm) with ice and snow and the physical and chemical properties of the material by conducting laboratory measurements of optical transmission, scattering, and refractive index on well-defined samples.

Location: 562 Booth Street, Ottawa

Previous Work: None in Ice Properties Section

Work in Progress: (March, 1976) A single beam spectrophotometer has been assembled in a cold room for transmission studies of ice and snow samples. A light scattering photometer using laser sources (488.0 and 632.8 nm) has been tested on liquid samples. Feasibility studies of measurements of the anisotropic effect of pressure on the refractive index of ice are being made with a Fabry-Perot system used previously on liquids (Adams et al., 1976)

Future Work: When the sample handling techniques are perfected, the radiation transfer processes, reflection, diffusion and scattering will be studied for different well-characterized snow and ice types.

PROJECT G-76-6

SOLAR RADIATION ATTENUATION BY
SNOW AND ICE COVERED SURFACE WATERS

Principal Investigators: W. A. Adams and P. Flavelle

Cooperating Agency: Canada Centre for Inland Waters, Process Research Division

Objectives: To determine the attenuation of solar radiation for wavelengths between 300 to 1000 nm by the ice and snow cover over surface waters at various locations in Canada to establish general relations relating the location of the water bodies to the radiation regime experienced. Water quality and meteorological conditions at the site of such measurements will be monitored in order to aid in the classification of the waters into different radiation regime types.

Location: Southern Ontario - Lake St. George (40 km north of Toronto)
Northwest Territories - lakes in the vicinity of Inuvik.

Previous Work: Studies of the light penetration through ice covered lakes in the Mackenzie Delta (W. A. Adams et al., 1975) and through sea ice (W. A. Adams, 1974 and 1975) have been completed for broad band shortwave radiation. Similar studies near Ottawa have been conducted by R. J. Maguire (Inland Waters Directorate, C.C.I.W. Scientific Series No. 54 and Technical Bulletin No. 91).

Work in Progress: (March, 1976) A small lake near Toronto has been instrumented with continuous monitoring light sensors below the ice. Spectral profiles from 400 to 700 nm and diffuse shortwave radiation profiles are being taken to supplement the monitoring. Considerable water quality data is being accumulated on the lake by C.C.I.W. Similar studies were conducted on several lakes in the vicinity of Inuvik in May and June, 1976 and Resolute, July, 1976.

Future Work: Field studies making use of newly acquired instrumentation for under ice spectral measurements and existing monitoring equipment will be continued both in Southern Ontario and at locations in the Arctic to broaden the data base for waters experiencing different sun inclinations, climatic regimes and geographical conditions. The project will be long-term, but data collection on specific sites will result in publications as work is completed for various locations. Aerial photography and satellite imagery will be correlated with ground truth obtained from the field work.

PROJECT G-76-7

LIGHT INTENSITY AND PRIMARY PRODUCTIVITY
UNDER SEA ICE CONTAINING ENTRAPPED CRUDE OIL

Principal Investigator: W. A. Adams

Cooperating Agencies: 1) Fisheries and Marine Service, Pacific Region, Victoria
2) National Museums of Canada, Canadian Oceanographic Identification Centre.

Objectives: To determine the short-term impact of crude oil released from below an ice covered bay near Cape Parry, N.W.T. by monitoring the rate of carbon fixation by phytoplankton and the water quality during the winter and spring (1974/75) of the oil discharge as part of the Beaufort Sea Project (#29) environmental study.

Location: Field study site at Balaena Bay near Cape Parry, N.W.T.; laboratory and data processing located at 562 Booth Street, Ottawa.

Previous Work: Small oil discharge experiments have been monitored in the Mackenzie Delta on shallow lakes (W. A. Adams et al., 1975).

Work in Progress: Field studies associated with winter and spring (1974/75) following the oil discharge have been completed and reports published (W. A. Adams, 1974 and 1975).

Future Work: The sea ice at Balaena Bay is to be surveyed for biological activity in the spring of 1976 prior to break-up. Three reports are being prepared for publication in 1976 which will terminate the project.

PROJECT G-76-8

THERMODYNAMIC AND ELECTRICAL PROPERTIES OF ICE IN ITS VARIOUS STRUCTURAL STATES

Principal Investigator: G. P. Johari

Cooperating Agency: Division of Chemistry, National Research Council, Ottawa.

Objective: To obtain data on the heat and the volume properties of ice in its various structural forms obtained either by application of pressure and/or by cooling.

Location: 562 Booth Street, Ottawa

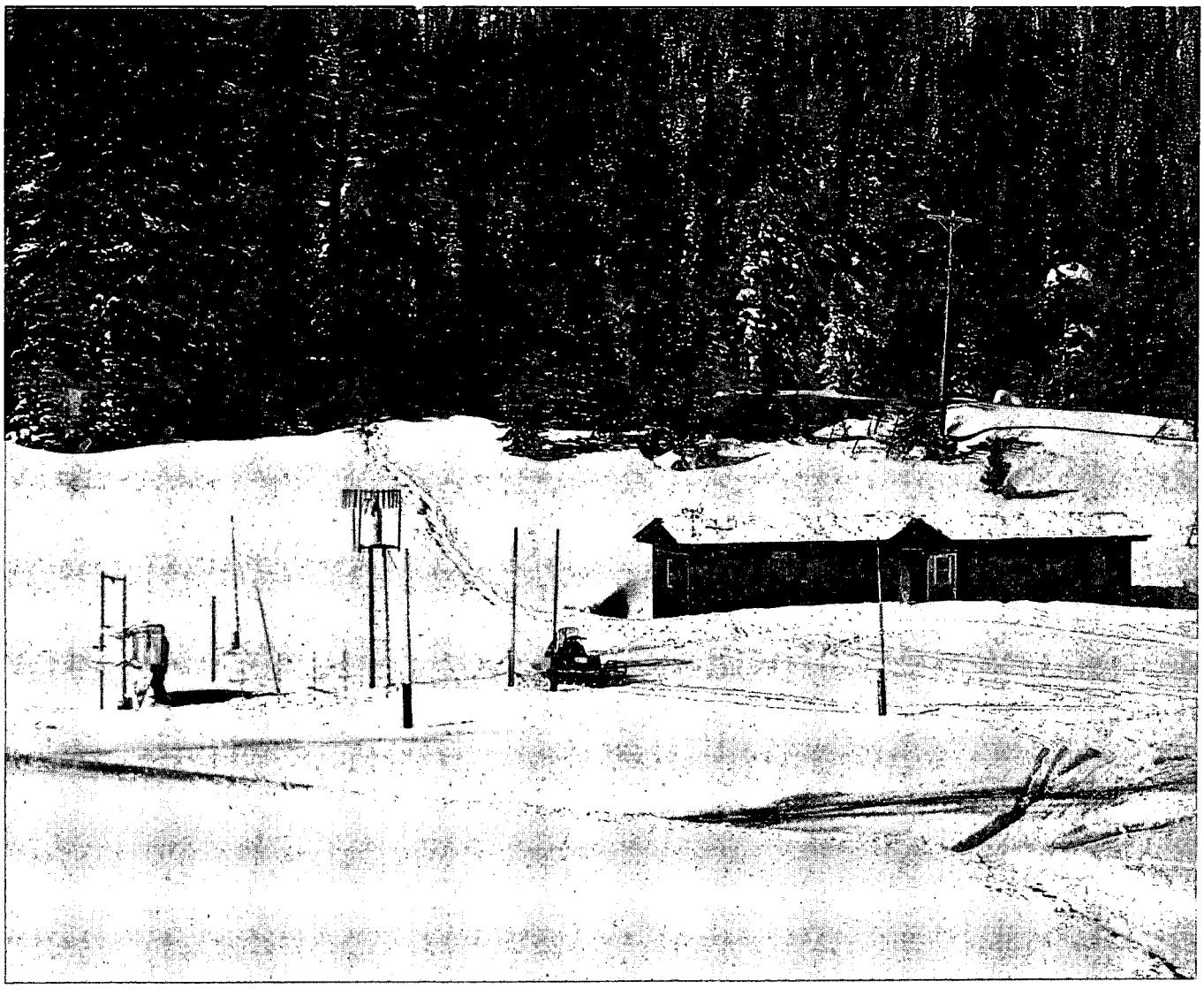
Previous Work: None by the Ice Properties Section

Work in Progress: Data have been obtained.

Future Work: To write the reports for publication.

Publications: Johari, G. P. and Whalley, E. (1974)
Johari, G. P. (1976c)
Johari, G. P. and Whalley, E. (1976)

Avalanche Research (Snow Physics)



Avalanche Research Station at Sunshine ski area, Banff National Park.

PROJECT G-74-10

STABILITY EVALUATION AND CONTROL OF AVALANCHE SLOPES

Principal Investigator: R. I. Perla

Cooperating Agencies: National Research Council of Canada and Parks Canada

Objectives:

1) To find improved methods of evaluating avalanche slope stability from snow stratigraphy and meteorological variables.

2) To optimize methods for artificial release of unstable slopes.

Location: University of Calgary; Banff National Park; Whistler Mountain, British Columbia

Previous Work:

1) Erected cold-laboratory adjacent to Parks Canada study plot, Sunshine ski area.

2) Erected meteorological observatory at top of Sunshine ski area.

3) Developed laboratory and in situ techniques for measuring shear strength, density, temperature, and crystal characteristics of snow stratigraphy.

Work in Progress:

1) Analysis of historical records of snow stratigraphy, meteorological variables, avalanche events, and avalanche control operations. Main emphasis on the Cordillera.

2) Statistical analysis of in situ snow sampling techniques with main emphasis on the shear failure of snow and the density and grain characteristics of thin shear layers.

3) Theoretical study applying finite element techniques to the solution of snow slab stability problems.

Future Work:

1) Study of snow stratigraphy at avalanche fracture zones.

2) Development of a laboratory apparatus for studying the shear strength of large snow samples.

3) Contractual work on alternate methods of releasing avalanches.

PROJECT G-75-4

IMPACT PRESSURES OF LARGE AVALANCHES

Principal Investigators: P. A. Schaerer and R. I. Perla

Cooperating Agency: National Research Council of Canada and Parks Canada

Objective: To determine the impact pressure of large avalanches.

Location: Rogers Pass, British Columbia; Banff National Park; University of Calgary.

Previous Work:

1) National Research Council pioneering studies published as:

   Schaerer, P. A. 1973. Observations of avalanche impact pressures. In: Advances in North American Avalanche Technology: 1972 Symposium. USDA Forest Service, General Technical Report RM-3. Fort Collins, Colo. pp. 51-54.

   Schaerer, P. A. 1974. Friction coefficients and speed of flowing avalanches. Paper presented at International Sympcsium on Snow Mechanics, 1-5 April, 1974, Grindelwald, Switzerland (in press).

2) Installation of high frequency pressure transducers and magnetic tape recording equipment at the Tupper Avalanche Shed, Rogers Pass, B.C.

3) Theoretical study of avalanche dynamic models. Invited lecture on the "Fluid dynamics of avalanches", presented by R. I. Perla at the Seminar series, Environmental Engineering, University of Utah, March 1975.

Work in Progress:

1) Analysis of pressure waves from avalanche events to date.

2) Development of a model to explain avalanche impact in terms of collision phenomena of snow clods with various sizes and energies.

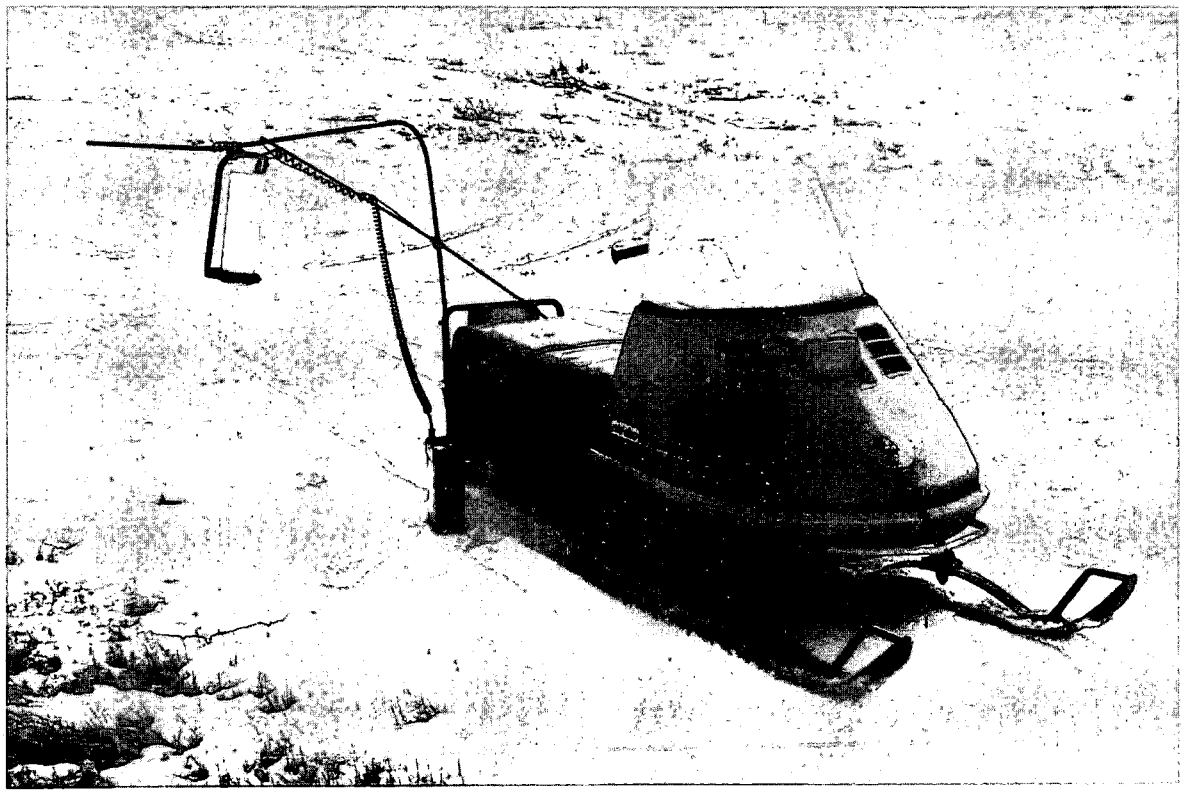
Future Work:

1) Continued analysis of avalanche events on existing sensors

2) Improvement of instrumentation reliability.

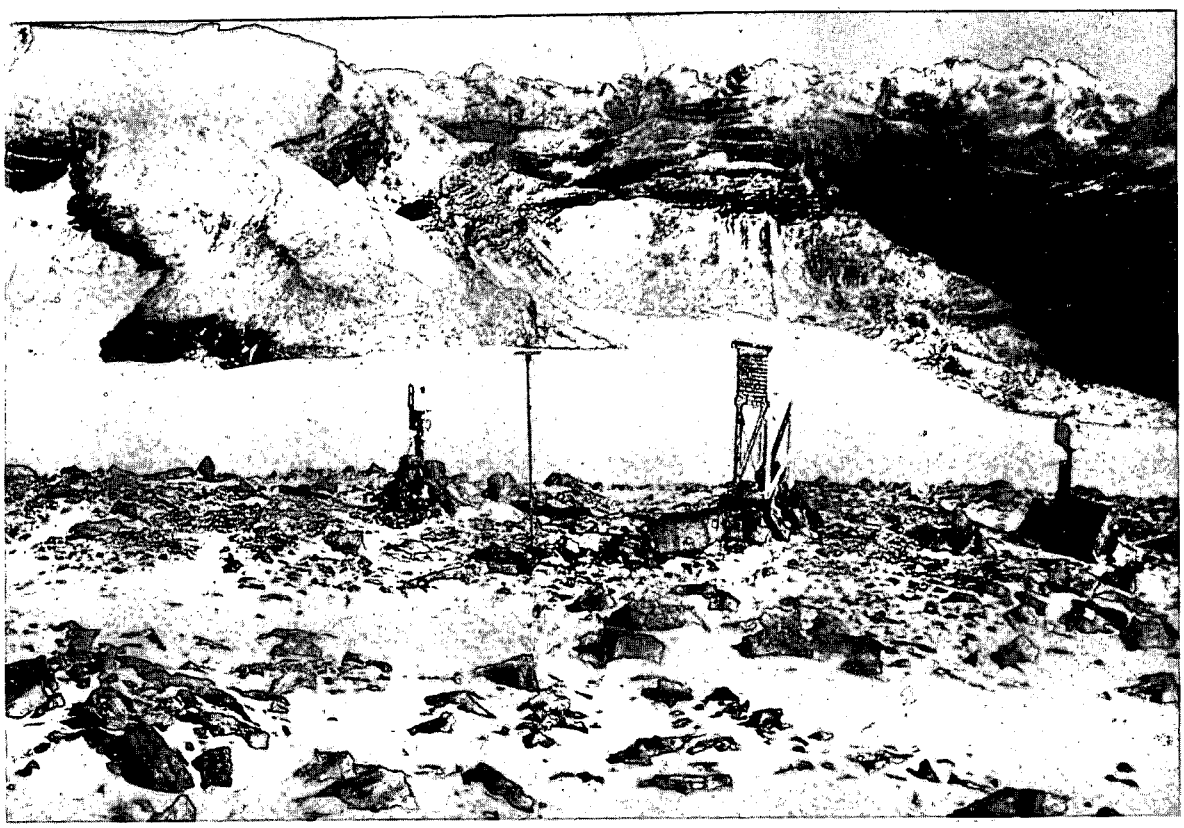
3) Installation of pressure sensor with larger area.

Snow Hydrology and Instrumentation



Snow surveying by portable gamma ray spectrometer. ▲

▼ High level data collection platform for satellite data retransmission; Rhondda Ridge, 9000′.



PROJECT G-67-6

GLACIOLOGICAL INVESTIGATIONS ON THE BERENDON GLACIER

Principal Investigators: G. J. Young and O. Mokievsky-Zubok

Cooperating Agencies: W. H. Mathews, University of British Columbia; Granduc Operating Company

Objectives: Mass balance and movement studies to assess likely future behaviour of the Berendon Glacier which threatens the Granduc mining operation.

Location: Coast Mountains (56°15'N, 130°10'W) 35 km N of Stewart, B.C.

Present Work: Annual survey of stakes on south area of the Glacier for movement and mass balance. Special approaches to the problems have resulted in 1) the perfection of a technique to detect wire mesh buried the previous summer and thus calculate quantities of snow added in the accumulation area of the glacier and 2) testing a survey system designed to locate stakes by theodolite resection rather than intersection.

Future Work: Time and money permitting, this project will continue as at present.

PROJECT G-69-3

GLACIER MELTWATER CONTRIBUTION TO THE FLOW OF THE NORTH SASKATCHEWAN RIVER

Principal Investigator: H. S. Loijens

Cooperating Agency: Water Survey of Canada

Objectives: To develop a parametric hydrologic model for the quantitative assessment of the glacier meltwater contribution to the flow of the North Saskatchewan River at Saskatchewan Crossing.

Location: North Saskatchewan River headwaters (52°45'N, 117°40'W) Banff National Park, Alberta

Project Completed

PROJECT G-69-8

MER BLEUE FIELD STATION

Principal Investigator: A. C. D. Terroux

Cooperating Agencies: None.

Objectives: To maintain a site in the National Capital Region where experiments in snow hydrology can be conducted.

Location: Mer Bleue (Central Experimental Forest)

Previous Work: The site was selected in 1969 for cooperative investigations of snowmelt and associated groundwater recharge. Various experiments have been conducted. Instrumentation installed includes precipitation gauges, snowmelt lysimeters, snow pillows, snow temperature profile probes, tubes for radioactive snow density gauges and a Stevenson screen.

Future Work: Support of projects requiring the facility.

PROJECT G-70-7

BAFFIN ISLAND CLIMATOLOGY

Principal Investigator: S. Fogarasi

Cooperating Agencies: Institute of Arctic and Alpine Research, Boulder, Colorado

Objectives: To develop a physical model that will relate short-term atmospheric parameters to glacier mass and water balance observations and to coastal ice conditions.

Location: Inugsuin Fiord, Baffin Island; Hull, Quebec

Future Work: Using available data, the effects of the short-term atmospheric energy budget on discharges from glacier fed streams will be determined. Extreme weather events that may result in severe flooding will be analyzed and the relationships between coastal winds, cyclonic outflows, fog, and coastal ice distributions investigated.

Publications: Fogarasi, S. and Strome, M. (1976)

PROJECT G-70-8

LASER FLUOROMETER

Principal Investigators: H. Gross and A. R. Davis

Cooperating Agencies: Canada Centre for Remote Sensing

Objectives: To gain further experience with the application of this technique in the remote sensing of pollutants and to transfer the device to a commercial entity for market exploitation, and to explore other targets.

Location: Ottawa

Previous Work: In the summer of 1975, flights were undertaken in the Atlantic off the southern tip of Nova Scotia to test the feasibility of the technique for remote sensing of chlorophyl in situ.

Work in Progress: Preparation of publications pertaining to the above work, and cooperation with RCA Canada in Montreal for future market development.

Future Work: This project is terminated. Further development is under consideration.

PROJECT G-71-6

APPRAISAL OF LONG TERM METEOROLOGICAL RECORDERS

Principal Investigator: A. C. D. Terroux

Cooperating Agencies: Atmospheric Environment Service; Atomic Energy of Canada Limited

Objectives: Obtain, modify and develop long term meteorological recorder capable of operating unattended under winter conditions in the Arctic and Cordillera.

Location: Resolute, N.W.T. (also Churchill, Manitoba and Arctic Red River, N.W.T.)

Previous Work: After a market survey in 1969, two Ott instruments were purchased. One operated in Resolute, N.W.T. from 1971 to 1975, powered and heated by a radioactive thermal generator produced by Atomic Energy of Canada Ltd. The other, using a wind generator and nickel-cadmium batteries, operated at Churchill, Manitoba and at a site on Arctic Red River. Several modifications have been made to both systems to determine causes of failure.

Work in Progress: The Arctic Red River Station and Resolute Station data are being analyzed and compared with data from neighbouring weather stations.

PROJECT G-72-10 (modified)

RETRANSMISSION OF DATA VIA LANDSAT AND GOES SATELLITES

Principal Investigator: A. C. D. Terroux

Cooperating Agencies: NASA and NESS

Objectives: To develop the capability of satellite data retransmission.

Location: National Capital Region and Cordillera

Previous Work:

1) LANDSAT - various instruments have been interfaced to a data collection platform (DCP) since 1972 with excellent results. Two DCP's of different manufacture have been used with a memory system to obtain up to 96 water level readings per day. A DCP was installed on Rhondda Ridge above Yoho and Peyto glaciers in October 1976 using a memory to obtain hourly temperatures.

2) GOES - water level and temperature sensors have been interfaced during 1976 with good results.

3) Numerous problems encountered by Water Survey of Canada DCP's have been located and repaired.

Future Work: New applications of both satellites will be examined and instruments interfaced as required. Other satellites and DCP's will be investigated.

Publications: Reid, I. A.; Terroux, A. C. D. and Halliday, R. A. (1976).

PROJECT G-72-11

INSTRUMENTATION DESIGN AND DEVELOPMENT

Principal Investigators: R. O. Christie and H. Gross

Cooperating Agency: None

Objectives: Provide technical advice and assistance to laboratory and field investigations.

Location: Point Gatineau Instrument Workshop

Previous Work: Design, construction and testing of electronic and other equipment.

Future Work: As previous, plus field support where required. Development of microprocessor based instrumentation.

PROJECT G-72-23

COMPUTER REDUCTION OF
GLACIER MASS BALANCE DATA

Principal Investigator: G. J. Young

Cooperating Agency: None

Objectives: To develop a computerized data reduction system for glacier mass-balance measurements.

Location: Ottawa, Ontario

Previous Work: Data collection was initiated in 1965, but computerized data processing started in 1970. The project uses data collected on projects G-67-1, G-67-2, G-67-3, G-67-4, and G-67-5.

Work Completed: A computer program has been completed and published which accepts raw mass balance data and outputs completed tables and maps of mass balance quantities.

Publications: Young, G. J. (1976b)

Project Completed

PROJECT G-72-24

APPLICATION OF THERMAL INFRARED TECHNIQUES TO DETECTION OF MELTING SNOW

Principal Investigator: A. C. D. Terroux

Cooperating Agency: Geography Department, University of Michigan

Objectives: To investigate if areas of melting snow can be determined by uncalibrated infrared line scan and radiometric techniques for both flat and glaciated areas.

Location: Calgary, Lake Louise and Saskatchewan Glacier, Alberta.

Previous Work: Thermal infrared line scan imagery was acquired outside Calgary in spring, 1972. Thermal infrared radiometer data was collected in Lake Louise for three days during the same period. Three IRLS flights were conducted over the Saskatchewan Glacier in June 1972 during a single day. Preliminary analysis of these three sets of data is complete.

Work in Progress: Final analysis is presently underway using a Spatial Data colour densitometer.

PROJECT G-72-25

PROVISION OF TECHNICAL ASSISTANCE IN REMOTE SENSING

Principal Investigators: A. C. D. Terroux, D. Sherstone, H. Gross and J. M. Power

Objectives: To provide technical assistance to Inland Waters Directorate in support of projects involving remote sensing.

Work in Progress: As requested.

PROJECT G-73-8

TESTING A PORTABLE PROFILING DENSITY GAUGE

Principal Investigator: G. J. Young

Cooperating Agency: None

Objectives: To field test a "Digiray" portable profiling snow density gauge.

Location: Peyto Glacier, Alberta and Sentinel Glacier. B.C.

Previous Work: None

Work Completed: Testing has been satisfactorily completed. There have been some minor mechanical and electrical malfunctions, but when functioning properly, results have been very satisfactory. The need for digging pits to make snow density measurements has been greatly reduced.

Publications: Young, G. J. (1976c)

Project Completed

PROJECT G-73-12A

MASS AND WATER BALANCE STUDIES IN THE WESTERN CORDILLERA

Principal Investigator: O. Mokievsky-Zubok

Cooperating Agencies: Water Survey of Canada; B.C. Hydro

Objectives: To study:

1) Annual mass balance;
2) The role of glaciers in the hydrologic cycle;
3) The long term changes of these factors.

Location: Place Glacier (50°18'N, 122°48'W) 120 km north of Vancouver, B.C.; Sentinel Glacier (49°54'N, 122°59'W) 70 km north of Vancouver, B.C. Helm Glacier (49°58'N, 123°00'W) 80 km north of Vancouver, B.C.

Previous Work: Glaciological, hydrological and climatological observations have been carried out on Place and Sentinel glaciers since 1965. Glaciological studies began on Helm Glacier in 1975. Special studies have from time to time been done on Sentinel Glacier. For recent results see publications.

Work in Progress: Winter and summer balances are measured on all glaciers and ablation is measured at intervals throughout the summer. Meteorological data are recorded during the larger part of the year. Meltwater discharge is measured during the summer by water level recorders (except on Helm Glacier). A summary of measurements for the IHD period (1965-1974) for Sentinel and Place Glaciers has been compiled and is in press.

Future Work: The existing basic mass balance measurement field program will continue on a reduced scale to provide material for studies of long-term changes in glacier behaviour.

Publications:

Mokievsky-Zubok, O. (1972, 1972, 1973a, 1973b, 1974, 1975)
Mokievsky-Zubok, O and Stanley, A. D. (1976a, b, in press)
Stanely, A. D. (1971)
Østrem, G. (1973).

PROJECT G-73-12B

MASS AND WATER BALANCE STUDIES AT PEYTO, RAM RIVER AND WOOLSEY GLACIERS

Principal Investigator: G. J. Young

Cooperating Agencies: Water Survey of Canada

Objectives: As part of a transect of 5 glaciers in the International Hydrological Decade Program, these glaciers were studied to investigate their mass and energy balances.

Location: Peyto Glacier (51°40'N 116°34'W) 45 km NW of Lake Louise, Alberta
Ram River Glacier (51°51'N 116°12'W) 45 km N of Lake Louise, Alberta
Woolsey Glacier (51°07'N 118°03'W) 15 km NE of Revelstoke, B.C.

Previous Work: The I.H.D. programs ended in 1974. In 1975 a partial mass balance program was maintained at Ram River and Woolsey Glaciers while a complete, but slightly revised program was maintained at Peyto.

Work in Progress and Future Work: The work at Ram River and Woolsey glaciers has now been terminated. Work at Peyto continues as an integral supplement to the nearby Yoho project. The glaciological work on Peyto is now being viewed in its context as part of overall alpine hydrology. Conditions on Peyto are being compared to those on neighbouring glaciers in the Wapta Icefield.

Publications:
Young, G. J. (1976a, b)
Young, G. J. and Stanley, A. D. (in press) (a, b)

PROJECT G-75-9

ROLE OF GLACIERS IN WATER MANAGEMENT IN REMOTE BASINS

Principal Investigators: O. Mokievsky-Zubok, A. C. D. Terroux, S. Fogarasi and J. M. Power

Cooperating Agency: B.C. Hydro

Objectives: Develop basis for managing reservoirs in remote glacierized basins.

Location: Upper Bridge River Basin, B.C.

Previous Work: Glacier mass balance studies in nearby area. Snow line surveys and prediction models by B.C. Hydro.

Future Work: Field program to relate snow line recession to snow water equivalent, aspect and orientation of slopes and nature of terrain (glacierized, rock, forest). Relate these parameters with meteorological data to seasonal runoff and remote sensing imagery. Evaluate usefulness of enhanced images.

PROJECT G-75-10

SNOWDROP EXPERIMENT

Principal Investigators: E. J. Langham and H. Gross

Cooperating Agencies: National Research Council

Objectives: Study the effect of the retention and detention of water in the snowpack on the spatial and temporal variations of percolation.

Location: Greber Boulevard and NRC Low Temperature Laboratory at Uplands Airport.

Previous Work: Apparatus for measuring the flow at sixty-four points in a square array has been constructed and partially tested.

Future Work: Complete tests including those for the microprocessor data acquisition system. Install at Uplands Airport for winter 1976-77. Collect and analyze data.

PROJECT G-75-11

REMOTE SENSING - MICROWAVE

Principal Investigators: H. Gross, A. C. D. Terroux, and E. J. Langham

Cooperating Agencies: Canada Centre for Remote Sensing; Geological Survey; Communications Research Centre

Objectives: Investigate the value of various methods of active and passive microwave systems to study the snow cover and its condition (complementary project remote sensing - thermal infrared).

Location: Highway 17 from Almonte to Ottawa River

Previous Work: Literature survey. This project also depends on previous work developing systems and computer programs by the cooperating agencies.

Future Work: Flights by aircraft during spring 1977 with L band microwave radiometer and scatterometer. X-band systems will also be flown if possible. Simultaneous ground data on snow extent and conditions using natural gamma ray and time domain reflectrometry among other methods.

PROJECT G-75-12

REMOTE SENSING - IMAGE ENHANCEMENT

Principal Investigators: E. J. Langham, A. C. D. Terroux and J. M. Power

Cooperating Agencies: Canada Centre for Remote Sensing

Objectives: Produce enhanced images for various snow-covered and glacier areas for selected times of year. Evaluate usefulness of such images in relation to other projects, in particular glacier movement, snowline definition and snowmelt.

Location: C.C.R.S. Sheffield Road

Previous Work: Development of enhancement technique (Langham and Taylor, 1975)

Future Work: Create enhanced images for selected sites, where ground truth is available. Create combined enhancements for images from different times of year. Compare results with other satellite imagery studies.

PROJECT G-75-13

REMOTE SENSING - THERMAL INFRARED

Principal Investigators: A. C. D. Terroux and H. Gross

Cooperating Agencies: Canada Centre for Remote Sensing; Geological Survey of Canada; Atmospheric Environment Service

Objectives: Investigate the value of thermal infrared images for study of extent of snow cover and its condition (complementary project: Remote Sensing-Microwave - G-75-11).

Location: Highway 17 from Almonte to Ottawa River. Later extension to include Cold Creek near Downsview.

Previous Work: General studies of thermal infrared imaging systems. Literature survey.

Future Work: Flights by aircraft during spring 1977 with thermal infrared scanner (DAEDELUS) coordinated with ground surveys of snow condition and temperature of snow and open water and thermal radiometer measurements. Analysis and evaluation of data collected. Assessment of possible extension of project to include satellite data (TIROS-N and Heat Capacity Mapping Mission in particular).

PROJECT G-75-14

YOHO AND AMISKWI STUDY OF
HYDROLOGIC ROLE OF GLACIERS

Principal Investigators: G. Young, A. C. D. Terroux, S. Fogarasi and J. M. Power

Cooperating Agencies: Water Survey of Canada; Environment Canada; Parks Canada; Atmospheric Environment Service

Objectives: Determination of role played by glacier melt in modifying the basin runoff. (These two valleys are similar in size and topography but one is glacierized and the other is not.)

Location: Yoho National Park

Previous Work: Preliminary investigation during 1975. Installation of some stream gauges and sites selected for others.

Future Work: Install remaining stream gauges. Establish meteorological stations; record data on snow depth and water equivalent and snow-line retreat during season. Relate these data to runoff and to satellite imagery. Evaluate use of enhancement of LANDSAT images.

PROJECT G-75-15

SATELLITE SNOW MAPPING

Principal Investigators: E. J. Langham and D. A. Sherstone

Cooperating Agencies: NOAA-NESS, Washington; Canada Centre for Remote Sensing, Ottawa; B. C. Hydro; Atmospheric Environment Service; WMO.

Objectives: Determination of aerial extent of snow cover for "WMO Snow Studies by Satellite Project" using NOAA-VHRR and LANDSAT imagery; develop methodology and test accuracy.

Location: Areas to be mapped are located in the Columbia River headwaters, Saskatchewan River headwaters and possibly the Okanagan basin.

Previous Work: Progress Report: "Snow Mapping in the Western Cordillera using Satellite Imagery", by D. A. Sherstone, dated November 24, 1975. All available VHRR visible band imagery between May and October 1975 has been interpreted for selected basins varying in size from 200 to 3,700 sq. mi. A few LANDSAT images have also been analyzed and related to VHRR data.

Project Completed

PROJECT G-75-17

GAMMA-RAY SPECTROMETRY

Principal Investigator: A. C. D. Terroux and E. J. Langham

Cooperating Agencies: Environment Canada: Water Planning and Management, Ontario Region; Water Survey of Canada; Canadian Forestry Service; Northern Research Centre, Edmonton. Energy Mines and Resources: Geological Survey of Canada. Canada Department of Agriculture. Saskatchewan Department of the Environment. Ontario Ministry of the Environment. Prairie Provinces Water Board. Division of Hydrology, University of Saskatchewan. U. S. National Weather Service, Washington.

Objectives: To develop operational techniques and methodology for measuring the water equivalent of the snow cover using gamma radiation emitted naturally from the soil using both air-borne and ground-borne systems.

Location: Field tests in various parts of Canada.

Previous Work: Air-borne measurements have been made over Souris River Basin (1975-1976); Wilmot Creek Basin (1974) and over a wide area of Southern Ontario (1972-1973). A portable spectrometer has been tested at the Central Experimental Farm and measurements started in Marmot Creek Basin (both in 1975). The portable system is particularly suited to surface measurements. It is thus cheaper to operate but has a more limited range.

Future Work: Further experimental and theoretical work is planned. Since results to date have been very good, demonstration projects are being arranged with the object of disseminating information on the techniques and evaluating them for operation purposes.

Publications: Loijens, H. S. (1973a)
Loijens, H. S. and Grasty, R. L. (1973)
Grasty, R. L., Loijens, H. S. and Ferguson, H. L. (1973)
Loijens, H. S. (1975a and 1975b).

PROJECT G-75-18

AN ICE-LANDSLIDE IN WESTERN CANADA

Principal Investigator: O. Mokievsky-Zubok

Cooperating Agencies: None

Objectives: To obtain information on the cause of the slide and evaluate advanced theories.

Location: Devastation - Capricorn glaciers (50°36'N, 123°32'W)

Previous Work: Analysis of data and study of literature

Work in Progress: The information collected has been written up for presentation and publication.

Project Completed

PROJECT G-75-19

HYDROCHEMICAL BALANCE STUDIES OF GLACIER MELTWATERS

Principal Investigators: O. Mokievsky-Zubok, J. Zeman

Cooperating Agency: University of British Columbia

Objectives: A reconnaissance study to

1) Obtain datum from undisturbed systems at high altitudes for comparison with ecosystems in lower altitudes which would be subject to some type of land and water use;

2) establish regional classification of hydrochemical characteristics of various glacier meltwaters.

Location: Sentinel Glacier basin (49°54'N, 122°59'W)

Previous Work: Chemical analyses have been carried out.

Work in Progress: Study of the results - publications to follow.

PROJECT G-75-20

T.D.R. STUDY OF SNOWPACK

Principal Investigator: H. Gross and E. J. Langham

Cooperating Agencies: None

Objectives: To investigate the application of Time Domain Reflectrometry to the study of snow, ice and water in the structure of the snowpack.

Location: Ottawa

Previous Work: None

Work in Progress: Construction of apparatus

Future Work: Possible contract to be given out for the design of probes. Also the emplacement of a probe network.

PROJECT G-76-9

REMOTE SENSING - EXISTING HYDROLOGIC MODELS

Principal Investigators: J. M. Power and E. J. Langham

Cooperating Agencies: Water Survey of Canada; Environment New Brunswick; New Brunswick Power; Environment Canada.

Objectives: To evaluate the usefulness of remotely sensed data as input to operational flood forecasting models.

Location: Ottawa River Basin; St. John River basin

Previous Work: none

Work in Progress: NOAA/VHRR imagery for the 1976 snowmelt period is currently being used to map the snowline in the Ottawa River basin and this will be used as a check against model calculations.

Future Work: A similar exercise on a real-time basis will be conducted on the Ottawa River for the 1977 spring flood forecast period.

PROJECT G-76-10

REMOTE SENSING - NEW HYDROLOGIC MODELS

Principal Investigators: J. M. Power and E. J. Langham

Cooperating Agency: None

Objectives: To develop new forms of hydrologic models uniquely suited to utilize the type of distributed information available from remote sensing.

Location: Bridge River, British Columbia

Previous Work: None.

Glacier Mapping

GLACIER MAPPING

Principal Investigators: I. A. Reid, J. O. G. Charbonneau, Applied Hydrology Division

Cooperating Agency: Water Survey of Canada

Objectives: To determine volumetric, areal and lineal changes from maps prepared biennially from Terrestrial Photogrammetric Surveys.

The following glaciers are mapped: Sentinel, Sphinx, Bugaboo, Kokanee and Nadahini in British Columbia and the Athabasca and Saskatchewan in Alberta.

Location: Hull, Quebec

Previous Work:

1) A Terrestrial Photogrammetric survey of five glaciers in British Columbia was made in 1964, 66, 68, 70, 72 and 74. A Terrestrial Photogrammetrical survey of the two glaciers in Alberta was made in 1963, 65, 67, 69, 71, 73 and 75.

2) References: Reid, I. A. "Glacier Surveys by the Water Survey of Canada". A paper presented at the Banff Symposia in September, 1972.

Work in Progress: Preparing reports on recent surveys.

Future Work: To continue the mapping project of the seven glaciers.

Indexes

PROJECT STATUS CHANGES THAT HAVE OCCURRED IN PROJECTS SINCE THE 1974 CATALOGUE

Project No.	Short Title	Status
G-67-7	Glacier Surges	Forms part of G-73-7
G-67-13	Decade Glacier Studies	Terminated
G-67-14	Per Ardua Glacier Studies	Terminated
G-69-8	Mass and Energy Transfer in a Shallow Snowpack	Terminated
G-70-3	Oil Pollution in Ice-Infested Waters	Transferred to MEDS* effective 1-4-75
G-71-2	Spreading of Oils on Ice and Snow Surfaces	Transferred to CCIW effective 1-4-75
G-71-3	Oil/Water Emulsion Studies	Transferred to CCIW effective 1-4-75
G-71-6	Appraisal of Long-Term Meteorological Recorders	Terminated
G-71-7	Applications of RS Techniques to Glaciology	Forms part of G-75-15
G-72-5	Aging of Oils on Ice and Snow	Transferred to CCIW effective 1-4-75
G-72-6	Precipitation climate at Some B.C. Glaciers	Forms part of G-75-14
G-72-8	Hydrology of Glacierized Basins	Forms part of G-75-14
G-72-9	Extraction of Hydrologic Information from ERTS (LANDSAT) Imagery	Terminated
G-72-10	Retransmission of Hydrologic Data	Terminated
G-72-17	Hydrology of D'Iberville Basin, N.W.T.	Forms part of G-75-2
G-72-24	Detection of Melting Snow by IR Techniques	Forms part of G-75-13
G-72-26	Fluvial and Cryogenic Processes in Mackenzie Basin	Suspended
G-73-1	Arctic Ice Island and Related Studies	Suspended
G-73-9	Ice Conditions Along Arctic Shores	Transferred to MEDS* effective 1-4-75
G-73-11	Ice Regime in the Upper St. Lawrence Basin	Transferred to MEDS* effective 1-4-75
G-74-1	Passive and Active MW Signatures of Floating Ice	Transferred to MEDS* effective 1-4-75
G-74-2	Ice Thickness Distribution in the S. Beaufort Sea	Transferred to MEDS* effective 1-4-75
G-74-3	Radar Techniques to Measure Floating Ice Thickness	Transferred to MEDS* effective 1-4-75
G-74-4	Dielectric Properties of Floating Ice in the MW Region	Transferred to MEDS* effective 1-4-75
G-74-5	Physical Properties of An Artificial Ice Platform	Transferred to MEDS* effective 1-4-75

* MEDS - Marine Equipment Data Service, Ocean and Aquatic Sciences.

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